

# Laryngealization or Pitch Accent – the Case of Danish Stød

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## Abstract

According to recent proposals Danish stød is the phonetic manifestation of a HL tonal pattern compressed within one syllable, making the stød/non-stød distinction a special case of the more general tonal word accent distinction in Swedish and Norwegian. This review of the relevant aspects of Danish stød and intonation demonstrates that (1) such a tonal representation of stød is contradicted by the phonetic reality. (2) Stød is distributed in words according to roughly the same principles across regional varieties of Danish, but tonal patterns are highly variable. (3) Word accents in Swedish and Norwegian are associated exclusively with stressed syllables, whereas stød occurs also in less than fully stressed syllables, devoid of autonomous pitch movements. (4) A word in Swedish and Norwegian can have one pitch accent only, but Danish words may have more than one stød.

**Index Terms:** stød, laryngealization, tone, Danish

## 1. Introduction

The acoustic, perceptual as well as formal properties of standard Danish stød and standard and regional Danish intonation are documented in [1-10]. There is a long tradition in Denmark to describe stød as a kind of creaky voice, explicitly independent of tone, from Høysgaard [11-13] through Martinet [14], Hjelmslev and Andersen [15-16], to Basbøll [17-18]. The phonology and morphology are extensively accounted for and formalized in Basbøll's *Non-Stød Model* [19-20]. Recent years, however, have seen proposals for a different analysis of Danish stød in [21-27], namely as the phonetic by-product of a H and L tone compressed within one syllable, inspired by Kiparsky's analysis of Livonian stød, [28], although Kiparsky himself confines the tonal analysis to Livonian and does not extend it to Danish. There could be several incentives for such a proposal. (1) It is entirely justifiable on physiological grounds, given what is known about the larynx and the vocal folds in  $F_0$  lowering [29-31]. (2) In several South East Asian tone languages, low tone is often accompanied by laryngealization, as in Mandarin and Cantonese [32]. (3) There is an undisputed diachronic relation between the stød/non-stød distinction and the Accent I/Accent II distinction in Swedish and Norwegian, and the idea that stød arises from tonal contours is common in diachronic theories of *stødgenesis* [33-34]. (4) There is also a certain synchronic similarity in the distribution of Accent I/II and stød/non-stød. (5) Stød as pitch accent would unify Danish stød and the Scandinavian word accents in the current autosegmental-metrical framework as, e.g., in [35].

## 2. Laryngealization

Stød is prototypically a kind of creaky voice: non-modal voice with aperiodic vibrations and irregular amplitude, often but not invariably accompanied by a local fundamental frequency perturbation, an abrupt and brief  $F_0$  dip, typically contained within the second half of long vowels or in the sonorant consonant after short vowels [1-2, 36], consonant with Basbøll's conten-

tion in [19] that stød is a property of the second mora of bimoraic syllables. A series of acoustic and perceptual investigations in the early 2000s, summarized in [3-4], showed, however, that the exact acoustic properties, the timing, and the segmental domain of stød are highly variable: vocal fold vibrations are more or less explicitly irregular; the irregularity may onset simultaneously with the stressed vowel or later in the syllable nucleus; it may be contained within the syllable rhyme or it may spill over into a succeeding post-tonic syllable. The considerable acoustic variability does not seem to affect perception: Stød is as clearly audible in the word in the middle as on the left in Figure 1 in spite of the rather stark contrast between the vibratory patterns in the two vowels. A further notable characteristic is its robustness: In fast or non-distinct speech styles, where segments and syllables are freely weakened or lost, stød is faithfully produced and perceived.

For a speculative account of the neuro-physiological mechanism behind this rather astounding acoustic variability in stød manifestation, see, e.g., [4]. – The variability in Danish stød is similar to what Blankenship reports in [37] about Mazatec and Mpi, and she finds *laryngealization*, i.e. stiffening of the vocal folds, which may or may not result in creaky voice, to be a better concept. So do Garellek and Keating in [38]. As in Danish stød, Gerfen and Baker find in [39] that laryngealization in Coatzacoapan Mixtec is highly variable within and across speakers and often realized with very subtle  $F_0$  and amplitude cues.

## 3. Pitch

Figures 1-6 and 8 are Praat pictures ([40]), displaying spectrograms with superposed linearly scaled  $F_0$  tracings. In figures 1 and 6 the microphone signal is included in order to elucidate the vibratory patterns underlying the  $F_0$  perturbations. But otherwise the pertinent facts about stød as they are outlined in the text appear unambiguously from  $F_0$  contour and spectrogram alone. Words depicted in apparent isolation in Figures 1, 4, 5, and 8 are spliced out from within longer utterance contexts. The utterances were scripted and read aloud, except in Figure 4 which presents non-scripted speech.

### 3.1 Standard Danish in Copenhagen is not HL

Figure 1 demonstrates that (1) the  $F_0$  perturbation, the deep and steep fall, in the word on the left is contained within a very narrow time frame, not to be mistaken for a falling tone distributed over the whole syllable; and (2) there is an evident overall similarity, from lower stressed to higher unstressed syllable, in all three words – the two with stød left and mid and the one without on the right. This is the  $F_0$  pattern associated with stressed and post-tonic syllables in Copenhagen Danish, cf. [8-10], apparent also in Figures 2 and 4-6. It would be characterized as L\*H in current notational practice. A maximally developed  $F_0$  pattern describes a very modest initial  $F_0$  fall in the stressed vowel, succeeded by a steep and considerably larger rise, typically 3-4 semitones, to the first post-tonic syllable, and then a fall through succeeding post-tonics, if any. The shorter the stress group, the less extensive the  $F_0$  pattern:

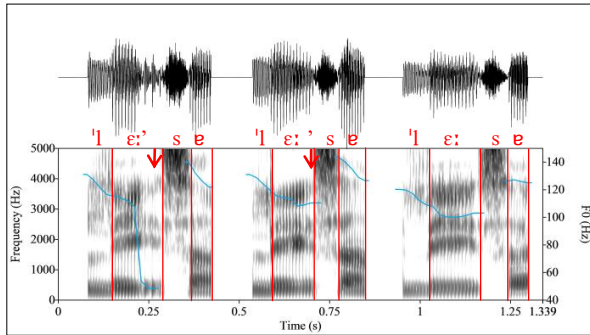


Figure 1: Three words: læser 'reads' with explicit stød (left), less explicit stød (mid), and læser 'reader' without stød (right). Arrows point to the laryngealized part of the vowel. Male Copenhagen speaker.

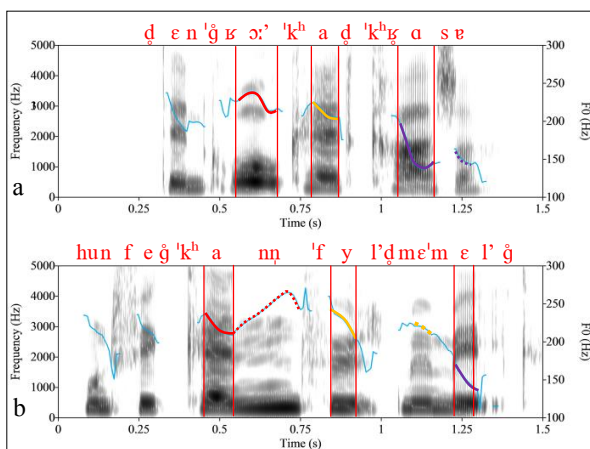


Figure 2: Den grå kat kradser 'The grey cat scratches' (a), and Hun fik kanden fyldt med mælk 'She had the jug filled with milk' (b). Stressed vowels are touched up in full lines: red (first), yellow (second), and purple (third); unstressed vowels and the syllabic consonant in corresponding dotted lines. Female Copenhagen speaker.

compare *kanden* in Figure 2b with the two long words in Figure 4. In the absence of any post-tonic syllable, all that remains is the slight initial fall as in *grå* and *kat* in Figure 2a. Note specifically the pairwise similarity between the  $F_0$  contours within the stressed vowels of (i) stødless *kan(den)* and *grå* with its nearly invisible stød (red lines); (ii) stødless *kat* and *fyldt* with stød and an explicit local  $F_0$  drop in the [l] (yellow lines); (c) stødless *krad(ser)* and *mælk* with stød and a likewise explicit local  $F_0$  drop in the [l] (purple lines). The red, yellow and purple stressed vowel lines are also situated, pairwise, at the same  $F_0$  level in utterance a and b, respectively. In other words, the presence or absence of post-tonic syllables does not affect the scaling of the stressed syllables in the speaker's range. That precludes a suggestion in [35:224-5] that the pitch pattern in Danish is in fact HL, only the H is delayed (i.e.: to the post-tonic). But in the absence of any post-tonic syllable to carry the H tone, one would expect the stressed syl-

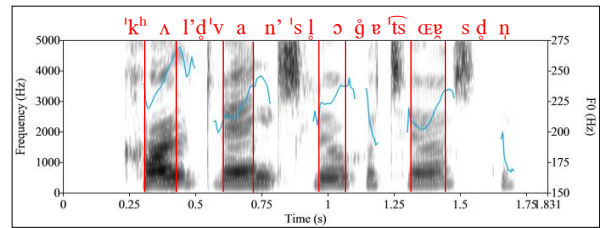


Figure 3: Koldt vand slukker tørsten 'Cold water slakes one's thirst.' Female Aalborg speaker.

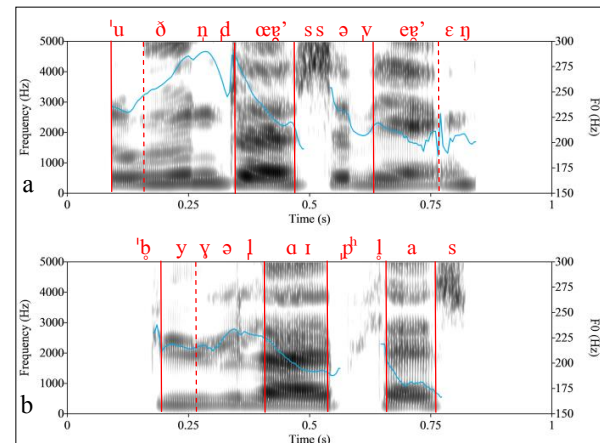


Figure 4: Two compound words: udendørsservering 'open air serving' with stød in the two syllables with secondary stress (a), and byggelegeplads 'adventure playground' without stød (b). Female Copenhagen speaker.

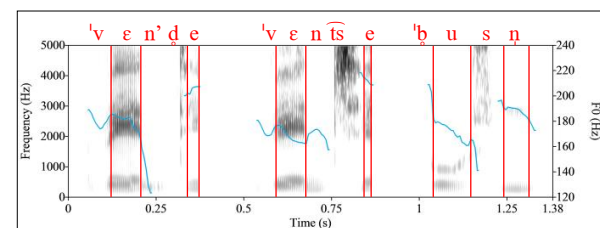


Figure 5: ... vend det ... 'turn it' (left), ... ven til ... 'friend to' (mid), and ... bussen ... 'the bus' (right). Same speaker as in Figure 2.

lable to move upwards in the range and take up its rightful H position. That does not happen.

Stød as a local  $F_0$  perturbation, a brief and more or less explicit lowering of  $F_0$ , is independent of its location on the  $F_0$  pattern. It may occur at the low turning point, prior to the rise to the post-tonic, as in *læser* in Figure 1 left, or *fyldt med* in Figure 2b. It may occur at the top of the  $F_0$  pattern as in *koldt* and *vand* in Figure 3, and low on the falling flank in a long series of post-tonics as in *udendørsservering* in Figure 4a. There is nothing to distinguish stød in one position from stød in any other position. The fundamental  $F_0$  similarity between stød and non-stød is also evident in the figures. Note particularly that there is nothing reminiscent of two HL pitch accents in the smoothly falling  $F_0$  contour associated with the

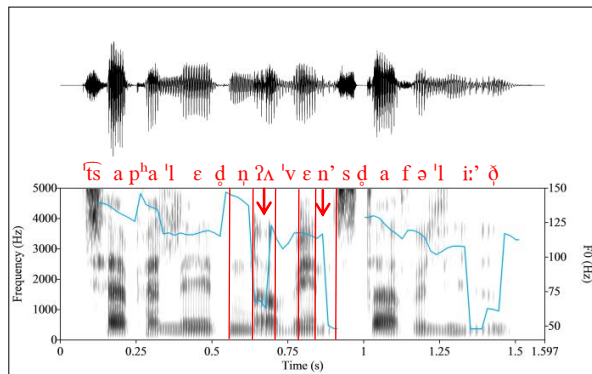


Figure 6: Tag paletten og vend staffeliet 'Take the palette and turn the easel'. Same speaker as in Figure 1.

second and third parts of the compound *udendørsservering* in Figure 4a. In this respect it resembles the stødless word below in 4b, *byggelejeplads*, though the latter is produced within a narrower frequency range.

Figure 5 depicts two stressed monosyllables succeeded by an unstressed word, *vend det* with stød, *ven til* without stød, and a stødless disyllable *bussen*. Again, the overall  $F_0$  patterns in the three disyllabic sequences are identical: a movement from lower stressed syllable to the higher post-tonic, three L\*Hs.

Below the two arrows in Figure 6 are two very similar  $F_0$  events: very steep and very local falls framing the sequence *og vend*. The first is associated with the glottal onset at the juncture before the vowel in *og*, the second accompanies the stød in *vend*. Presumably, no one would suggest that glottal attack at vowel onset be associated with a phonological pitch accent. Under a tonal analysis, then, the leftmost  $F_0$  perturbation is the result of a glottal onset which is not quite a complete glottal closure here, but comes out as creaky voice, whereas the same  $F_0$  perturbation on the right would be an autonomous tonal gesture with a laryngealized side effect.

Note also how microprosodic effects may induce extensive  $F_0$  movements in a vowel. An uninitiated observer might ascribe a falling pitch accent to the first syllable of *bussen* in Figure 5: the extent of its  $F_0$  fall is nearly as comprehensive as the fall in *vend*. But the first steep part of the fall in *bus-* is due to the transition from the unvoiced stop consonant to the vowel, the final steep movement is due to the transition from vowel to obstruent, and in fact the vowel is perceived as a non-dynamic level pitch. The pertinent, perceptible movement in the three disyllabic sequences – whether or not they contain a word boundary – is the movement from the lower stressed syllable to the higher post-tonic. None of these patterns contain a HL tonal sequence, they are all perceptually LH.

To sum up: The pitch pattern in Copenhagen Danish is essentially the same in words with and without stød, and it is LH, not HL. Furthermore, under temporal constraint the pattern is *truncated* rather than *compressed* into the stressed syllable. A representation in terms of a HL tone compressed into one syllable is as far removed from the phonetic reality as can be.

### 3.2 Regional varieties of Standard Danish

Figure 7 depicts, in six different locations in Denmark, stylized tracings of the  $F_0$  patterns associated with the *prosodic*

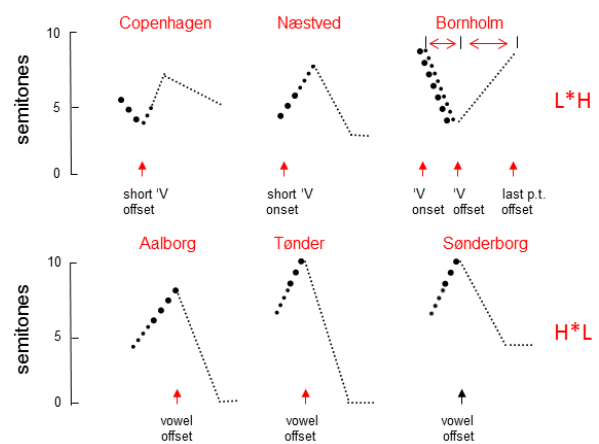


Figure 7: Prosodic stress group patterns in six varieties of Standard Danish. Vertical arrows point to the segmental anchor point. See further the text.

*stress group*: a stressed syllable plus all succeeding unstressed syllables, if any, irrespective of intervening word boundaries. They are not impressionistic drawings or educated guesses but based on acoustic data from a considerable number of recordings of four speakers from each region, recording the same scripted material under identical conditions, cf. [8]. Heavy dots depict the location of short stressed vowels on the  $F_0$  pattern, medium dots depict the extension in long stressed vowels, and fine dots depict the course of unstressed syllables in the prosodic stress group. In Bornholm, the vertical strokes enclose movements which may be expanded or compressed in time, as suggested by the horizontal arrows, in concordance with the duration of the stressed vowel (long or short, the falling part), and the number of post-tonic syllables in the stress group (the rising part).

These  $F_0$  patterns would adequately represent trisyllabic prosodic stress groups. This is of no particular concern for Næstved, Aalborg, Tønder and Sønderborg, because  $F_0$  will generally reach its low minimum already in the second post-tonic and continue low and level. But in Copenhagen, where the fall from the high turning point in the first post-tonic is less steep, it would typically continue to fall further, beyond what is depicted in Figure 7, only to level out around a fourth or fifth post-tonic, as in *udendørsservering* in Figure 4a. In other words, there is no fixed pitch relation between a L\* and the termination of a *preceding* stress group pattern: the L\* will be approached from above after short stress groups, cf. *fylgt* in Figure 2b, and from below after long stress groups, cf. ... *med ru-* ... in Figure 8.

The variation in shape and range of  $F_0$  patterns is considerable. Differences among them are easier to capture when the governing principle in their execution is made explicit: In all of them, except Bornholm, there is one point only in the melodic fragment which is constrained in terms of its alignment with a segment in the prosodic stress group, as indicated by the vertical arrows in the figure. This point is low relative to the first post-tonic in Copenhagen and Næstved and high in Aalborg, Tønder and Sønderborg. The former two may accordingly be characterized as L\*H, the latter three as H\*L.

The anchor is invariably associated with the stressed vowel, namely with its offset across the board in the H\*L

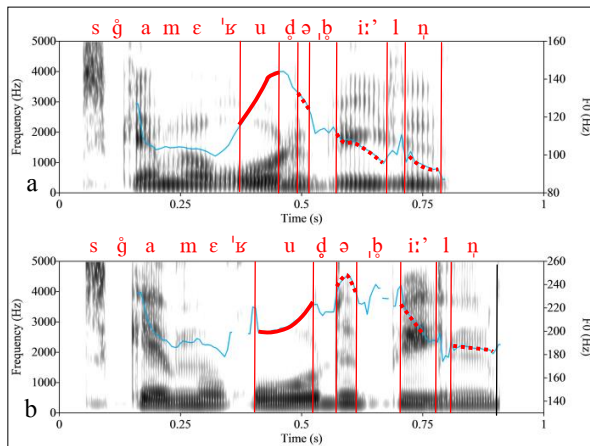


Figure 8: ...skal med rutebilen... 'are going by bus', male Aalborg speaker (a), female Næstved speaker (b).

varieties, but with its onset in Næstved. In Copenhagen the low turning point coincides with the offset of the stressed vowel if that vowel is short, and occurs about halfway through a long stressed vowel. Leaving out Bornholm for the moment, *neither segments nor syllables in the prosodic stress group on either side of the anchor have separate tonal representations*. They are simply strung out on the melody like pearls of varying length on an undulating string. Voiceless segments interrupt the melody and may have very local microprosodic effects but do not otherwise interfere with the score. A complete pattern only materializes in so far as there are syllables to carry it, otherwise it is truncated from the end. Accordingly, monosyllabic stress groups with a short vowel surrounded by voiceless consonants exhibit only the part of the melody indicated by the heavy dotted line part in the five patterns in Figure 7.

Figure 8 shows two actual passages, ... *skal med rutebilen...* by a male speaker from Aalborg (a) and a female speaker from Næstved (b). The frequency scale spans exactly an octave in both cases, so the ranges covered by the two patterns are immediately comparable. The offset of the stressed vowel (full red line) coincides exactly with the peak of the  $F_0$  pattern in Aalborg, as stipulated in the stylization in Figure 7, and the fall from the peak is rapid and extensive. Since the vowel is short, it does not make it to the peak of the pattern in Næstved, and the peak therefore coincides with the first post-tonic syllable, also as stipulated in the stylization in Figure 7. The fall is not as extensive as in Aalborg. The stød in the second part of the compound is acoustically rather weak in both instances, introducing a moderate perturbation only, although it is clearly audible in both cases.

Bornholm stands out from the other varieties by the very elastic relation between segments and  $F_0$ : the duration of the falling part of the tonal pattern varies – albeit slightly – with the duration of the stressed vowel so that that the low turning point coincides with the offset of the vowel, be it short or long. The duration of the rise varies with the duration of the unstressed part of the stress group so that the rise terminates on the last post-tonic syllable. This latter variation is considerable, between one and many post-tonics, and perceptually the rise is more conspicuous than the fall. In other words, the pattern has three targets, a high onset, a low turning point and

a high offset. There is, however, a limit to how fast the fall-rise may be executed, a compressibility maximum, and when this limit is reached, as in a monosyllabic stress group with a short vowel surrounded by voiceless consonants, the fall disappears, and what remains is a steep rise from a low onset to a high offset. Given that the fall may be deleted and that otherwise the rise in the  $F_0$  pattern is perceptually more salient than the fall, Bornholm may also be adequately represented as  $L^*H$ .

Among the  $L^*H$  varieties, two have stød, Copenhagen and Næstved, whereas Bornholm does not. Likewise, among the  $H^*L$  varieties Aalborg has stød, but Tønder and Sønderborg do not. So much for an insoluble correlation between tonal movement and stød in Danish.

### 3.3 Stød under non-primary stress

Pitch accents in Swedish and Norwegian are associated with primary stressed syllables, and hence words – also compounds – can each have one pitch accent only, [41]. But we have stød in syllables with non-primary stress, cf. *udendørsservering* in Figure 4a and *rutebilen* in Figure 8. And, contrary to expectations in a tonal representation, these syllables are not associated with independent, autonomous  $F_0$  movements. And of course, when syllables with secondary stress can have stød, words will have more than one when the stressed syllable also has stød as in, for example, [ $ǰal'$ ʔ $ǰal'$ ʔ] *golfbold* 'golf ball', [ $lan'$ ʔ $sman'$ ] *landsmand* 'fellow countryman'.

## 4. Discussion and conclusions

Despite all the pros listed in the introduction, stød as the manifestation of a compressed HL tone faces insurmountable empirical obstacles. There is nothing in the phonetic reality to support it. The overall  $F_0$  pattern is similar in words with and without stød, and when stød is not accompanied by any  $F_0$  perturbation at all, stød and non-stød  $F_0$  patterns are identical. Likewise, the principles which govern the presence or absence of stød in words of different structure, are roughly the same across regional varieties of Danish, in so far as they have stød at all, but  $F_0$  patterns are not. In other words, the laryngealization typically present in Danish stød is not a phonetic accompaniment to a compressed HL pitch accent. On the contrary: the  $F_0$  perturbation is a by-product of the laryngealization and not invariably present. Laryngealization is the articulatory, acoustic, and perceptual constant in stød production,  $F_0$  perturbation is not. Such a state of affairs is not exclusive to Danish either. Voice quality differences in some of the South East Asian languages are not merely the synchronic phonetic accompaniment to tonal differences. On the contrary, tones developed from phonation types, not the other way around [42-44]. Furthermore, in so-called *laryngeally complex* languages, like Mpi [45], Jalapa Mazatec [38], and Comaltepec Chinantec [46], tonal and phonatory contrasts co-exist and cross-classify. Thus, laryngealization may accompany any tone, whether high or low.

Space does not permit a review of the similarly serious obstacles in the phonology and grammar of Danish stød, if represented as a H and L tone compressed in one syllable. The reader is referred to [6].

In conclusion: laryngealization as an autonomous syllable prosody, orthogonal to pitch and intonation, suffer none of the shortcomings attached to a tonal representation and is altogether more satisfactory than any representation of Danish stød as underlyingly tonal in nature.

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