Danish Stød: Laryngealization or Tone

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Abstract
In the light of previous acoustic analyses of Danish stød and Danish intonation, we discuss two different phonological theories. In one, stød is an autonomous laryngeal syllable prosody. In the other, stød is the phonetic manifestation of a HL tonal pattern compressed within one syllable. The tonal representation is found to be contradicted by the phonetic reality, and it cannot account for the structurally determined alternation between non-stød and stød in inflection and derivation, nor for latent stød or stød in compounds. Furthermore, stød patterns are largely constant across regional varieties of Danish, but tonal patterns over the relevant structural domains are highly variable. Thus, stød may occur on any kind of tonal configuration, anywhere in the speakers’ pitch range, a variability which is hard to reconcile with a fixed HL representation.

1 Introduction
Historically stød may have developed in parallel with the Norwegian and Swedish word accents, it may have preceded the word accents in time, or it may be a further development of a word accent. This issue is of no concern here, and we are exclusively concerned with the synchronic state of affairs.

The basic acoustic and perceptual properties of standard Danish stød and standard as well as regional Danish intonation are well documented [Fischer-Jørgensen, 1987, 1989a, 1989b; Grønnum and Basbøll, 2001, 2007, 2012; Grønnum, 1983, 1984, 1990, 1992, 1995]. Against this background we shall look at two phonological stød theories. On the one hand, there is a long and uninterrupted tradition in Denmark to describe stød as a kind of creaky voice independent of tone: Autonomous Stød. Dissociating stød and tone is explicit already in the work of J.P. Høysgaard [1743, 1747, 1769] and has been reproduced and developed further in more recent treatments of Danish phonology, from Martinet [1937], through Hjelmslev [1951], Andersen and Hjemslev [1967],
Basbøll [1972], and Grønnum and Basbøll [2001, 2007, 2012], culminating in Hans Basbøll’s Non-Stød Model [1988, 2003, 2005, 2008]. Recently, a diametrically opposite view has been proposed where stød is a synchronic reflex of a H and a L tone compressed within a single syllable, thus Riad [1998, 2000, 2007, 2009], Itô and Mester [1997, submitted] and Morén [2005a, 2005b]. We call this approach Tonal Stød. The idea that a glottal accent may arise from tonal contours is not new in the literature, especially in diachronic theories of stødgenesis [Verner, 1878; Storm, 1874]. New is the claim, however, that stød is derived from an underlying tonal representation in the synchronic grammar. It is inspired originally by Kiparsky’s [1995] analysis of Livonian stød – a phenomenon phonetically similar to, but structurally different from, Danish [Thomsen, 1890: 58-63; Vihman, 1971]. In the updated and amended 2006 version of his [1995] handout Kiparsky still confines the tonal analysis to Livonian and does not extend it to Danish.

How do the two models fare when confronted with acoustic analyses of Danish stød and intonation? And how do they account for alternating stød patterns in morphologically complex words and under different conditions of prominence? Section 2 summarizes the phonetics and function of stød. Sections 3 and 4 outline the two phonological models. Section 5 presents the relevant analyses of Danish intonation, before arriving at a discussion and conclusion in section 6. Note that some of the details of the Non-Stød Model have been published before, e.g. in Grønnum and Basbøll [2012], but we report them fairly extensively again here, in order to adequately assess the explanatory power of the Tonal Stød model.

2 Phonetics and function of stød

2.1 Acoustic properties

Stød has previously been characterized as a kind of creaky voice, i.e. non-modal voice with aperiodic vibrations and irregular amplitude, often but not invariably accompanied by a local fundamental frequency perturbation, an abrupt and brief F₀ dip [Grønnum and Basbøll, 2007]. That is its prototypical appearance, but the manifestation may be weaker and resemble modal voice
more: a somewhat compressed voice quality lacking creak proper and/or lacking \( F_0 \) perturbation. It occurs only under conditions of more than zero stress. Most noteworthy, stød requires a certain minimum amount of voiced material in the syllable rhyme in order to be present, so-called *Stød-Basis* [Martinet, 1937; Hansen, 1943]:

either a long vowel, as in \([p^h\epsilon^n]\) *pen* ‘nice,’ \([s\epsilon^n\partial]\) *sent* ‘late,’ \([sbj^\epsilon\partial]\) *spist* ‘eaten’

or a short vowel followed by a sonorant consonant, as in \([p^h\epsilon^n]\) *pen* ‘pen,’ \([\lambda^n\partial]\) *langs* ‘along,’ \([h\lambda^n\partial]\) *halm* ‘straw.’

(Stød is conventionally written after the long vowel symbol and after the first post-vocalic sonorant following short vowels, respectively. For lack of a more appropriate notation we use a superscript glottal stop symbol \([^\cdot]\).)

Syllables which fulfil these segmental and prosodic requirements are heavy in Danish phonology. That is how they were characterized in Basbøll [1988], adopting ‘weight unit’ from Hyman [1985]. Later he came to call them bi-moraic [Basbøll, 2005, 2008]. The idea of stød as a mora-counting device can also be found in the work of some Prague phonologists [Trubezkoy, 1935: section 34; Martinet, 1937: 100-102; Liberman, 1982; Rischel, 2008]. Smith’s [1944] and Fischer-Jørgensen’s [1987, 1989a, 1989b] phonetic description of vowels with stød as having two distinct phases, a preparatory non-stød phase succeeded by a stød phase proper, is in accordance with such a moraic analysis.

A series of acoustic and perceptual investigations in the early 2000s [Grønnum and Basbøll, 2001, 2002, 2003] showed 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; and it may be contained within the syllable rhyme or spill over into a succeeding post-tonic syllable. Blankenship
[2002] finds a similar variability in Mazatec and Mpi and suggests that laryngealization, i.e. stiffening of the vocal folds – which may or may not result in creaky voice – is a better concept, as do Garellek and Keating [2011]. Gerfen and Baker [2005], in the same vein, find that laryngealization in Coatzopan Mixtec is highly variable within and across speakers and often realized with very subtle F₀ and amplitude cues. Kohler’s [1994, 2001] analysis of German glottalization yields a corresponding variability in phonatory explicitness, less surprising perhaps since the non-modal voice is not contrastive, but a feature of stop consonant production. For a general overview of phonation types, see Gordon and Ladefoged [2001]. – We should add a reservation about a phonetic or psycholinguistic understanding of the mora in Danish: it is undoubtedly a convenient formal device in the account of syllable structure and the conditions for stød as well as stress. But it is not a rhythmic entity as in mora-counting languages like, for instance, Japanese [Nagano-Madsen, 1992; Itô and Mester, 1995]. Syllables, not morae, determine poetic metre in Danish. Furthermore, Danes can easily be induced to count the number of syllables in a word, but morae evoke no reaction. An interesting aspect of the considerable acoustic variability is that it does not seem to affect the perception of stød: Stød is as clearly audible and identifiable in the word on the left as in the middle of fig. 1.

[Figure 1]

There are two important points to be made about fig. 1. First, the F₀ perturbation, the deep and steep fall, is contained within a very narrow time frame, not to be mistaken for a falling tone distributed over the whole syllable. Secondly, note the overall F₀ pattern similarity, from lower stressed to higher unstressed syllable, in the two words with (more and less explicit) stød and the one without stød on the right. For a more comprehensive account, see Grønnum and Basbøll [2007]. Note that the acoustic data depicted in fig. 1, as well as figs. 3, 4, 6, 7, and 9 below, are extracted from recordings of scripted speech produced under laboratory conditions. But the data in fig. 5 is
extracted from the non-scripted dialogues in DanPASS [Grønnum, 2009]. There is no principled
difference, whether qualitative or quantitative, in the way stød behaves in the two genres – not in
these particular instances nor generally.

A further interesting property of stød is its robustness. Even under the most unfavourable
circumstances, as in fast and/or non-distinct speech styles, where segments and syllables are freely
weakened or lost, stød is faithfully produced and perceived.

2.2 Production of stød

Danish stød is very reminiscent perceptually of the glottalization found in German [Kohler, 1994,
2001]. Its function is different, though, Danish stød being phonologically and morphologically
conditioned on the one hand, and distinctive on the other. Presumably, at least certain aspects of its
production would also keep it apart: Fischer-Jørgensen [1987, 1989a, 1989b] contains an account of
various phonation types, particularly creaky voice. She concludes that many features are identical in
creaky voice and stød, but that stød is not simply creaky voice. Grønnum and Basbøll [2007, 2012]
speculate about the kind of articulatory mechanism which could be made responsible for the rather
astounding acoustic – if not perceptual – variability:

The laryngeal activity is a ballistic gesture which – minimally – makes for a slightly
compressed voice quality, at one end of a continuum, and – maximally – creates a
distinctly creaky voice at the other. Under emphasis it may become a complete glottal
closure.

The laryngeal activity is a property of the sonorant part of the syllable rhyme.

The laryngeal activity is aligned with the onset of the rhyme.

The laryngeal activity is variable with respect to strength and to temporal extension.

The proposed ballistic gesture is to be understood as the low-pass filtered muscular response to a
transient neural command, basically a stiffening of the vocal folds. The neural command is presumably timed to coincide with the onset of the syllable rhyme. The impulse may be stronger or weaker, resulting in more or less irregular vocal fold vibration of shorter or longer duration, but once the command is executed, the speaker can no longer control the way the vocal folds respond to the excitation, just as one can no longer control the trajectory of a tennis ball once the ball has bounced off the racket. This proposal is consistent with the fact that speakers cannot choose to increase the duration of stød ad libitum, the way one may choose to lengthen creaky voice at the end of an utterance. In the same vein, parents addressing their infants may produce extremely long stødless vowels, but they do not similarly lengthen vowels with stød [Bleses et al., 2008]. It is also consistent with the way we have seen the stød to behave acoustically: (1) the more explicit (fig. 1 left) or less explicit (fig. 1 mid) non-modal vocal fold vibration; (2) the variable timing of the onset of actual creaky voice in the waveform and the spectrum; (3) the variable total duration which often makes the laryngealization continue well into the following syllable. Furthermore, our proposal is consistent with EMG-data: the onset and offset of the higher vocalis muscle activity in stød relative to modal voice are executed as a smooth, gradual rise and fall [Fischer-Jørgensen, 1987, 1989a, 1989b]. It would be curious indeed if the actual mechanical change in vocal fold vibration mode were not also gradual. At present we have no indication that the variability in strength and timing not be random. However, investigations of stød in the non-scripted monologues and dialogues in the DanPASS corpus may reveal individual differences among speakers, and variation as a function of speech rate, or – more likely – degree of prominence on the syllable.

2.3 The function of stød

Stød is indisputably distinctive on the surface, distinguishing words like

\[
\begin{align*}
[\text{ven}^?] \text{ vend! ‘turn!’} & \quad \text{vs.} \quad [\text{ven}] \text{ ven ‘friend’} \\
[\text{sigail}^?] \text{ skal ‘shell’} & \quad \text{vs.} \quad [\text{sigail}] \text{ skal ‘must’}
\end{align*}
\]
['lɛːɾə] læser ‘reads’ vs. ['lɛːɾə] læser ‘reader’

['væːlɔn] hvalen ‘the whale’ vs. ['væːlɔn] valen ‘numb’

['huːsɔ] huset ‘the house’ vs. ['huːsɔ] huset ‘housed’

['tɔemə] tømmer ‘timber’ vs. ['tɔemə] tømmer ‘empties’

['ɡelə] gælder ‘is valid’ vs. ['ɡelə] gæller ‘gills’

(['v] is the manifestation of oɛl, as in ['lɛːɾə] læser ‘reader;’ and oɛl assimilates to a neighbouring vowel or sonorant consonant, as in ['væːlɔn] hvalen ‘the whale.’)

Although stød distinguishes words, it is to a very large extent predictable from syllabic and morphological structure.

Whatever their diachronic development and mutual historical relation, the present-day stød/non-stød distinction roughly parallels the Accent I/Accent II distinction in the standard languages as well as the mainstream dialects of Swedish and Norwegian. Words with stød in Danish generally correspond to words with Accent I in Swedish and Norwegian, and words without stød correspond to words with Accent II. The tonal implementation of the Accent I/Accent II opposition varies substantially from dialect to dialect. Thus, Accent I, the structural cognate of stød, may be HL in one area of Norway or Sweden, but LH in another. This variability in the tonal realization of Accent I provoked quite opposite views, already in the late 19th century, about which one among the diverse tonal realizations of Accent I could be posited as the predecessor of stød in diachronic terms: HL [Sweet, 1873-4; Storm, 1874] as well as LH [Verner, 1878].

Apart from the phonetic realization there are some notable differences also at the purely functional level between stød and word accents which distinguish stød from a typical Scandinavian pitch accent system:
The stød/non-stød distinction is a difference in laryngealized versus modal voice; the standard Swedish and Norwegian word accent distinction is purely tonal.

There are segmental restrictions in stød occurrence; no such restrictions apply to the word accents. (See, however, Lorentz [2006, 2008] for a discussion of exotic instances of toneme-basis restrictions in a couple of Norwegian dialects.)

Stød is associated with syllables, not words; the opposite is true of word accents. It takes at least two syllables in Swedish or Norwegian for Accent II to occur; furthermore, Danish compounds may have more than one stød, whereas Norwegian and Swedish compounds never carry more than one word accent.

Danish monosyllables may have stød or not; monosyllables in Swedish and Norwegian always carry Accent I.

Danish words may have more than one stød; Swedish and Norwegian words can have only one word accent.

Together these differences make any direct comparison of tonal word accents in Swedish and Norwegian with Danish stød and non-stød opaque. In addition, to our knowledge no trends have been reported for Swedish or Norwegian to match recent observations about new trends in stød distribution, cf. section 4.5.

3 The distribution of stød in word

A phonological analysis has to account for the fact that the same heavy syllable rhyme in different lexemes may carry stød or not, as in [sɔɡalˈ] skal ‘shell’ and [sɔɡal] skal ‘must.’ But it must also accommodate the alternation between stød and non-stød in the same lexeme due to inflection and derivation, as in [bɔlˈkɔnə] balkon ‘balcony’ and [bɔlˈkɔnə] balkonen, ‘the balcony,’ and [ˈsɔːylɔ]=[ˈsɔːylɔ]
skyde ‘shoot’ and [uðsɡiː] udskyde, ‘postpone.’ That is what the Non-stød Model [Bassbøll, 2003, 2005, 2008] was developed to achieve. The governing principle is that:

Stød is a property of the second mora of heavy syllables in the native-like vocabulary;

and heavy syllables generally have stød, but not invariably. Hence it is the absence of stød in heavy syllables, i.e. non-stød, which must be accounted for. This is in contrast to past literature with its very complicated rules for the presence of stød, thus also in Basbøll’s earlier publications [1972, 1985]. Non-stød has two sources: it is either lexically specified, or it is conditioned by properties of the word, namely the nature of the stem (oxytone/monosyllabic or not) and the nature of the suffix in inflection and derivation (more or less productive).

3.1 Lexically specified non-stød

This is merely an outline of what lexical specification of stød entails, leaving the comprehensive treatment to Basbøll [2005, 2008, forthcoming].

There is a phonologically motivated bi-partition of the Danish lexicon into the native-like and the non-native-like vocabulary. The native-like vocabulary includes German, Greek and Latin loans. They have stød in heavy syllables according to the same principles as genuinely native Danish words, thus, e.g., [braːms pʰɔlʲˈɡɔːn ˈen̩ˈsula] *Brahms, polygon, insula*. In this part of the vocabulary non-stød applies to individually marked words, like [jɑ vɛn tʰal ʰað] *ja, ven, tal, bad* ‘yes, friend, number, bath,’ not to the stem in general, and stød may turn up in other morphological contexts, as in [tʰaːlˈdøː ʰaːn̩ˈdøː] *tallet, badet* ‘the number, the bath.’ The non-native-like vocabulary contains, inter alia, English loans with long stødless vowels, like [tʰim ʰæn̩d] *team, band*, and French loans with stressed final light syllables, like [pʰaːtɛ ʰaːlən] *patē, ballot*. In this part of the vocabulary non-stød in heavy syllables is general. Accordingly, they will appear without stød.
throughout the inflectional and/or derivational paradigms, as in [tʰɛmɔ ðæːmɔðɔ] teamet, bandet
‘the team, the band.’ In similar fashion, there are native words like [tʰɔːsɔ] torsk ‘cod,’ [ðɔsɔ] barsk ‘rough’ which are lexically specified for non-stød and which never participate in stød alternations. (This type previously had a short vowel succeeded by an unvoiced [ɡ] and therefore lacked stød basis. Lack of stød survived the transition to the present-day pronunciation.) The final syllables in the French loans become heavy when inflected and receive stød in accordance with the same phonological and morphological rules which apply to the native-like vocabulary, as in
[pʰaːtɛ pʰaːtɛːŋ ʰaːlɛŋ ʰaːlɛŋːŋ] paté, patéen, ballon, ballonen ‘pâté, the pâté, balloon, the balloon.’ This is analogous with words in the native-like vocabulary, like [ja ˈjaːːð vɛn ˈvenːŋ] ja, jaet, ven, vennen ‘yes, the yes, friend, the friend.’ The uninflected words, ja, ven, paté, ballon, are stødless because – in modern phonological terms – the length in ja, paté is extrametrical (and does not surface) as is the consonant in ven, ballon. Therefore they do not enter the weight equation.

According to the universal theory of extrametricality [Hayes, 1982, 1989; Harris, 1983] extrametrical elements are only licensed at the edge of their domain. So when a suffix is added to the stem, the element is no longer final/extrametrical. Accordingly, the syllable becomes heavy, and it receives stød. Riad [2007] calls this phenomenon slumrende stød (‘slumbering stød’) quoting Jespersen [1922]. Basbøll [2005] called it productive stød-addition. We opt for latent stød.

Monosyllabic contrasts, like [vɛn vɛnː] ven, vend!, ‘friend, turn!,’ are difficult to reconcile with a Scandinavian tonal model. Likewise, lexical non-stød has no analogy in Norwegian and Swedish where the accent contrast is absent in oxytones/monosyllables, because accent II requires at least one post-tonic syllable in the word [Aasen, 1848; Rischel, 1960, 1963; Haugen, 1967; Kristoffersen, 2000; Riad, 2000].

3.2 Structurally determined non-stød

Again, the account here is merely a superficial account of the complexity which confronts any
phonological theory of Danish stød.

Disregarding lexically specified non-stød, it is almost invariably true that heavy syllables in native-like monomorphemic words have stød in monosyllables and oxytones and non-stød in disyllables and paroxytones, as in [huːs ʰɛlə'fan̩d] hus, bil, elefant ‘house, car, elephant’ versus [ˈmɔːnə 'hansə ʰa'læ:d] måne, handske, ballade ‘moon, glove, rumpus.’ This neat pattern evaporates, however, in inflection and derivation. Thus, plural of hus and bil is [ˈhuːsə] and [ˈbʲiːle], respectively, i.e. huse is stødless but biler retains its stød. The noun plural, like a number of other inflectional categories, has two different (non-null) members in addition to zero, |ɔl| and |ɔrl|. One of them, |ɔrl|, is productive, being added inter alia to new words, whereas |ɔl| is not. Productive (non-lexicalized) suffixes do not eliminate stød, as in biler, whereas non-productive suffixes are integrated into the stem and make the word behave like a monomorphemic disyllabic stødless entity, as in huse. A stem plus an unproductive suffix is called a min-word. In verbs, there are two inflectional suffixes which are intermediate between productive and unproductive, one of them is the semi-productive infinitive |ɔ|. Semi-productive suffixes have a significant property: added to a monosyllabic stem, the stem loses stød as in [viːs ˈvisə] vis!, vise ‘show!, to show,’ otherwise stød remains as in [bɛ'viːsə] beвисe, ‘prove.’ A stem plus a semi-productive suffix is called a basic word. Briefly stated, we observe an inverse relation between suffix productivity and its integration into the stem which translates straightforwardly into two principles:

The penultimate syllable in a min-word has non-stød.

A monosyllabic stem before a syllable in a basic word has non-stød.

With just a hint at the true complexity of stød and suffixation, note that a suffix – from a well-defined subset of fully productive ones – like noun plural |ɔrl|, may nonetheless join a stem in
typical non-productive fashion. Compare [ˈbiːlə] *biler* ‘cars’ which retains its stød with [tɪˈdøːr] *tider* ‘times’ where the suffix would seem to be integrated in the stem and induce non-stød. Note that this interpretation, integration into the stem, would be suspicious – and the argument obviously circular – if it were not for the fact that only old and well-established monosyllables (like *tid* ‘time’) exhibit this apparent integration of the suffix into the stem, and it is to be expected that endings may become lexicalized over time. Furthermore, in a different context loss of stød with suffixation is accompanied by vowel shortening, e.g. [lyːs], [lyːst] *lyst* ‘light (adj; uter, neuter),’ where [lyːst] *lyst* conforms to the structural phonological constraint that a vowel in a monomorphemic monosyllable with two coda consonants must be short. For a comprehensive account of suffixes and stød, see Basbøll [2003, 2005, 2008, 2009, forthcoming].

4 Stød and tone

Stød and non-stød as determined by specific structural properties of the word is common to both phonological models, tonal and non-stød. But whereas the structural brackets of the non-stød model are the result of a comprehensive morphological analysis of Danish, the prosodic brackets of the tonal model are not independently justified. The two models also diverge by the introduction in the tonal model of a separate tonal register to make stød a reflex, a phonetic side effect, of a time-compressed falling tone, a HL pitch accent within one syllable. Finally, the tonal model does not account for the presence of stød in less than fully stressed syllables.

4.1 Stød and non-stød

The formal implementation of stød as a tonal accent first appeared in Itô and Mester [1997], essentially maintained in Itô and Mester [submitted], and approximatively recreated and applied to our examples thus:

In the tonal model, stød contrasts arise when two disyllabic sequences, say, [‘bi:t] biler ‘cars’ and [‘ti:d] tider ‘times,’ receive two different metrical representations, like ((bi:) ler) and (ti:.der), with brackets indicating some kind of prosodic boundary. The metrical boundaries first generate a tonal contrast, [(Hbi:) ler] versus [(Hti:.der)], by assigning tonal levels to designated parts of the prosodic representation: H is assigned to the metrical head and L to the right boundary of the innermost bracket. Stød then arises when HL is compressed within a single syllable, as in (Hbi: ler), in contrast to stødless (Hti:.der).

4.2 Lack of stød basis

Some tonal analyses are similar to the non-stød model when stød basis is missing. Thus, Morén [2005a, 2005b] repeats the segmental constraints in section 2.1. However, his proposal of a tonal
contrast to account for the lack of stød in words like \([k^b\text{ad}]\) *kat* ‘cat’ makes inaccurate phonetic predictions about tonal distinctions between monosyllables with and without stød:

\[
\begin{array}{ll}
\text{kat} [k^b\text{ad}] & \text{tand} [\text{tan}^2] \\
\sigma & \sigma \\
\mu & \mu \\
\text{H*} & \text{H*} \\
\text{kaat} & \text{tan} \\
\end{array}
\]

In the non-stød model, where stød is an autonomous laryngeal syllable prosody, there is no need to posit an unrealistic tonal configuration to derive the lack of stød basis. The principle which assigns stød to the second mora of a stressed syllable is sufficient for the purpose and would be formalized thus:

\[
\begin{array}{ll}
\text{kat} [k^b\text{ad}] & \text{tand} [\text{tan}^2] \\
\sigma & \sigma \\
\mu & \mu \\
\text{kaat} & \text{tan} \\
\end{array}
\]

4.3 Lexical non-stød

Morén (2005a, 2005b) is also in accordance with the non-stød model when the absence of stød basis is not phonologically determined, but induced via lexically assigned extrametricality.
However, there is nothing in the acoustic analysis of Danish intonation to support such a proposal either. Monosyllables like [ven ven²] do not exhibit significantly different F₀ patterns. Nor is stød restricted to occur on falling F₀ movements. Altogether, stød is more appropriately represented as an autonomous syllable prosody, laryngealization, phonologically independent from tone. A formal representation would be:

Incidentally, proponents of tonal stød models appear to be unaware of stødless bi-moraic monosyllabic words like [tʰɔsŋ] torsk ‘cod’ and [tʰi:m] team which would require a proviso to ensure that a monosyllabic HL tone not automatically give rise to stød.

4.4 Latent stød in lexical and structural non-stød

Latent Stød is a highly productive process, unparallelled in any of the Scandinavian pitch accents systems, whether in Norway and Sweden, or in the traditional stødless dialects of Southern Denmark [Kroman, 1947; Ejskjær, 1990]. Decisive in the confrontation of the two stød models,
latent stød – indicated in the orthography here with an apostrophe – appears in syllables with both primary and non-primary stress.

Latent Stød – primary stress

(a)  nu, nu’et; ja, ja’et; vue, vu’et; paté, paté’en
‘now, yes, view, pâté’ – indefinite and definite

(b)  tal, tal’let; bad, ba’det; metal, metal’let; balkon, balkon’en
‘number, bath, metal, balcony’ – indefinite and definite

Latent stød – non-primary stress

(c) nabo, nabo’en; sofa, sofa’en; vindu, vindu’et; bolero, bolero’en
‘neighbour, couch, window, bolero’ – indefinite and definite

(d) bygning, bygning’en; dronning, dronning’en; turban, turban’en; pensum, pensum’et
‘building, queen, turban, curriculum’ – indefinite and definite

In tonal models pitch accents are assigned exclusively to primary stress, which would preclude stød in the post-tonic syllables of (c) and (d).

The only attempt among the tonal analyses to account for this specifically Danish phenomenon is Morén [2005a, 2005b], and is limited to syllables with non-primary stress of type (c). Consistent with his claim that stød is just a reflex of a L tone within stressed syllables, Morén assumes that a word like [ˈvenli] venlig ‘friendly’ consists of a HL contour distributed over the two syllables and that the second syllable, when inflected in the definite and/or plural, receives secondary stress while, curiously, remaining mono-moraic, [ˈvɛnliː] venlige:
Morén does not make the correct observation, namely that the post-tonic vowel in ['venli] acquires length (hence secondary stress, hence stød) when succeeded by the suffix: ['venliːi] [Basbøll, 2005: 320]. This length is not a rationalization after the fact: the word may also be pronounced without stød but still with a long vowel in the first post-tonic: ['venliːi]. (In either case, the suffix |a| assimilates to the preceding vowel.) On the contrary, Morén specifically represents the first post-tonic as mono-moraic. In other words, he assigns stød to a syllable which – in his account – actually lacks stød basis. Ito and Mester [1997, submitted] do not mention latent stød.

Basbøll [2005] formalizes latent stød patterns as exemplified here:

<table>
<thead>
<tr>
<th>venlig</th>
<th>venlige</th>
</tr>
</thead>
<tbody>
<tr>
<td>H*</td>
<td>H*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>µ</td>
<td>µ</td>
</tr>
<tr>
<td></td>
<td>µ</td>
</tr>
<tr>
<td>[(ven) lig]</td>
<td>[(ven) (lig)] i</td>
</tr>
</tbody>
</table>

{oil ‘beer’}   {øllen ‘the beer’}

<table>
<thead>
<tr>
<th>σ</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>µ</td>
<td>µ</td>
</tr>
<tr>
<td>ø</td>
<td>&lt;i&gt;</td>
</tr>
<tr>
<td>[øl]</td>
<td>['ølø]</td>
</tr>
</tbody>
</table>
4.5 Stød and non-stød in compounds

In prototypical compounds, the first member retains its primary stress and generally loses its stød if it is monosyllabic, unless otherwise specified in the lexicon. The second member of the compound, on the contrary, loses primary stress but retains stød, as in ['lan,man'] landmand ‘agricultur’ from [lan] land ‘country’ and [man] mand ‘man.’ In this way a possibility for contrast arises, as in ['udtale'] ‘pronounce’ from [ud] ud ‘out’ plus [tæ:l] tall ‘speak!’ plus infinitive |ə| (cf. pp. ['udtæ:l] udtalt ‘pronounced’: [uːd] plus [tæːl] plus [d̥]) versus ['udtæ:la] udtale ‘pronunciation’ from [ud] ud ‘out’ plus ['tæ:la] tale ‘speech.’

Thus, we have recorded from radio broadcasts words like ['vin,ʊmni] vingummi ‘wine gum’ from [vi:n] vin ‘wine’ and ['gummi] gummi ‘gum;’ ['livsɡle:ɔ] livsglæde ‘joie de vivre’ from [liw] liv ‘life’ and ['ɡleːd] glæde ‘joy;’ ['bæsɛd] bagsædet ‘the back seat’ from [bæs] bag ‘back’ and ['seːd] sed ‘seat.’ If stød in syllables with secondary stress were to be merely the phonetic manifestation of a HL pitch accent, we would expect that secondary stress be associated with an autonomous F₀ movement from higher to lower. That is not the case. The only significant F₀ movements are in the patterns associated with syllables with primary stress.

As far as we know, only Itô and Mester [1997, submitted] provide a specific analysis of compounds. They assign pitch accents to secondary stresses, i.e. to the non-initial member of the
compound, incorrectly, and simultaneously reject the possibility of a HL pitch accent, i.e. stød, on the primary stressed first member of the compound, also incorrectly, cf. e.g. [\textquoteleft \textsc{g}\textsc{a}l\textsc{d}\textsc{f}\textsc{h}\textsc{a}l\textsc{d}\textquoteleft] golfbolde, vinterhile, blomsterstand ‘golf ball, winter lair, inflorescence.’

The phonological potential for stød contrasts in the second member of compounds, as in [\textquoteleft \textsc{k}\textsc{b}\textsc{a}\textsc{f}\textsc{o}\textsc{b}\textsc{n}\textsc{e}\textsc{n}\textquoteleft] kaffebønner ‘coffee beans’ versus [\textquoteleft \textsc{k}\textsc{b}\textsc{a}\textsc{f}\textsc{o}\textsc{b}\textsc{n}\textsc{e}\textsc{n}\textsc{v}\textquoteleft] kaffebønder ‘coffee growers’ would require phonological representations like the ones below which are without any foundation in the phonetic record, be it in Denmark, in Scandinavia, or in the Germanic languages in general, where words normally have only one pitch accent.

\[ \begin{array}{c}
\text{\textsc{kaffe} bønner} \\
\begin{array}{c}
\omega \\
\omega \\
\Sigma \sigma \\
H^* L \\
\end{array}
\end{array} \quad \begin{array}{c}
\text{\textsc{kaffe} bønder} \\
\begin{array}{c}
\omega \\
\omega \\
\Sigma \sigma \\
\Sigma \sigma \\
\Sigma \sigma \\
\Sigma \sigma \\
H^* L \\
H^* L \\
\end{array}
\end{array} \]

The non-stød model does not require any special means to account for the presence or absence of stød in the rightmost member of a compound. The phonology of compounds fulfills the predictions of the non-stød model in straightforward fashion, without further stipulations: heavy syllables with more than zero stress have stød, unless either lexical or structural non-stød dictate otherwise.

Itô and Mester [submitted] attempt also to account for what they conceive of as stød-loss in simplex (root+suffix) versus complex (prefix+root+suffix) forms. They propose a difference in foot structure, where root+suffix is wrapped into a single disyllabic foot, as in (\textquoteleft \textsc{tal}-e) tale ‘speak,’ whereas in prefix+root+suffix the root forms a monosyllabic foot, excluding the suffix, as in
('ud)(tæ:ɪ)l-e udtale ‘pronounce.’ The difference in parsing is ascribed to different preferences for quantity relations in the syllables of iambic and trochaic feet, which in their turn are a reflex of the influence of the Perfect Prosodic Word. A discussion of the merits of such an approach in general is beyond the scope of this paper. Suffice it to say that if stød in the verb ['uðtæːlɔ] udtale ‘pronounce’ is due to the distribution of quantity, it leaves unexplained why the noun ['uðtɑːlɔ] udtale ‘pronunciation’ is without stød. In the non-stød model this difference in stød assignment in segmentally identical words is uncontroversially due to a difference in morphological parsing: the compound ud+tale ‘pronunciation’ versus inflected udtal+e ‘pronounce,’ cf. 3.2 above.

5 Danish intonation

5.1 The structure of intonation in short Standard Copenhagen Danish utterances

Pitch, i.e. the perceived correlate of F0, is the most explicit among the cues to the phonetic prominence which normally accompanies the stressed syllables of a Danish utterance.

[Figure 2]

Fig. 2 depicts, in slightly stylized fashion, the course of F0 in a model utterance with four stressed syllables [han 'læe sa pʰɛsɔ'læŋ] ɪn 'tʰɛŋdə ɳ kʰami'nanˈdə] Han lagde sig på chaiselongen og tændte en Caminante. ‘He lay down on the chaiselongue and lit a Caminante [a cigar].’ F0 movements in the consonants have been suppressed in the stylization. The onset of each stressed vowel coincides with the onset of a qualitatively constant and recurrent melodic pattern (depicted with heavier and lighter dots in the figure) which extends over all succeeding unstressed syllables within the utterance, irrespective of their morphological or syntactic affiliation (and regardless of the distinction between secondary and zero stress), until the onset of the next stressed vowel, in casu Hanl[agdesigpåchaisel][onogenogt] [øendteenCamin][ante] [Grønnum, 1980, 1984].
The recognition of this association between stress and F₀, i.e. the anchoring of a recurrent melodic pattern to the stressed (the phonetically prominent) syllables of the utterance, irrespective of their location within the word, prompted the definition of a **prosodic stress group**. It further prompted the analysis of intonation in short Danish utterances as having two hierarchically organized components, a *global* intonation contour defined by the succession of the stressed syllables (the fictitious full line in fig. 2) and – superposed on this contour – a succession of *local* F₀ patterns associated with the prosodic stress groups [Grønnum, 1992, 1995].

Further properties of Danish prosody and intonation, relevant in this context are: absence of perceptible final lengthening; lack of sentence accents in the shape of specially elaborate or complex pitch patterns at the end of phrases and utterances; absence of boundary tones no matter what the domain. Finally, Danish does not exhibit final, local pitch cues to utterance function. In so far as the non-terminal, non-declarative function of the utterance is signalled with prosodic means, it is expressed through a less steeply declining overall intonation contour slope. This is well-documented [Grønnum, 1983, 1990, 1992, 1995] and completely uncontroversial among Danish phoneticians. The paucity of autonomous tonal events – which in other languages crowd up on phrase final stress groups – make the intonation model of Danish surprisingly simple: a sequence of qualitatively identical F₀ patterns the ensemble of which exhibit a more or less declining overall contour. Accordingly, words produced in isolation would have served well for most of the illustrations. However, in accordance with good standard procedure, we have chosen to depict words spliced out from non-initial and non-final position in complete utterances.

The description – and the model in fig. 2 – of intonation in Danish is based on speech produced under laboratory conditions. But the phonetic annotation of approximately 10 hours of non-scripted speech in the DanPASS corpus did not reveal major, principled differences between scripted and non-scripted speech in the shape of a richer inventory of prosodic parameters in non-scripted speech. The most pertinent difference between the two genres is the much greater variation in the prominence of stressed syllables in non-scripted speech, as expressed by the magnitude
(greater or smaller) of the $F_0$ pattern excursion and its location (higher or lower) in the speaker’s range.

Intonation in most regional varieties of Danish is structured in basically the same way as in Copenhagen, but they differ considerably in the shape of the $F_0$ pattern of the prosodic stress group, in its typical $F_0$ range, in the steepness of the $F_0$ rises and falls, and in the exact timing of the $F_0$ turning points relative to the onset and offset of the stressed vowel.

5.1.1 Properties of the $F_0$ pattern in Standard Copenhagen Danish

A maximally developed pattern describes a brief and very modest initial $F_0$ fall succeeded by a steep and considerably larger rise (typically 3-4 semitones) to the first post-tonic syllable and a fairly steep fall through succeeding post-tonics, as in the initial stress group in fig. 2. The shorter the stress group, the less extensive the $F_0$ pattern: compare the first and second stress groups in fig. 2. With the absence of post-tonic syllables, all that remains is the slight and brief initial fall as in grå and kat on the left in fig. 3. Compare those with the two disyllabic stress groups, kanden and fyldt med on the right. Note also the pairwise fundamental similarity between the $F_0$ contour within the stressed vowels of (1) $[\text{ˈgʁæc̃}]$ grå (with its nearly invisible stød) and stødless $[\text{ˈkʰaɾ}]$ kan(đen); (2) stødless $[\text{ˈkʰad}]$ kat and $[\text{ˈfyl̩d}]$ fyldt (with its explicit local $F_0$ drop in the [l]); (3) stødless $[\text{ˈkʰɛɾə}]$ krad(ser) and $[\text{mɛl̩ɡ}]$ mælk (with its likewise explicit local $F_0$ drop in the [l]). The vowels are also situated, pairwise, at approximately the same level in the speaker’s $F_0$ range. The pertinent observation here is that stress group patterns are subject to truncation.

[Figure 3]

The implementation of $F_0$ patterns is highly sensitive to the prosodic environment. Rises diminish progressively through an utterance, cf. fig. 2, and compare the low final disyllabic stress group
'kʰəsəv' in fig. 3 with the higher initial disyllabic stress group ['kʰənən]. There are further dependencies on the magnitude of the F₀ rise and its prosodic context, immaterial here; see Grønnum [1995].

The nature of F₀ patterns associated with prosodic stress groups in Standard Copenhagen Danish has an important implication: Pitch patterns are not contrastive. There is only one tonal configuration, LH; it always aligns in the same fashion with the segmental material; and its phonetic manifestation is predictable. Thus, a speaker does not make choices between various lexically distinct pitch accents. And when the magnitude of stress group pattern rises is manipulated in order to cue varying degrees of phonetic prominence among the stressed syllables, we are dealing with a scalar, not a binary, phenomenon. Speakers are not making a choice in those circumstances either of a particular pitch accent from a set of lexically distinct ones, but are simply subordinating the manifestation of stress to the demands for signaling more, or less, acoustic/perceptual prominence.

Some speakers appear capable of reversing their F₀ patterns, from LH to HL, across a whole utterance with a resulting change in perceived speech style or register. No empirical studies exist of this phenomenon in Danish, but if our intuition is valid, reversing the neutral F₀ pattern makes a speaker rather dogmatic or insisting. However, such a long component or setting does not warrant the introduction in Danish prosody of a separate lexical pitch accent. It only shows that the manifestation of stress interacts with parameters at other (para-linguistic) levels of description. In brief: F₀ patterns are not part of the representation of pitch at the lexical level: they are post-lexical. For the sake of comparison with proposals for pitch accent analysis, we shall nevertheless proceed to talk about LH (or L*H with a star which anchors the low tone to the stressed syllable) and HL (or H*L), but when applied to Danish they are to be understood as phonetic labels or cover terms for melodic configurations, not lexical entities. Kohler [2007, 2008] reports a similar phenomenon in Alemannic dialects, Southwest German and Swiss, where phrase final neutral statement L*HL contours become H*L under reinforcement.

F₀ tracings do not exactly mirror perceived pitch contours. Not every F₀ movement is
perceived as a dynamic pitch event [Rossi, 1971, 1978; House, 1990]. So, for instance, the modestly falling $F_0$ in the six stressed vowels depicted in fig. 3 is not perceived as such, and these vowels/syllables are heard as level pitches. In other words, $F_0$ patterns in Copenhagen do not lend themselves to interpretations as bi-directional pitch accents within a single syllable.

5.2 $F_0$ and stød

It was evident already from fig. 1 that the $F_0$ pattern is basically identical in words with and without stød. In [‘leːsʊ], left and mid, as well as [‘leːsʊ], right, the pattern would be characterized as L*H in current notational practice. And note again that the $F_0$ perturbation, when it is apparent at all, is a very local modification in the last part of a vowel whose $F_0$ movement is slightly falling for independent reasons.

[Figure 4]

[Figure 5]

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 [‘leːsʊ] in fig. 1 left, or [‘fyɬ³ me] in fig. 3. It may occur at the top of the $F_0$ pattern as in [kʰɭɬ³] and [van³] in fig. 4, and very low on the falling flank in a long series of post-tonics as in [‘uðnɒfægssə,veɡ³ en] in fig. 5. 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 three figures. Note particularly that there is nothing reminiscent of a HL pitch accent in the smooth $F_0$ contour associated with the second part of the compound in the lefthand side of fig. 5, [‘uðnɒfægssə,veɡ³ en]. In this respect it resembles the stødless word on the right, [‘byyəˌlaɪp³as].
Figs. 6 and 7 are further proof that the F0 movement associated with stød, when present, is not the result of an autonomous pitch gesture, but rather a side effect of laryngealization.

Below the two arrows in fig. 6 are two very similar F0 events: very steep and very local falls framing the sequence \[\text{og vend} \quad \text{‘and turn.’}\] The first one is associated with the glottal attack at the juncture before the vowel in \text{og}, the second one accompanies the stød in \text{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 F0 perturbation is the result of a glottal attack which is not quite a complete glottal closure here, but comes out as creaky voice, whereas the same F0 perturbation on the right would be an autonomous tonal gesture with a laryngealized side effect.

Fig. 7 depicts two stressed monosyllables with a succeeding unstressed word, \text{og vend}. The overall patterns in the three sequences are identical: a movement from lower stressed syllable to the higher post-tonic, three L*Hs.

Note furthermore how microprosodic effects may induce extensive F0 movements in a vowel. An uninitiated observer might ascribe a falling pitch accent to the first syllable of \text{bussen} in fig. 7: the extent of its F0 fall is as comprehensive as the fall in \text{vend}. But the first steep part of the fall in \text{bus} is due to the transition from the 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 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.

5.3 Copenhagen Danish is not a H*L variety

The most explicit analysis of Copenhagen Danish stress group patterns as H*L accents is in Gussenhoven [2004]. He is aware of the acoustic nature of prosodic stress group patterns in Copenhagen Danish, i.e. the lower stressed syllable and higher first post-tonic. However, he claims that the low turning point in the F0 pattern occurs before the onset of the stressed syllable and states [pp. 224-5] that “The stressed syllable thus typically lies somewhere halfway up the upward slope. This suggests that the usual autosegmental interpretation of Danish as having a L*H pitch accent [Pierrehumbert, 1980: 116] is incorrect, and that it is rather H*L, whereby the H* is aligned late, and downstepped, and L is right-aligned.” But his contention about the alignment of the stressed syllable with the F0 pattern is incorrect. There is ample empirical evidence that the low turning point in the F0 pattern coincides with the offset of the stressed vowel if it is short; if long, the latter part of the stressed vowel commences the upward F0 movement, cf. figs. 1, 3, 6, 7. (The first stressed vowel of an utterance may deviate from this pattern, often being acoustically slightly rising, not – presumably – as an autonomous gesture, but rather as target undershoot to the high onset of the intonation contour.) Gussenhoven goes on to review Grønnum’s [1983] account of the manifestation of utterances with emphasis for contrast (“narrow focus” in his account) and finds – in the way he interprets F0 patterns adjacent to the emphasized item – further support for his proposal that the pitch accent is more appropriately rendered as (delayed) H*L. But again, Gussenhoven’s account is not in accordance with the empirical facts. If stressed syllables were indeed H*, then a stressed syllable in a stress group with no post-tonic syllable(s) to push it back down the rising flank should move upwards to claim its rightful high position. There is plenty of evidence to the contrary: as far as F0 is concerned stressed syllables are unaffected by the presence or not of post-tonic syllables, as also evidenced in the two utterances in fig. 3.

Incidentally, although perhaps not explicitly stated in the tonal models, the assumption seems
to be that stød is inevitably associated with falling pitch. This assumption is partly justified by the fact that low F₀ at the end of an utterance may be accompanied by creaky voice – as an individual feature or characterising a whole speech community as in Eskiltuna Swedish, [Riad, 2009]. It is also entirely justifiable on physiological grounds, given what is known about the larynx and the vocal folds in F₀ lowering, cf. Lindblom’s [2009] review of Lindqvist-Gauffin’s [1969, 1972] proposals.

It is also true that in a number of South East Asian tone languages, low tone is often accompanied by laryngealization, as e.g. in Mandarin and Cantonese [Yu, 2010]. But note that voice quality differences in 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 [Egerod, 1971; Abramson et al., 2004; Michaud, 2004]. Furthermore, in so-called *laryngeally complex* languages, like Mpi [Ladefoged and Maddieson, 1996], Jalapa Mazatec [Garellek and Keating, 2011], Comaltepec Chinantecc [Silverman, 1997], tonal and phonatory contrasts co-exist and cross-classify. Thus, laryngealization may accompany any tone, whether high or low.

[Figure 8]

5.4 Fundamental frequency patterns in regional varieties of Danish

Let us turn now to some geographically distant and tonally distinct Danish regiolects [Ejskjær, 1964]. Fig. 8 depicts prototypical stylized tracings of the F₀ patterns associated with the prosodic stress group in six varieties of Standard Danish. They are not impressionistic drawings or educated guesses but based on empirical data from a considerable number of recordings of each of four speakers from each region. All the speakers recorded the same material and under identical conditions.

These F₀ patterns would adequately represent trisyllabic prosodic stress groups. This is of no particular concern for Næstved, Aalborg, Tønder and Sønderborg, because F₀ 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 is less steep, it would typically continue to fall further, beyond what is depicted in fig. 8, only to level out around a fourth or fifth post-tonic, cf. fig. 2. 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. ÅEND in fig. 2) and from below after long stress groups (cf. ONG in fig. 2).

The variation in shape and range of the $F_0$ patterns in fig. 8 is rather astounding. Differences among the patterns 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 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, and 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 varieties but with its onset in L*H Næstved. In L*H Copenhagen the low turning point coincides with the offset of the stressed vowel if it 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 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 of five patterns in fig. 8.

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 in order that the low turning point coincide 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 in order that the rise terminate 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 the rise from a low onset to a high offset. Given that the fall may be deleted and that otherwise the rise in the F0 pattern is perceptually more salient than the fall, Bornholm may also be adequately represented as L*H.

Note that among the L*H varieties, two are languages with stød, namely Copenhagen and Næstved, whereas Bornholm does not have stød. 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.

[Figure 9]

Figure 9 shows two concrete examples, spliced out from a longer utterance, [sɔg̊a me 'ʃʌð̊a bjerg̊ ɫn̥] by a male speaker from Aalborg and a female speaker from Næstved. 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 coincides exactly with the peak of the F0 pattern in Aalborg, as stipulated in the stylization in fig. 8, 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 fig. 8. The fall is not nearly as extensive as in Aalborg. The stød in the second part of the compound is
rather weak in both instances, introducing a moderate perturbation only in Aalborg and hardly any at all in Næstved – although it is clearly perceptually identifiable in both cases.

6 Discussion and conclusion

No one in the long series of distinguished Danish linguists and phoneticians ever suggested a synchronic causal relation between stød and tone in Danish, despite the irrefutable fact that the Danish stød/non-stød contrast shares distributional properties with Norwegian and Swedish tonal word accents. This is not to imply, of course, that history and tradition should prevent phonologists from trying to develop new theories which better fit the empirical facts and/or integrate the known facts in a broader frame of reference. Thus, when in the 1990’s Hans Basbøll turned the question on its head, asking “when does a heavy syllable not have stød?” rather than “when does a heavy syllable have stød?” he made a significant step forward. He greatly simplified the account of stød alternations in inflection and derivation and created a unitary whole of hitherto somewhat disparate observations.

Kiparsky’s [1995] analysis of Livonian stød inspired Itô and Mester [1997] and Riad [1998] to analyse Danish stød in similar fashion, as the phonetic manifestation of an underlying HL pitch accent compressed into a single syllable. Morén [2005a, 2005b] in a similar vein made Danish stød the result of associating a low prosodic word boundary tone with the head syllable of the foot. Two things are worthy of note: For one thing, Kiparsky presented reasonable, if sparse, acoustic evidence for his contention that in Livonian “[...] the glottal constriction and shortening that often accompany stød are phonetic enhancements of the distinctive falling pitch contour.” [p. 4 in the 2006 version]. Secondly, Kiparsky, although he notes a perceptual similarity between Danish and Livonian stød (quoting Thomsen [1890] and Vihman [1971]), does not himself extend his phonological analysis to Danish stød. By contrast, neither Itô and Mester, nor Riad, nor Morén present any empirical evidence for their tonal analysis of Danish stød. Furthermore, there are
significant aspects of the phonology, and even more so of the morphology of Danish stød, as well as a rather rich body of empirical phonetic data, which they do not consider.

The most obvious formal difficulty with the tonal model is the assumption that the F_0 pattern associated with stressed syllables – in so far as they are also prominent in the actual utterance – is the manifestation of a lexical pitch accent. But F_0 patterns are not lexical, they are post-lexical in Danish. The tonal model makes stød a mere synchronic reflex of a constant underlying HL pitch accent. But then why is one and the same F_0 pattern in some instances associated with stød words, in others with non-stød words? The overall 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, there is an inherent contradiction in the tonal model in the fact that stød distribution is approximately constant over regional varieties, in so far as they have stød at all, but F_0 patterns are not. Furthermore, an attempt to explain the otherwise abnormal presence of stød in post-tonic syllables in composite words as involving a sentence accent and/or a boundary tone is also bound to fail: there is nothing in the acoustic analyses of Danish intonation to prove the existence of either.

At a more concrete phonetic level, we know that low and falling tones may involve creaky voice in tone as well as non-tone languages, and it may be that such an association lies behind the historical development of stød. But as a modern phonetic explanation for the laryngealization in Danish stød across regional varieties it is not viable: In a putative scenario to explain how such divergent F_0 patterns can give rise to stød, one might propose that any combination of tones involving a L, whether bitonal HL/LH or tritonal HLH/LHL, gives rise to laryngealization. But if laryngealization is a mere articulatory side effect of tone production, it really cannot be brought to bear on any but low falling F_0 movements, it has no place in rising pitch. That is not, of course, tantamount to saying that creak cannot occur on high tones. It can and does in languages where creaky voice is contrastive, but laryngealization is not an involuntary accompaniment to high and rising tones. Let us say, however, for the sake of the argument and in order to attempt to salvage a
tonal analysis of the F<sub>0</sub> pattern in Aalborg which is the most strikingly aberrant variety in a tone/stød perspective, that a L tone is introduced at the onset of the rising stressed vowel, yielding a tritonal LHL: first of all stød would occur on a rise, secondly the onset L tone is not low in the speaker’s range at all, on the contrary, it is situated in the upper part of the range, a true low being consigned to the post-tonic. It is simply not phonetically reasonable to make laryngealization on a rising contour, at the top of the speaker’s range, a natural articulatory side effect of tone production. If phonetic reality is to have any significance at all in the formal representation, such a proposal must be rejected.

To sum up: The tonal model of stød makes laryngealization a side effect of – more or less realistic – tonal configurations. But the causal relation is the exact opposite: the F<sub>0</sub> perturbation is a side effect of laryngealization and not invariably present. Laryngealization is the articulatory, acoustic, and perceptual constant in stød production, F<sub>0</sub> perturbation is not.
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Figure legends

[Figure 1]
Microphone signal (above), spectrogram (below), and F₀ tracing superposed on the spectrogram of 
[ˈleːsø\r] læser ‘reads’ with explicit creaky voice and F₀ perturbation (left), weaker laryngealization and no F₀ perturbation (mid), and stødless [ˈleːsø\r] læser (right); all by the same male Copenhagen speaker, produced in the course of one and the same recording session. Arrows point to the laryngealized part of the vowel. The words were spliced out from three utterances: *Peter læser om de gamle sejlskibe* ‘Peter reads about the old sailing ships;’ *Bodil læser en bog om Indien* ‘Bodil reads a book about India;’ *Bodil er en ivrig læser af kriminalromaner* ‘Bodil is a keen reader of crime novels.’ Like figs. 3-7 and 9, this is a Praat screen dump, cf. Boersma & Weenink (2006). The fundamental frequency scale is linear.

[Figure 2]
Stylized F₀ tracing of a model utterance *Han lagde sig på chaiselongen og tændte en Caminante* ‘He lay down on the chaiselongue and lit a Caminante [a cigar]’ with four stressed words. Stressed syllables are depicted in heavier dotted lines, unstressed syllables in finer dotted lines. Voiceless consonants leave no F₀ trace, and F₀ in the voiced consonants have also been suppressed in the drawing. The sloping full line depicts the global intonation contour.

[Figure 3]
Microphone signal (above), spectrogram (below), and F₀ tracing superposed on the spectrogram of a short read utterance [ˈdɛn ˈθʁɔː ˈkʰaɭ ˈkʰʁæsø\r] *Den grå kat kradser* ‘The grey cat scratches’ with two monosyllabic stress groups (left), and a corresponding read utterance [ˈhun feːɡ ˈkʰɔn̩ ˈfyl̩d me ˈmeːl̩g\r] *Hun fik kanden fyldt med mælk* ‘She had the jug filled with milk’ with two disyllabic stress
groups (right). The first stressed vowel in each utterance has been touched up in heavy dots, the second stressed vowel in heavy squares, and the third stressed vowel in full lines; unstressed vowels and the syllabic consonant, respectively, are in lighter dots. Female Copenhagen speaker. The fundamental frequency scale is linear.

[Figure 4]
Microphone signal (above), spectrogram (below), and $F_0$ tracing superposed on the spectrogram of an utterance ['kɔldt vɔnd słuktor tɔɐsten] Koldt vand slukker tørsten ‘Cold water slakes one’s thirst.’ Female Aalborg speaker. The fundamental frequency scale is linear.

[Figure 5]
Microphone signal (above), spectrogram (below), and $F_0$ tracing superposed on the spectrogram of a long compound word ['udɛnørstɔrørerving] udendørsservering ‘open air serving’ with stød in the syllable with secondary stress late on the $F_0$ pattern (left), and a corresponding compound word ['byggeleplaːs] byggelegeplads ‘adventure playground’ without stød (right). The arrow points to the laryngealized part with the $F_0$ perturbation. Female Copenhagen speaker. The words were spliced out from two utterances in a non-scripted dialogue: ... på niveau med den udendørsservering du ikke har ... ‘... on a level with the open air serving which you do not have ...’ ... altså parallelt med den byggelegeplads du havde, ikke? ... ‘... so parallel to the adventure playground you had, right?’ The fundamental frequency scale is linear.

[Figure 6]
Microphone signal (above), spectrogram (below), and $F_0$ tracing superposed on the spectrogram of a read utterance ['tøːpa ˈpʰaˌleːdɔn ˈvɛnˈˌsɔdəfɔlɪːdɔ] Tag paletten og vend staffeliet ‘Take the palette and turn the easel’ by the same male Copenhagen speaker as in fig. 1. The leftmost arrow points to
the glottal attack and the rightmost arrows points to the laryngealized part of the syllable coda. The fundamental frequency scale is linear.

[Figure 7]
Microphone signal (above), spectrogram (below), and F$_0$ tracing superposed on the spectrogram of ['ven̂ ɖe] vend det ‘turn it’ (left), ['ven̂ t̩e] ven til ‘friend to’ (right), and ['busn̩] bussen by the same female Copenhagen speaker as in fig. 3. The words were spliced out from three read utterances: Tag glasset og vend det i lyset ‘Take the glass and turn it against the light;’ Jeg savnede min ven til at dele oplevelserne med ‘I missed my friend to share the experiences;’ De studerende venter på bussen ved Hovedbanen ‘The students are waiting for the bus at the Central Station.’ The fundamental frequency scale is linear.

[Figure 8]
Model prosodic stress group patterns in six regional varieties of Standard Danish. Heavy dots depict the location of short stressed vowels on the F$_0$ pattern, medium dots depict the extension of the F$_0$ movement in long stressed vowels, and fine dots depict the course of unstressed syllables in the prosodic stress group. In Bornholm the horizontal arrows enclose movements which may be expanded or compressed in time, 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). Vertical arrows point to the segmental anchor point. “p.t.” is shorthand for “post-tonic.” Adapted from Grønnum [1990].

[Figure 9]
Microphone signal (above), spectrogram (below), and F$_0$ tracing superposed on the spectrogram of [s̥a me 'ɾuðõi ʰiln̩] spliced out from Kofoed og Thorsen skal med rutebilen fra [by A] til [by B] klokken fire på tirsdag ‘Kofoed og Thorsen will be going by bus from [town A] to [town B] at four
o’clock on Tuesday’ by a male Aalborg speaker (left) and a female Næstved speaker (right). The stressed vowels have been touched up in heavy dots, and the unstressed vowels in lighter dots, smoothing out the microprosodic effect of laryngealization on the F₀ pattern. The fundamental frequency scale is linear.
Figure 1
Figure 2
Figure 4
Figure 7
Figure 8
Figure 9