THE PHONOLOGICAL SYLLABLE WITH SPECIAL REFERENCE TO DANISH

Hans Basbøll

1. Introduction

The present paper¹ is divided into three main parts. In the first of these (section 2) it will be argued that the syllable must be recognized as an important linguistic unit in any adequate phonology of Standard Danish. In section 3 I shall discuss the status of the syllable in a generative phonology, including such questions as the functions of the syllable in phonological rules, phonetic vs. phonological syllable, and the principles of syllabification. In section 4, finally, the nature of the syllable will be discussed in more general terms, and a distinction between what I call "hierarchical" and "cross-classificatory" distinctive features will be proposed. It will be shown that the hierarchy of phonological features can explain nearly all order relations among Danish consonants. These considerations have bearing on what the feature [syllabic] may actually mean.

Although the language material discussed in the present paper is taken almost exclusively from Standard Danish, the conclusions arrived at in sections 3 and 4 seem to be relevant to general phonological theory. The paper is thus not only meant to be a contribution to the phonological description of one language, viz. Standard Danish; it is intended to be a contribution to phonological theory as well.

¹) This is an enlarged version of a paper entitled "Stavelsen i dansk fonologi" ('The syllable in Danish phonology') which I read at the Meeting of Nordic Linguists at Kungälv, March 30 - 31, 1974. I am indebted to Niels Davidsen-Nielsen for stylistic suggestions.
2. Arguments to the effect that any adequate phonology of Danish must include the syllable as a phonological unit

2.1. Allophonic variation of short /o/ and /a/

Since I have discussed the allophonic variation of the short /o/ and /a/ phonemes in Danish and their dependency upon syllabification elsewhere, I shall here only give a brief summary of what appear to be the main facts (see further Basbøll 1972a, p. 187-190).

The vowels [u:, u], [o:, o] and [ɔ:, η] have generally been taken to be manifestations of /u:, u/, /o:, o/ and /ɔ:, η/ respectively (e.g. Ege 1965). However, the vowel [o] also occurs, partly as shortened /o:/ (in positions where the other long vowels are shortened too), partly in some foreign words like *foto* [fɒtɔ]. The vowel [ɔ] also appears in foreign words, e.g. *tundra*, *centrum* [tʊndrə, sɛntrəm]. It has been pointed out (Basbøll 1969, p. 44) that the short vowels [o] and [ɔ] both occur posttonally in complementary distribution, [o] occurring in open syllables and [ɔ] in closed ones. This principle generalizes to all occurrences of [o] and [ɔ] not derived from long vowels. Such a principle of course presupposes a syllabification, and this syllabification turns out to be identical with the one which is presupposed by the other phonological rules examined here, and which is stated explicitly in section 3.4.1 below. (The distribution of short [o] and [ɔ] in French is in part due to similar principles, e.g. *sot*, *sotte* [so, sɔt].)

The short /a/ phoneme in Danish is pronounced as a back vowel in the environment of /r/, as a front vowel ([a]) before zero and dentals, and as a mid or back vowel ([ɔ] or [a]) before velars and (in most language usages) labials. The fact
that the first vowel of words like Amerika, akademi, tapir is pronounced [a] as opposed to the first vowel of e.g. amfiteater, Absalon, akkeleje suggests that this manifestation rule applies with the syllable rather than the word as its domain. The syllabification presupposed for this purpose is identical to that presupposed for the prediction of the manifestation of /o/ and of the consonant gradation phenomena mentioned below in section 2.2 (according to these principles a single intervocalic consonant goes to the preceding syllable if the following vowel is shwa, but to the following syllable if its vowel is a "full vowel", i.e. non-shwa, see section 3.4.1 below).

Particularly suggestive of an explanation in terms of syllables are alternative pronunciation patterns like the following. Amerikaner is either pronounced [ame̱ei̱kʰæːʔnʌ, am̥ei̱kʰæːʔnʌ], where the first /a/ is followed by /m/, which again is followed by the full vowel /e/, i.e. /a/ occurs in an open syllable and is thus pronounced [a]; or it is pronounced [am̥ei̱kʰæːʔnʌ], where the second vowel is dropped (possibly via a reduction to shwa), and consequently the first /a/ occurs in a closed syllable ending in a labial, and it is thus pronounced [a] (or [a]). Forms of the stem abbed like abbed, abbeder, abbedisse can be pronounced as [ab̥ed, ab̥e(ː)ɛ̃, ab̥edi̱se], where the second vowel is the full vowel /e/ (which can even be long in abbeder), and /a/ thus occurs in an open syllable and is pronounced [a]; or it can be pronounced as [ab̥e̱d, ab̥e̱ɷ̃ ab̥edi̱se], where the second vowel reduces to shwa, and the /b/ therefore belongs to the first syllable with the effect of retracting the vowel /a/.
2.2. Consonant gradation

The term "Consonant gradation" is used here in accordance with Rischel 1970a. It covers a number of morphological alternations among which are the following (alternation (i) is mentioned by Uldall 1936, (ii) by Rischel 1970a, (iii) by Basbøll 1972a, (iv) by Hjelmslev 1951, and (v) by Rischel 1969):

(i) Word-final unaspirated plosive alternates with aspirated plosive before a stressed vowel. Among the examples are a number of derived verbs in -ere, e.g. galopere, vattere, lakere [galopʰeː?ː, vatʰeː?ː, lakʰeː?ː], derived from galop, vat, lak [galAb, vad, lag]. Note particularly the last example where the /a/ is pronounced [a] before the word-final and hence syllable-final /k/, whereas in lakere /k/ belongs to the following syllable, /a/ thus being pronounced [a].

1) For reasons of space, it is impossible to treat this very complicated subject in any detail here. I have discussed the "Consonant gradation"-phenomena extensively in my ditto'ed notes (in Danish) Konsonanter I-II (87 p., unfinished). (These notes, which will be continued, also include a chapter (46 p.) on the diphthongs.)

2) When I use formulations like "word-final X alternates with Y before Z" it does not imply that all instances of word-final X alternate with Y before Z, nor does it mean, of course, that all occurrences of Y before Z alternate with word-final X (notice that I do not use the word "alternates" in a "process" sense: the only implication here is that X before word boundary and Y before Z are in a relation of alternation, cf. Rischel 1974, p. 320ff). E.g. in (i) below it is said that word-final [b d ɡ] alternate with [pʰ tʰ kʰ] before stressed vowel, but alternations like klaustrofob-klaustrofobi [klʌsˈtrofɔbʰiː?b, -foː?i] show that some instances of word-final [b] alternate with [b] and not [pʰ] before stressed vowels. And in (iv) below there are examples like dyr, dyrisk [dyrʰ?/dyː?ː, dýː?ːisɡ/dýː?ːisɡ] which exhibit no alternation [ɡ] ~ [ɡd] (where the latter should occur before the derivative ending -isk). In most of the other cases, the alternations are general in the sense that the mentioned word-final sound types do not alternate with other sound types in the said context than those mentioned. It should be added that alternations (i)-(iii) and (v) are limited to "learned" derivations, cf. section 3.4.1 below.
(ii) Word-final voiced non-labial continuant consonant alternates with unaspirated plosive before stressed vowel. Examples are foreign words like **perfidi**, **pädagogik** \([p^h\text{ɛ}fidiː?], p^h\text{ɛ}dagogig]\), derived from **perfid**, **pädagog** \([p^h\text{ɛ}fliː?δ], p^h\text{ɛ}dagoγiː?γ]\).

(iii) Word-final [ŋ] alternates with [ŋg] before a stressed vowel. There is at least one example of this alternation, viz. **(di-, mono-, poly- etc.)-fëtongere** \([(di)ft^s\text{ŋ}ge?:?\lambda]\), derived from **(di- etc.)-fëtong** \([(di)ft^s\text{ŋ}γ]\).

(iv) Word-final [n?, l?, r?] alternate with [nd, ld, rd] before derivative endings like -ig, isk. Examples are **mandig**, **skyldig**, **jordisk** \([m\dot{\text{ándi}}, s\dot{\text{gyldi}}, j\dot{\text{ðdís}}]\), derived from [man?, sgyl?, joʔ? joːʔ?] (in words with -rd, conservative usages have a long vowel in the un-derived word but the corresponding short one in the derived form).

(v) Word-final [γ] alternates with [s] before stressed vowels. Examples are **kontorist**, **professorat** \([k\dot{\text{onte}}\text{sofis}d, p\dot{\text{yocefso}}\text{siː}d]\), derived from **kontor**, **professor** \([k\dot{\text{onte}}\text{so}s?\], p\dot{\text{yoxefsa}}\lambda]\).

Now it is very interesting that all these alternations can be subsumed under a single principle, viz. the well-known one of consonant weakening in syllable final position. According to this principle the phonemes /p t k d g r/ are manifested as \([p^h t^s k^h d g s]\) in syllable initial position and as \([b d g δ γ p]\) in syllable final position (where [γ] is in younger standards substituted by [δ], [u] or zero). It should be added that in utterance-final position, i.e. before pause, any final consonant can be followed by an [h]-sound, and that /t/ can be manifested \([t^s]\), i.e. affricated (whereas
final \([b \ g]\) followed by \([h]\) are not discernable from \([p^h \ k^h]\).

It should also be mentioned that syllable-initial /p t k/ in word-internal position before an unstressed vowel can be pronounced \([b \ d \ g]\), especially in non-distinct pronunciations, that \([γ]\), but not \([g]\), is dropped after nasals, and that \([δ]\) is dropped after sonorants. (There are certain complications in accounting for the syllable-final pronunciations of the labial obstruents /b v/, which may also be weakened as compared with the syllable-initial manifestations \([b \ v]\), but these cannot be treated here for reasons of space; the reader is referred to the notes referred to in footnote 1 on p. 42 for further information.)

The above-mentioned principle accounts not only for a great number of morphological alternations (as (i)-(v) above), but also explains (in a weak sense) quite a few distributional gaps like the following: \([δ \ γ η]\) occur only before \(♯\), consonants and shwa, never before full vowels; /h/ only occurs before full vowels, etc.

As already mentioned, it is, for reasons of space, impossible in this paper to fully discuss or even survey the very complicated phenomena connected with "Consonant gradation". However, it is clear that the value of the above-mentioned principle depends on whether there can be given explicit (and not unnatural) principles of the location of syllable boundaries that can account for all of the above-mentioned phenomena without giving rise to complications elsewhere in the phonology. This will be attempted in section 3.4.1 below.

By way of conclusion of this section it should be mentioned that there exists one explicit proposal for the delimitation of the consonant manifestations here called "syllable initial" and "syllable final" which does not include
the syllable as a theoretical unit, viz. Rischel 1970a, p. 462. In order to show that the syllable is a necessary prerequisite for correctly accounting for the mentioned consonant phenomena, we must therefore demonstrate that Rischel's proposal is unsatisfactory. Rischel gives the following "working definition" for two positions, viz. "strong" and "weak", which "here will be taken as essentially synonymous with (syllable-)initial and (syllable-)final position":

"A consonant is in strong position if it fulfils the following two requirements: (1) it is preceded by juncture (morpheme border) or by a segment that is (phonemically) voiced; (2) it is followed by a full vowel (i.e., not shwa) with or without an intervening voiced consonant but without an intervening juncture. Examples are: [g] in [gli:ða] 'glide', [b, g] in [lom'bæ:go] 'lumbago'.

Otherwise a consonant is in weak position. Examples are: [y, ð] in [to:γæða] 'foggy' (plur.), [ð, g] in [jø:ðisg] 'jewish' (the latter word has a morpheme border between [ð] and [i]), and [ð] in [feðme] 'fatness'."

It follows from Rischel's definition that a consonant is in weak position if it fulfils at least one of the following three requirements: (i) it is preceded by a (phonemically) voiceless segment belonging to the same morpheme; (ii) it is followed by a juncture; (iii) it is followed by a shwa, with a possible intervening consonant. (The alternations mentioned at the outset of this section show, in agreement with Rischel's note on p. 464, that "juncture" cannot simply mean "morpheme border" as the definition suggests, see section 3.4.1 below.)

In conservative varieties of Standard Danish there are certain counter-examples to implication (iii) of Rischel's definition. E.g. words like kæntre, andre need not rhyme, and verden, værten can be distinguished: kæntre and værten can
be pronounced with unvoiced /r/ ([kæntə, vægten]), which is never possible in andre, verden, and in some usages, where the possibility of unvoiced /r/ in one or both of these examples does not exist, a distinction of length can be made in the non-syllabic sonorant so that /n, r/ etc. can be shorter before (written) p, t, k than before b, d, g (see Fischer-Jørgensen 1973, p. 146f).

Of course it can be argued that the proposed definition should only cover (younger) standards where these distinctions are not made, but I find it highly significant that the only way to account for these distinctions by means of "strong vs. weak position" is to claim that the obstruents in question are in strong and not weak position as they would be according to Rischel's definition; and this agrees well with the fact that [ð] is excluded in such positions, and that there is also a possible contrast between [p] and [b] (e.g. jambe, lampe [jam(.)(-)be, lambe(lampe)]. If Rischel's definition should be amended to cover these facts, it becomes even more complicated and unnatural. This brings me to my other point.

Rischel is, of course, well aware of the striking arbitrariness of his definition as shown e.g. by his term "working definition". It seems clear, to me at least, that if the [b] of [lom'ba:go] is in strong position, it is not because it follows a phonemically voiced segment, viz. [m]; rather the voicedness (or better: sonority) of the preceding segment is a factor influencing the location of the syllable border, i.e. [b] is "strong" because it is syllable initial.

2.3. The stød

The stød has traditionally been considered to be a phonologically suprasegmental entity characterizing a syllable, although its place has generally been indicated as phonetically
concurrent with a vowel or a consonant. Among the arguments that can be given for this phonological analysis are the following (cf. Basbøll 1972b, p. 6f): unlike most segments the stød can be lost under certain accentual and grammatical conditions, its place within the syllable is completely predictable (there is at most one stød which falls "on" the vowel if this is phonemically long, otherwise "on" the following consonant which in this situation is a sonorant), and the stød can be moved from a sonorant consonant to the following sonorant consonant without ever changing the identity of the word (Hjelmslev's (1951, p. 17) example jar'l = jarl').

However, the notational conventions used in what might be termed orthodox generative phonology (as codified in SPE) give no way to represent the stød as a characteristic of the syllable. Instead, the stød has been considered a feature characterizing the segment where it was normally said to occur phonetically (e.g. Austin 1971). Let us briefly consider some consequences of this latter stød-notation, contrasting it with the more traditional prosodic stød-description, which may be rephrased like this: The stød characterizes certain syllables (which syllables is, at least in part, predictable from grammatical and phonological information, but this is of no concern to us here). If the stød-syllable contains a long vowel, the stød is manifested on the vowel; if it contains a short vowel immediately followed by a sonorant consonant, then the stød is on this consonant. It might be added that if it contains a short vowel followed by an obstruent (such a combination is normally said to be unable to receive the stød), then the stød is not manifested (compare alternative pronunciations like pust [puːʔsd/pusd]) except by a "stød-like" intonation in certain Western varieties of Standard Danish; this amounts to considering an abstract stød ("Accent 1"), falling on syllables which never have stød phonetically.
but which occur in a morphological context normally implying stød (e.g. prefixed verbs, cf. beflitte, bestille [beflīde, besdēl?]e]), further see Rischel 1970b, p. 128f, and Basbøll 1972b, p. 30.

Before the oral non-lateral non-syllabic sonorants ([ð, ð, ʁ] manifesting /d, g, g/ syllable-finally) a stød-vowel can be shortened and the stød "moved" to the following sonorant, where it is normally placed (e.g. [fo:ð/ foð/, daːʔi/daːj?, sgε:ʔu/sgeʔ?, sbi:ʔŋ/sbiŋ?]). Phonetically, it is quite possible that there is no "stød-movement" (i.e. change of the location of the stød) at all, the stød occurring at (roughly) the same place in the syllable (cf. Riber-Petersen 1973 and references cited there). If this is correct, a prosodic treatment of the stød would seem to present itself, but let us, for the sake of the argument, accept the segmental location of the stød (in the output) as traditionally given in phonetic notation and taken over by Austin. A non-syllabic treatment of the stød would then seem to need a phonological transformation like the following:

\[
\begin{align*}
V &\quad C \\
+\text{long} &\quad +\text{son} \\
+\text{stød} &\quad -\text{nas} \\
\text{1} &\quad 2 \\
\text{OPT} &\quad \Rightarrow \\
-\text{long} &\quad -\text{stød} \\
\end{align*}
\]

(i)

However, this is clearly inadequate because part of the transformation states that the vowel is shortened before certain consonants, e.g. [ð], and a phonological rule with exactly this effect is needed since the shortening also occurs in words without stød (although less frequently), e.g. bide [biːðə/biðə]. We may then change the phonological transformation to the following, in order to avoid the duplication of
the vowel-shortening rule (which it must follow in the ordering):

\[
\begin{array}{ccc}
V & C & 1 \\
\text{[-long]} & \text{[\alpha \text{son}]} & \text{[-st\text{\&d}\]} \\
+\text{st\&d]} & \text{OBL} & \text{[\alpha \text{st\&d}]} \\
\end{array}
\]

The point to be emphasized is that this transformation (of a dubious formal status) is completely superfluous with a syllabic treatment of the st\&d, whereas it is, as far as I can see, indispensable in an orthodox generative framework.

Another type of st\&d-rule where a non-syllabic treatment seems hopelessly inadequate is constituted by rules ascribing st\&d to certain stressed syllables (e.g. ultimates and antepenultimates in foreign words). If an ad hoc transformation like (ii) is not recognized, it must in a non-syllabic framework be formulated as two processes, one concerning vowels and one concerning consonants, although it is clearly the same phenomenon which is involved. Such a rule will be explicitly formulated in section 3.1 below.

3. The syllable in a generative phonology

In the preceding section we have presented a number of facts taken from the phonology of Danish, the correct description of which seemed to presuppose, so we claimed, that the syllable should be included in phonological theory. But so far we have said next to nothing about the precise way in which the syllable should be included in phonology. In the following we shall discuss a number of different functions the syllable can have in phonological rules. We shall for
this purpose accept the general framework of (non-orthodox) generative phonology (in section 4 the perspective will be widened). Since the most detailed and explicit discussion in print which I know of on the functions of the syllable within the framework of generative phonology is Hooper 1972, I shall mainly refer to her paper in section 3, and postpone the inclusion of some non-generative literature on the syllable until section 4.

3.1. The syllable as a unit in the structural description of phonological rules

Consider how a very simple stress rule (like the one in Polish) placing stress on the penultimate syllable of polysyllabic words and stressing monosyllables too would be formulated within an orthodox generative framework:

(i) \( V \rightarrow [+\text{stress}] /___ C_o (V)C_o # \)

or (ii) \( V \rightarrow [+\text{stress}] /___ C_o(VC_o)# \)

or (iii) \( V \rightarrow [+\text{stress}] /___ (C_oV)C_o # \)

The notational distinction between the three ways of parenthesizing the last syllable apparently does not correspond to anything empirically; this, of course, is a shortcoming of the notation. Another drawback is the fact that one has to state two instances of \( C_o \) in the structural description of a rule. Now, what does \( C_o \) mean? \( C_o \) means that it is irrelevant for the application of the rule whether there are any consonants after the vowels mentioned in the structural description or not. Of course, the over-all principle of what ought to be mentioned in the structural description of a rule is that only what is
relevant for the application should be included in the notation. But in the case under discussion here it is the notational convention that stress cannot be ascribed to syllables which forces one to state the irrelevant consonants. Compare how the rule can be formulated when stress is ascribed to the syllable (the S-symbol) (cf. McCawley 1968, p. 36):

(iv) \[ S \rightarrow [+\text{stress}] / \quad (S) \quad \#
\]

Rule (iv) avoids all the difficulties of rules (i)-(iii).

As mentioned in section 2.3 above, the basic principle governing the occurrence of the Danish stød in foreign words of a Latin-Greek type as well as the traditional school pronunciation of these languages (according to which the main stress is placed in agreement with the target language, whereas the other features of pronunciation have in general no connection with the classical languages) is the following:

if stress is on the ultimate or the antepenultimate syllable, the stressed syllable has stød if it has "stød-basis" (i.e. contains a long vowel and/or a postvocalic sonorant), whereas a stressed penultimate syllable does not have stød (the relation between non-main stresses and stød is more complicated and can be ignored for the present purpose).

If the notation does not allow one to ascribe the stød to a syllable, then either one must rely on the ad hoc-transformation (ii) of section 2.3, or the rule in question must be split up into two parts, viz.:

(v) \[ \left[ \begin{array}{c}
V \\
\text{+long} \\
\text{+stress}
\end{array} \right] \rightarrow [+\text{stød}] / \quad [\text{C}_0(\text{VC}_0\text{VC}_0) \quad \#
\]

or (vi) \[ \left[ \begin{array}{c}
V \\
\text{+long} \\
\text{+stress}
\end{array} \right] \rightarrow [+\text{stød}] / \quad [\text{C}_0(\text{VC}_0V)\text{C}_0 \quad \#
\]
or (vii) \[ \begin{array}{c}
V \\
+\text{long} \\
+\text{stress}
\end{array} \rightarrow [+\text{ståd}] / \underline{C_0} (VC_0 V) C_0 \# 
\]

and (viii) \[ \begin{array}{c}
C \\
+\text{sonorant}
\end{array} \rightarrow [+\text{ståd}] / \underline{V} \\
+\text{stress} \underline{C_0} (VC_0 VC_0) \#
\]

or (ix) \[ \begin{array}{c}
C \\
+\text{sonorant}
\end{array} \rightarrow [+\text{ståd}] / \underline{V} \\
-\text{long} \\
+\text{stress} \underline{C_0} (VC_0 V) C_0 \#
\]

or (x) \[ \begin{array}{c}
C \\
+\text{sonorant}
\end{array} \rightarrow [+\text{ståd}] / \underline{V} \\
-\text{long} \\
+\text{stress} \underline{C_0} (VC_0 V) C_0 \#
\]

Notice that rules (v)-(vii) as compared to rules (viii)-(x) are notationally quite different: in (v)-(vii) the vowel is the affected segment (i.e. the segment which is changed by the rule), in (viii)-(x) it is the consonant; in (v)-(vii) the affected segment is stressed, which is not the case in (viii)-(x); and in (viii)-(x) the environment to the left is relevant which is not the case in (v)-(vii). I shall argue that all these differences have nothing to do with the rule itself. Furthermore, there is a notational ambiguity in the parenthesizing of the environment to the right which has no empirical content.

Quite independently of the phenomena under discussion here, there are good arguments for a general "ståd-manifestation principle" according to which ståd is manifested on the vowel if this is phonemically long, on the consonant immediately following the vowel if this consonant is a sonorant, and not manifested as a ståd in the normal phonetic sense (but eventually by a "ståd-like" intonation, at least in certain Western varieties of Standard Danish) if the short vowel is immediately followed by an obstruent (see section 2.3).
Granted this stød manifestation principle, the rule in question can be formulated quite simply in a syllabic framework:

\[(xi) \quad \left[ \begin{array}{c} S \\ [+\text{stress}] \end{array} \right] \rightarrow [+\text{stød}] / \_\_ (SS) \neq \]

The phonological behaviour of the Danish stød thus strengthens the traditional concept of the syllable as bearer of prosodic features like stress and tone.

It should be added that the recognition of the syllable as a possible unit (S) in the structural description of phonological rules as recently used e.g. by Hooper (1972) in no way implies that one is forced to accept Hooper's definition of this symbol as "a sequence of segments between two syllable boundaries" (p. 537), see section 4.1 below.

3.2. Syllable boundaries in the structural description of phonological rules

There is no doubt that phonological theory should allow the notation of a syllable boundary ($) in the structural description of phonological rules. This is typically the case when $ constitutes the left-hand side or right-hand side environment of the segment affected by the rule, i.e. when the rule expresses a process taking place in absolute syllable-initial or absolute syllable-final position. (I use the qualification "absolute" to resolve the ambiguity of e.g. "syllable-final position" as meaning either the final segment (perhaps the final consonant) of the syllable (i.e. "absolute syllable-final position"), or a segment (perhaps a consonant) in the final part of the syllable, i.e. occurring after the syllabic peak.) Examples of such processes, which should be stated by means of the syllable boundary symbol $ in their structural
description, are strengthening of glides (in Spanish) in absolute syllable-initial position (cf. Hooper p. 528, where the environment is given as $/___$/ and tensening of non-low stressed vowels (in Castilian) in open syllables, i.e. in absolute syllable-final position (cf. Hooper p. 530, where the environment is given as $/___$/).

However, Hooper mentions the $-$ symbol in a much wider range of phonological rules than those referred to above, and in most of these other cases I find that her use of $-$ in the structural description of phonological rules is unjustified and in fact obscures the nature of the processes. This is the case with several assimilation rules which, according to her statements, apply only across $-)$. We shall now devote some attention to a typical example of this sort, viz. the place-of-articulation assimilation of nasals before consonants in Spanish (in "Allegretto" speech style, p. 525f).

The problem to account for is that nasals assimilate to obstruents both within words (e.g. campo, ganga [-mp-, -ng-]) and across word boundaries (e.g. un beso, un gato [-mb-, -ng-]). Before glides ([j, w]), on the other hand, the assimilation occurs only across word boundaries (e.g. un hielo, un huevo [-nj-, -nw-]), not within words (e.g. miel, nieto, nuevo, nuevo [mj-, nj-, mw-, nw-]). Hooper writes:

"With the syllable boundaries included in the strings, the solution to the problem becomes obvious. Nasal assimilation occurs before a consonant or a glide only if a $-$ boundary intervenes. Thus one rule generates the desired output for all cases:

(1) $[+\text{nasal}] \rightarrow \begin{array}{c}
\text{coronal} \\
\text{anterior} \\
\text{back} \\
\text{distributed}
\end{array} /___$/

\begin{array}{c}
\text{coronal} \\
\text{anterior} \\
\text{back} \\
\text{distributed}
\end{array}
Rule 1 accomplishes all that is required of a phonological rule: it generates all instances of nasal assimilation; it states the constraints on nasals followed by non-vowels; and it provides an explanation of the facts. Using $-$ boundaries, the difference between the glides of [uŋ$ye$lo] and [nyeto] can be stated formally: the first [y] begins a syllable and thus is functioning as a non-syllabic segment, while the second is part of the syllable nucleus. Rule 1 states the appropriate generalization, that nasals assimilate only before segments that begin syllables, i.e. segments in a non-syllabic function." (p. 526; my italics.)

The first thing to be noted in the passage quoted is that Hooper's "explanation" (which even "can be stated formally") does not follow from her rule formulation, but that it presupposes an additional axiom like the following: a glide which begins a syllable is a non-syllabic segment as opposed to a glide which does not begin a syllable. If this is not in plain contradiction to other passages of hers, e.g. "two contiguous syllabic segments form separate syllables. This rule applies to Spanish ..." (p. 534), at best her terminology is confusing (the word "syllabic" apparently meaning "part of the syllable nucleus" while the feature name "[syllabic]" seems to mean "constitutes the peak of a syllable"; see section 4.5 below). Anyhow, the "explanation" is based upon a dubious distinction between those prevocalic glides which do and those which do not form part of the syllable nucleus, and I find this far from convincing (it should be noted that in the speech style discussed here, the glides in absolute syllable-initial position are not strengthened to obstruents, p. 528).

But if her explanation in the text is not connected with her rule formulation and in itself unconvincing, let us then take a look at her notation. The rule in fact states
that the assimilation takes place only if the segment to be assimilated is separated from the segment causing the assimilation by a $-boundary. But to me it is unbelievable that it is the occurrence of a boundary which conditions the assimilation. I suggest the universal principle that if a certain assimilation under certain conditions takes place across a certain boundary, then the same assimilation under the same conditions will also take place in the absence of this boundary (and in the presence as well as absence of a weaker boundary).

This is, of course, not to deny the observational adequacy of Hooper's assimilation rule, but I think the explanation should be sought in a different direction, although within the same basic framework, viz. that the syllable plays a crucial role for the assimilation. Even though the function of the glides in un hielo and nieto is the same, as I suggest is the case, the function of the nasals in the two examples is quite different. In the final part of the syllable there is no contrast of place-of-articulation among nasals, and - with the Prague School terminology - there is thus only one nasal archiphoneme syllable-finally, whereas syllable-initially there is a three-way contrast between labial, dental, and palatal nasals (similarly the contrast between dental and palatal laterals is neutralized in syllable-final position). These neutralizations in syllable-final position are only one manifestation of a more wide-spread phenomenon: that syllable-final consonants are "weaker" than their initial counterparts in a number of respects: they are shorter, have a laxer articulation, and are much more susceptible to assimilatory phenomena (cf. Grammont 1933, p. 184ff). Whatever the correct formulation of the rule may be, I think this is the heart of the matter. Notice that Hooper must claim that her rule
"states the constraints on nasals followed by non-vowels" in such a way that if a nasal should be followed by a word-final obstruent, the former would not necessarily be homorganic with the latter. Such a word-final cluster does not, of course, occur in normal Spanish words, but it seems improbable that a nasal preceding e.g. a word-final /p/ could be anything but [m].

According to Hooper, "these assimilation rules are two examples of generalizations that cannot be stated without the $-boundary" (p. 526; my italics). This assertion can only be due to lack of imagination, and I shall just sketch two alternative ways of accounting for the nasal assimilation in what seems to me a more insightful way. I have at present no strong arguments in favour of one or the other of these two proposals, and I do not believe that they are completely independent of each other.

One possibility is to re-include the notion of the archiphoneme in phonology, in the sense that a rule can refer to a segment which is not fully specified, i.e. which has zero as its coefficient for one or more features. Furthermore, the place-of-articulation assimilation expressed by the rule is obviously not a simultaneous but independent assimilation of four distinct features: [coronal, anterior, back, distributed], as the formulation suggests. If we therefore use one multi-valued feature [place-of-articulation] (abbreviated [art]) (cf. Ladefoged 1971, p. 42ff) ¹, the rule can

¹ By the term "multi-valued" I mean that the feature can take a finite number larger than two (but in practice a small number) of coefficients. Schane (1973, p. 96) apparently considers "multi-valued" equivalent to "scalar" in the sense that multi-valued features (i.e. features on a late, "phonetic" level of representation within his framework) can specify fine phonetic distinctions, e.g. between different languages, within a certain "scale". I should emphasize that this implication
be formulated as follows:

\[
\begin{align*}
&\text{[+nasal]} \\
&\text{[\(\emptyset\) art]} \rightarrow \text{[\(\alpha\) art] / \(\alpha\) art} \\
&\text{[C]}
\end{align*}
\]

This rule expresses the generalization that the nasal archiphoneme is assimilated as regards place-of-articulation to a following consonant, whereas a fully specified nasal is unchanged by the rule; this explanation also holds true for the lateral assimilation. (This statement in terms of archiphonemes may be interesting in view of evidence from speech error analysis discovered by Niels Davidsen-Nielsen (forthcoming) which points to an encoding of 'sp-', 'st-', 'sk-' as /s/ followed by a stop archiphoneme unspecified as regards the feature(s) distinguishing /ptk/ from /bdg/.)

Another possible solution would be that [-syllabic] segments are subcategorized into [+final] and [-final]. Thus the underlying forms could be - but need not be - sequences of syllables, each syllable consisting of an unordered set of segments which would then have to become a sequence by a process of linearization in accordance with the syllabic hierarchy, see section 4 below. This idea of linearization

1) (cont.) (due to the orthodox generative (Jakobsonian) unwillingness to recognize non-binary features on the phonological level) does not apply to my use of "multi-valued" (which is in agreement with Ladefoged). Ladefoged, however, uses "scalar" synonymously with "linearly ordered" (as opposed to "independent"), i.e. a ternary feature can be scalar according to him. I think this terminology should be refined so that "scalar" means "continuously varying within certain limits" (this is in fact a normal property of a "scale"), in agreement with Schane's use of the word, whereas "a multi-valued linearly ordered feature" can take only a finite number of values on a certain "scale". Whatever terminology is chosen, the distinctions mentioned above all seem necessary, i.e. both Schane's and Ladefoged's terminologies are too crude.
has evident parallels in higher parts of the grammar (cf. Chafe 1970, p. 250ff). Thus the assimilation rule could be stated like this:

\[
\begin{array}{c}
\text{[+nasal]} \\
\text{[+final]}
\end{array}
\rightarrow [\text{\&art}] /\ \\
\begin{array}{c}
\text{C}
\end{array}
\]

In favour of a solution along these lines would be the fact that for a large number of assimilation processes the segment affected could be defined as being [+final], and this is true also in cases where there is no neutralization in final position, as in the voicing assimilation rule which Hooper states (p. 530) in the following way:

\[
[ ] \rightarrow [+\text{voice}] /\ \\
[+\text{voice}].
\]

3.3. The syllable as a domain for phonological rules

At the outset of section 3.2 we mentioned certain types of phonological rules where it seemed to be the best solution to mention the $-boundary in the structural description, viz. mainly processes applying to segments in absolute syllable-initial and absolute syllable-final position (there are maybe some others as well, cf. Hooper p. 531). We claimed, however, that in a number of cases this was not the correct solution. In this section we shall discuss some further phonological rules where the syllable seems to play a crucial role although not the one ascribed to it by Hooper.

The $-boundary is, of course, not the only boundary in phonology which can constitute the left or the right-hand side limit of a rule environment. For example, special processes can occur phrase-finally (aspiration (and affrication in the case of /t/) in Danish is such an example), and such rules
must contain the boundary symbol in their structural description (devoicing before # or ## in many languages is another well-known example).

It must be emphasized that such cases by no means illustrate the only function of boundaries in phonology; they do not even constitute the most important one. This is not the place for a general discussion of grammatical boundaries in phonology (cf. Basbøll (forthcoming) for an extensive discussion of (particularly word-internal) boundaries in French phonology). However, in order to place syllable boundaries in their proper perspective, I find it useful very briefly to discuss the function of the boundaries in SPE and to compare it with the proposals of McCawley (1968, p. 55ff).

Let us begin with the conceptually simpler proposal, viz. that of McCawley. He suggests that the grammatical boundaries in phonology (junctures) in a given language can be arranged in a unique rank order B₁, B₂, ..., Bₙ, in the sense that B₁ is the weakest (of lowest rank), then comes B₂, etc. (B₁ is the morpheme boundary, Bₙ the pause.) The main function of the boundaries is to define the domain of phonological rules in the following way: Each phonological rule has a certain rank expressed in terms of a specific boundary, e.g. [B₃]; when an input string to a rule of the rank [B₃] is scanned to see whether it matches the structural description of the rule, the string is divided into chunks in such a way that each chunk is limited on both sides by a boundary of rank 3 or a higher rank (i.e. Bₙ³), and that the only boundaries that occur within each chunk are of a rank lower than 3 (i.e. B₁³); each such chunk is thus separately matched to the structural description of the rule, ignoring those internal lower rank boundaries (i.e. B₁²) in the input string which are not mentioned in the structural description of the rule.
(According to McCawley, a rule of rank $B_n$ is higher valued than a similar rule of a lower rank.) Although the proposal is in need of precision as to the restrictions on the inventory of possible boundaries, it is conceptually very satisfying.

The same can scarcely be said about the use of boundaries in SPE. First of all, boundaries (which are [-segment]) are cross-classified by means of distinctive features, just like vowels and consonants (+segment). This is a very powerful principle (the inclusion of which in the phonology of boundaries seems by and large unmotivated). Chomsky and Halle use three different intra-phrase boundary symbols, viz. + ("morpheme boundary", i.e. [-segment, +formative boundary, -word boundary]), # ("word boundary", i.e. [-segment, -formative boundary, +word boundary]), and = ([-segment, -formative boundary, -word boundary]). This latter boundary, forming separate natural classes together with + ([-segment, -word boundary] defining = and +) and # ([-segment, -formative boundary] defining = and #), destroys the hierarchical principle inherent in McCawley's proposal, but since it is limited to certain quite specific non-native formations (SPE p. 94f), we shall ignore it here. Boundaries stronger than # are in SPE represented by sequences of #, which in fact approaches the idea of a hierarchy of boundaries; e.g. a rule applying in the environment /___# will also necessarily apply in the environment /___###, but not inversely.

Now, what is the function of the boundaries + and # in rules? According to SPE, the distribution of the boundary + is irrelevant to the application of phonological rules unless their structural description explicitly mentions a
+-boundary.1 A #, on the other hand, prevents the application of a phonological rule which does not mention a # -boundary at the indicated place in its structural description. This is empirically equivalent to saying that a phonological rule which does not mention any boundaries in its structural description only applies if the string of segments matching the structural description does not contain any instances of #. For non-cyclical rules, this amounts to saying that their domain of application is the maximal string between two successive #-boundaries unless boundaries occur in the structural description. And, in fact, also the maximal string between two successive +-boundaries containing no internal boundaries defines a rule domain, viz. the domain for morpheme structure rules or morpheme structure conditions.

The point I wish to make by this digression is the following: despite the great differences between the boundary theories of McCawley and SPE, they in fact agree that a main function of boundaries in phonology is to define the domain of rules. This follows from the fact that boundaries can block the application of rules where the sequences of segments

1) The condition expressed in the last clause does not seem very well motivated. Jørgen Rischel has suggested that the distinction between the boundaries # and + should be, simply, that # can have phonological effects, whereas the distribution of the boundary + in phonological strings is irrelevant to the application of phonological rules, i.e. neither the presence nor the absence of + can be presupposed for the application of a phonological rule. This hypothesis is a way of formulating the well-known insight that certain grammatical boundaries, but not all, have phonological consequences, cf. Rischel 1972, p. 226 (notice that the argument above does not apply to morpheme structure rules or -conditions). However, compare Kiparsky 1973, p. 57ff.
match the structural description (the occurrence of + blocks a morpheme structure rule, and the occurrence of other junctures can block phonological rules).

Now, if this is true of grammatical boundaries let us then examine the possibility that also syllable boundaries can block certain phonological rules, or that the syllable could be a domain of phonological rules. Apparently this possibility is not considered by Hooper (who seems implicitly to assign the same junctural status to the $-boundary as to the +-boundary, i.e., that if a $ occurs in the structural description, then the rule applies only to input strings containing $ at the indicated place, whereas rules not mentioning $ apply regardless of the distribution of $; in an SPE-framework, this seems in fact to be the only possibility). A case in point is the following example:

"Many P-rules in Akan depend upon syllable shape and thus syllable boundaries[...] For example, consider the nasalization of high vowels which occurs before a nasal consonant in the same syllable. (Note that this environment is extremely common for vowel nasalization - it occurs in French for all vowels in just such an environment.) It is possible to avoid the mention of 'syllable' in formally stating the rule, by recognizing two environments: before a nasal before another consonant, and before a morpheme-final nasal:

(15) \[
\begin{array}{c}
V^{\text{[+high]}} \\
\end{array} \rightarrow \left[ \begin{array}{c}
\text{[+nasal]} \\
\text{/ } \\
\text{[+nasal]} \\
\end{array} \right] \left\{ \begin{array}{c}
C \\
\# \\
\end{array} \right\}
\]

It is simpler, however, to state the environment in terms of $-boundaries:

(16) \[
\begin{array}{c}
V^{\text{[+high]}} \\
\end{array} \rightarrow \left[ \begin{array}{c}
\text{[+nasal]} \\
\text{/ } \\
\text{[+nasal]} \\
\end{array} \right] \left[ \begin{array}{c}
$ \\
\end{array} \right]
\]
Note that Rule 16 is NOT an abbreviation of 15. Rule 16 is the real statement of the environment, while Rule 15 is merely an ad-hoc contrivance that produces the same results" (Hooper, p. 533; my italics).

The point to be emphasized is that the two formulations do not in all cases produce the same results, but that the "ad-hoc contrivance" gives the right output, whereas her rule 16 often gives the wrong output. For example, French words like cent, sans [sā] (I use examples from French where I know the data) in their underlying forms end in obstruents (cf. centaine, centenaire [sōten, sōt(e)n̩eː] and sans amour [sā z amuː].) The latter example suggests that the phonological $-boundary should occur after the /z/ at the point of the derivation where the vowel is nasalized, since this is the place of the word boundary (according to Hooper, one should not expect a realignment of the $-boundary to the place before /z/ until /z/ is intervocalic, i.e. after the nasal has dropped, see p. 527, 537). This conclusion seems strengthened by the observation that a word like sens [sā:s] has a nasalized vowel before a word-final pronounced obstruent (in certain varieties of French, at least, there is no underlying shwa in such words). A further argument for the position that nasalization of vowels in French can occur also before nasals that are not in absolute syllable-final position comes from words like pente [pāː:t] in which the vowel is nasalized before a pronounced obstruent followed by pause. Such words end in an underlying shwa, and it might be claimed that the /t/ is syllable-initial at the point of the derivation where the vowel is nasalized. However, this does not agree with the fact that in a word like étiquette [etiket] (which is underlying /#etikete#/), cf. étiqueter [etikte]), the phonological syllable border must go after the final /t/
since the /a/ is converted to ε, see Dell 1973, p. 198ff and Basbøll, forthcoming. Although each of these arguments taken alone is not irrefutable, they nevertheless give a certain implausibility to Hooper's formulation. And at any rate, it is certain that the two formulations are not equivalent in all cases; and I find it hard to accept a notation in which every form /VN$/ is nasalized, but no form /VNC$/.

We therefore claim that the nasal consonant in these examples does not occur immediately before the $ which Hooper's formulation demands. In order to make her rule 16 work, it should be changed to (for the French material):

(i) \[ V \rightarrow [+nasal] /__ [+nasal] C_0 $ \]

But this is only one more example where one is forced to state in the rule what is irrelevant for the application of it, viz. \( C_0 \).

How should this rule, then, be formulated? In the text Hooper in fact gives the correct condition, viz. "before a nasal consonant in the same syllable". Thus it is irrelevant whether the $-boundary occurs immediately after the nasal or not, what counts is that it does not occur between the vowel and the nasal consonant. If we recognize the possibility that a rule can have the syllable as its domain, or can have the $-boundary as its rank, or can be blocked by the occurrence of a $-boundary within its structural description (all these formulations here being equivalent), then the rule can be formulated like this:

(ii) \[ V \rightarrow [+nasal] /__ [+nasal] \]

where it should be a property of the rule, but not of its structural description, that it has the syllable as its domain.
(If it cannot be deduced from the process itself that the syllable is the domain of the rule, this must be given as an index of the rule, as McCawley must state the rank of rules with smaller domains than the string occurring between two pauses; however, as far as I know, it is the normal case for rules assigning consonant features to vowels, as well as for rules coalescing a vowel and a following consonant, that they do not apply across syllable boundaries.)

Let us now turn to a rule from Danish in which there is absolutely no way out of mentioning $C_0$ in the structural description if we are to accept Hooper's framework. I have in mind the rule for the manifestation of short /a/ (see section 2.1 above). The colouring of /a/ by the following homosyllabic consonant is quite independent of any additional final consonants, e.g. the /a/ in samt [sam?t] is pronounced exactly like the /a/ in Sam [sam?]. Consequently Hooper would have to formulate the rule like this:

\[(iii) \quad a \rightarrow [+\text{back}] / \underline{-}\text{cor} [C_0] \]  

(Notice that in the SPE-framework of distinctive features used by Hooper, there is no way to capture the assimilatory nature of the process in question, because what is alike in the vowel and the consonant is not articulatorily defined, see below.)

However, I argue that the domain of the rule is the syllable, and that its correct formulation is the following:

\[(iv) \quad a \rightarrow [+\text{grave}] / \underline{+\text{grave}} \quad (\text{domain: syllable}) \]  

This rule too is a case where a feature of a consonant (viz. the acoustically-auditorily defined feature $[+\text{grave}]$ characterizing labials and velars, cf. Ladefoged 1971, p. 44) is ascribed to a preceding homosyllabic vowel.
Of course, I do not claim that the syllable is the only domain for phonological rules, not even that it is the most important one. Some other domains of phonological rules in Danish will be briefly mentioned below.

It is clear from the discussion of grammatical boundaries in phonology at the outset of the present section that according to the notational conventions of SPE, non-cyclical rules which do not include any boundary symbol in their structural description have the maximal string between two consecutive #-boundaries as their domain. The rule [-son] → [-voi]/[-voi] in Danish is such an example. This rule turns an underlying voiced obstruent, i.e. b, d, g, v, y, into its voiceless counterpart, i.e. p, t, k, f, y, in the position before a voiceless obstruent not separated from the preceding segment by any #-boundary (on this rule, see the notes referred to in footnote 1 on p. 42).

The compound stress rule in Danish seems to have the word as its domain: it is characteristic that the stress pattern which is typical of ordinary Danish compounds never applies to more than one word (cf. Rischel 1972). Finally, certain assimilation rules have larger domains, in part depending on stylistic factors, and so on.

It is an urgent need in phonology to find the relations which undoubtedly exist between the nature of a phonological process and its domain. I suggested above that rules which assign consonant features to a preceding vowel normally have the syllable as their domain. However, this relation is probably not a universal law, since certain rules seem able to change their domain. Such conditions of rules changing their domain ought to be investigated; for example, rule (iii) above seems to be in the process of enlargening its domain by younger speakers, so that words like papir, akademiker are now often pronounced [pʰapʰɪʁ?, ˀakʰadɛˀːmɪɡʰ] (the pronunciation [pʰ, kʰ] suggests that it is not the syllable boundary which has been moved).
3.4. Syllabification

By "syllabification" I understand the division of a phonological string (consisting of phonological segments and boundaries) into consecutive syllables. "Syllabification" is thus roughly equivalent to "placement of syllable boundaries", and it therefore concerns the border between contiguous syllables, and not their internal structure in terms of peak, nucleus, margin, and the like (see further section 4).

As to the cases where the syllable functions as a unit in phonological rules (i.e. typically in rules concerning prosodic features like stress, tone, and stress, cf. sections 2.3 and 3.1 above), syllabification is not required for the correct application of the rules: what is necessary is only that the number of syllables be known, and this information can possibly be given with an identification of the syllabic peaks. The consequences of this fact for the formal definition of the syllable will be taken up in section 4.1 below.

Obviously, if a syllable boundary occurs in the structural description of a phonological rule (section 3.2 above), the input string to this rule must be syllabified. Similarly, regarding the rules having the syllable as their domain (section 3.3 above), their input strings also appear to presuppose a previous syllabification.

However, on this point I would like to claim that phonological syllable boundaries can be partly indeterminate, i.e. they need not always be fully determined. In a great number of cases where the syllable plays a role in determining phonological processes, the only relevant distinction is one between open and closed syllables, whereas a distinction between syllables ending in one, two, or three consonants does not matter. This is the case e.g. with the stress rule in classical Latin and with the rule predicting the manifestation of Danish short /ø/ (section 2.1 above).
Let me briefly discuss a third example of this sort, viz. the rule E-Adjustment in French which in certain contexts (which can tentatively be defined as "in closed syllables") converts an /e/ or /a/ into /ɛ/ (see Basbøll, forthcoming, for a discussion of this rule in connection with syllabification problems). Examples like genevois, jetterons [ʒənvwa,ʒɛtʁɔ̃], derived from /#ʒənv+uaz#, #ʒæt+a+r+ɔN#z#/, show that an intervocalic consonant between two unstressed shwas belongs to the following vowel if no morpheme boundary intervenes between it and the consonant, otherwise to the preceding vowel. But where does the syllable boundary occur in an example like sévrerons [sɛvrɔ̃], derived from /#səvr+a+r+ɔN#z#/ (cf. sevrer [səvʁ] /#səvr+a+r#/)? If we say that the syllable boundary coincides with the morpheme boundary, then the first syllable ends in the otherwise unknown final consonant combination /vr/ (see below); but if we say that the syllable boundary occurs between /v/ and /r/, then we must recognize that the factor determining the syllable boundary, viz. the morpheme boundary, occurs at a different place, i.e. that it can only retract the syllable boundary one place, and this sounds somewhat mysterious to me. In fact I think the choice between the two mentioned locations of the syllable boundary is a pseudo-problem which only arises in a theory forcing one to state one unique inter-segmental location of every syllable boundary. A more realistic solution is to define the notions open and closed syllable formally in such a way that the first shwa in sévrerons will occur in a closed syllable, but without commitment to the choice between several locations which will in any context under any circumstances give the same result. Before we turn to the discussion of several factors which can influence the syllabification of phonological strings, a word should be added about the level at which syllabification applies.
First of all, I do not think it makes much sense to speak of syllables and syllabification at very abstract levels of representation (cf. Fudge 1969). Of course, one can claim (Hooper 1972, p. 538) that Spanish estable is derived from /$sta$ble$/ via (by an e-epenthesis rule followed by a resyllabification) /$es$ta$ble$/; but I fail to see why there must be $-boundaries (before /s/) in the abstract string /$sta$ble$/.

Similarly, she notes that Spanish pan is derived from /$pa$ne$/ via (by an e-deletion rule followed by a resyllabification) /$pan$/.

In fact, I think that the only arguments for abstract syllable boundaries different from the phonetic ones are the impact of such boundaries on the application of phonological rules. There is thus no reason to postulate an "abstract syllable boundary" between /a/ and /n/ in pan if this boundary can have no phonological effect whatever and, of course, no phonetic existence at all (this is in line with our proposal above that phonological syllable boundaries are in some cases partly indeterminate).

Notice that the present discussion concerns the level of description, i.e., I do not intend to exclude an abstract syllabification /$pa$ne$/ if this word-internal syllable boundary could be phonologically justified in other forms with e-deletion; but a phonological syllabification applying before a certain rule P should be excluded in principle if the syllabification in question can have no effects on the application of P or of any phonological rule ordered before P. ¹

At the other end of the abstractness scale there is ample evidence for the existence of phonetic syllables and phonetic syllable boundaries. At the phonetic level the postulation of a syllable boundary should, of course, be justified on purely phonetic (i.e. non-phonological) grounds, including the distinction between syllable initial- and syllable-

1) The rule order involved here is descriptive order, i.e. priority is concerned, not time (e.g. in a psychological sense), see Rischel 1974, p. 311ff.
final extrinsic allophones, etc. The postulation of phonetic syllable boundaries can thus be confirmed or disconfirmed by experimental-phonetic evidence, as opposed to phonological syllable boundaries which are merely "descriptive devices" in cases where they differ from the phonetic ones. Since the subject of the present paper is the phonological and not the phonetic syllable, I shall leave the purely phonetic questions here (but cf. section 4), and turn to the relation between phonological and phonetic syllable boundaries.

"The claim made here is that Rule 22 [which inserts syllable boundaries in certain contexts defined in terms of segments; HB] represents the universal definition of the phonological syllable, and that languages may or may not have additional late rules that define a language-specific, phonetic syllable" (Hooper 1972, p. 536; my italics). Cf. the following quotation: "We have been assuming that it is always possible to assign a non-arbitrary syllable division in any word; this assumption is justified on the grounds that we are referring to the phonological syllable, not to the phonetic syllable" (ibid.). Hooper refers to Hoard 1971 who shows that stress influences syllabification (which is not predicted by her Rule 22) in English. Apparently Hooper here confuses two issues; what is specific to English is not, as Hooper suggests it is, that "a stressed syllable attracts a maximum number of segments to it" (ibid.), but rather the fact that English is a language which has heavily stressed syllables contiguous to unstressed ones, as well as (naturally) the regularities and irregularities of the location of the stresses.

In fact, I think that the relation between phonetic and phonological syllable boundaries is just the opposite of what Hooper believes (cf. Basbøll 1972a, p. 193\(^1\)). It is highly

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1) I have permitted myself to restate some of the points I made in Basbøll 1972a, since Hooper's article had not appeared at the time I published my paper, and I could therefore not take into consideration her partly similar, partly deviant proposals on that occasion.
significant that the universals concerning syllable types in
different languages, possible consonant clusters and their
division by syllable boundaries, etc. which have been signalled
in the literature (cf. e.g. Jakobson 1941, Greenberg 1965, and
Cairns 1969) all apply at a phonetic or a "classical" phonemic
level, but not at an abstract phonological (morpho-phonemic)
level. This suggests that an abstract phonological syllable
may be more or less language-specific (although there is also
here a high degree of convergence between the syllabificational
criteria used by different languages, e.g. as to the specific
role of the unstressed shwa in both French and Danish); phon­
etically, on the other hand, languages seem to agree, and I
suggest that the universally unmarked way to syllabify a given
sound chain is the phonetic syllabification (but it depends,
of course, on a number of language-specific factors, such as
the distribution of stresses (and maybe junctures, see below),
a dependence which is probably not language-specific). As a
hypothesis, I think it has much more inherent plausibility
than Hooper's, and it seems to be supported by observations
like the following:

In Danish, phonological criteria clearly point to a syl­
lable division after [ø] in words like bade [bæːðə] (e.g., [ɔ]
ever occurs word-initially, and it alternates with [d] before
stressed vowels as in abbed, abbedisse [ábeð, abedíssə]), but
both phonetically and psychologica]ly (see below) it seems to
occur before [ø], which is in agreement with the tendency
towards CV-syllables, especially when the vowel is long (note
that in this example there is no question about segments being
inserted or deleted, or changing their coefficient for the
feature [syllabic], which could motivate a resyllabification
within Hooper's framework).

As for the psychological reality of syllable boundaries,
the only thing that can be said here is that the problem of
determining whether such psychologically real syllable boundaries exist, and if so, where they are, is empirically quite distinct from determining both the phonetic and the phonological syllable boundaries. This question should be enlightened by means of psychological test methods, but its interwovenness with orthography will probably make the issue extremely difficult to settle.

Let us now return to the phonological syllable boundaries. Below I shall discuss briefly a number of factors which can influence the location of the phonological syllable boundaries, viz. the following: grammatical boundaries; the existence of initial and final segment combinations in the utterance and/or the word and/or the morpheme; stress; the surrounding vowels; and the sequences of consonants. It should be emphasized that these do not represent a number of alternative principles of syllabification of which every language chooses one; on the contrary, those principles interact in different ways in different languages. In section 3.4.1 below I shall state briefly how Danish uses these different criteria in an ordered fashion to form a set of principles of phonological syllabification.

Sensitivity of syllable boundaries to grammatical boundaries. It has always been recognized that grammatical boundaries can determine the place of syllable boundaries in such a way that the latter must coincide with the former (cf. Hooper 1972, p. 527, 537). For example, it seems to be true for a great number of languages that boundaries between words are also phonological syllable boundaries, if the latter are relevant at all.

The relation between intra-word grammatical boundaries and syllable boundaries is more complex. If the hypothesis
sketched in the footnote on p. 62 can be upheld, viz. that the distinction between the boundaries # and + is that the former but not the latter can play a role for the application of phonological rules, then the hypothesis suggests itself that the boundary # always coincides with the syllable boundary (this hypothesis seems by and large valid for the Danish and French material I have investigated with regard to syllabification); however, the general examination of it is an enormous task because the junctural structure of the language in question must be established independently of syllabificational phenomena if the reasoning shall avoid circularity (see Basbøll, forthcoming).

The last problem I shall mention concerning the relation between grammatical and syllabic boundaries is the well-known fact that, in general, Germanic languages as opposed to Romance languages exhibit a phonetic syllabification which is sensitive to word boundaries (compare the fact that in German word-initial vowels have a glottal attack, e.g. ein Esel [ʔainʔɛːz̩], with the liaison- and enchaînement-phenomena in French, e.g. en avril [œnəvʁil]). In my view, this casts doubt on the existence of a phonological rule of universal applicability that erases all grammatical boundaries at the end of the phonological component. An alternative would be that (intra-phrase?) grammatical boundaries are erased at an earlier point of the derivation in French than in German, or maybe that they are not erased in German at all but manifested phonetically in various ways. This issue has scarcely been investigated at all.
Sensitivity of syllable boundaries to the existence of initial and final segment combinations in the utterance and/or the word and/or the morpheme. It is a traditional insight that there is generally a high correlation between the possible initial and final consonants in a syllable on one hand and in grammatical units like the utterance, the word or the morpheme on the other, in the sense that an intervocalic consonant cluster can be partitioned on different syllables so that the syllable final cluster is also found finally in the grammatical unit in question, and that the syllable initial cluster is also found initially in the grammatical unit.

As for the grammatical unit used for the comparison, I think most can be said in favour of the word, which is in fact also the traditional choice. In general, there seem to be no phonological restrictions determining which words can be combined in utterances, can occur utterance initially or finally, etc. (of the type "words with three initial consonants never start utterances"), this of course being related to the fact that the word is the "minimal free form". Thus the word will give the same results as the utterance for this purpose, and is of a more manageable size (there may be methodological reasons for preferring one or the other frame of reference within different linguistic schools, but this can be ignored here). On the other hand, there can be phonological restrictions on the combination of morphemes into words (for a Danish example, cf. Basbøll 1973, p. 129f) and, furthermore, one morpheme often has several alternants differing with respect to consonant combinations (i.e. with different phonological rules being applied in different contexts), and this makes the consonant combinations less well defined. A Danish example showing the difficulty in using the morpheme as frame of reference is mentioned in section 3.4.1 below.
Within generative phonology, a similarity between initial and final consonant combinations in the syllable and in the morpheme has often been pointed to (e.g. Hooper 1972, p. 535f). The interest of this comparison within the orthodox generative framework is no doubt due to the fact that the concept "possible morpheme initial (final) cluster" can be given a well defined theoretical status by means of the morpheme structure rules or -conditions applying in the lexicon (cf. Stanley 1967). But it should be emphasized that these morphemes are generally taken to be very abstract entities, and in cases where the initial or final clusters of these morphemes are changed by phonological rules, they do not play any role for syllabificational phenomena, as far as I know. The dangers in using abstract morphemes as frame of reference for syllabificational phenomena can be seen in the following quotation from Hooper:

"In Spanish the division is /s$1/, as in is$1a, but in English it is /$s1/. Again the constraints for syllable-initial position correspond to the constraint for word-initial position.

To account for such exceptions [viz. to the general principle that the syllable boundary occurs before the obstruent in an obstruent-liquid sequence; HB] formally, I propose that, in addition to the general rule for inserting $-boundaries, the metatheory provide a list of possible exceptions [...] The choice of exceptions applicable in a given language is determined by the morpheme structure conditions of that language [...] The fact that such a relation obtains may bear on the question of the existence of $-boundaries in the lexicon." (p. 535f; my italics).

Hooper jumps easily from the similarity between the syllable-initial constraint and the word-initial constraint of /s1/ in Spanish (which is real), to an imaginary similarity
between the syllable-initial constraint and the morpheme-structure constraint which is in flagrant contradiction to her underlying forms on p. 538 like /$sla$bo/ which has an initial /sl-/ . The correct conclusion is, of course, that there is no relation between clusters in abstract morphemes and syllabification, unless these abstract clusters are also found at more concrete levels of representation.

This conclusion agrees well with one of the claims made at the outset of section 3.4, namely that phonological syllable boundaries are merely descriptive devices in cases where they differ from the phonetic syllable boundaries, and that it is unjustified to speak of phonological syllable boundaries on more abstract levels than those on which they are used by phonological rules. It follows, then, that the comparison between word-initial (or -final) and syllable-initial (or -final) clusters cannot be made on such abstract levels.

However, the comparison in question cannot always be made on the phonetic level either, since the clusters to be compared may differ in ways which have no bearing on the validity of the comparison. E.g., if final voiceless stops in a given language are aspirated in word-final position but not in syllable-final position within the word, then it seems reasonable to disregard this difference in aspiration when comparing a certain postulated syllable-final cluster to the set of word-final clusters to see whether one of these matches it. A level appropriate for this comparison would be something like a phonemic level in the pre-generative sense, and this has in fact been used for distributional descriptions by many authors, e.g. Sigurd 1965 and Vestergaard 1968. However, within orthodox generative phonology no such intermediate level between the systematic phonemic and the systematic phonetic level has been given any theoretical status (cf. Chomsky 1964). If the genera-
tive model is not expanded to include one or more theoretical levels of this sort (which it probably should, cf. Rischel 1974, p. 361ff), then the distributional description - including the comparison between word-initial (or -final) and syllable-initial (or -final) clusters - can, at any rate, be given at an intermediate level defined by the rules which have, respectively have not, applied at that level (cf. Basbøll 1973 for a distributional description of Danish consonants at such a level, and Basbøll 1974 for a partly similar description of Italian).

It should also be said that the relation discussed in these lines obtains between syllable-initial and -final clusters on the one hand, and possible word-initial and -final clusters on the other, not necessarily registered clusters in a given corpus (i.e. clusters which are accidentally missing should be included in the material). It is of course a moot question how to define the distinction between structurally missing and accidentally missing clusters (cf. Spang-Hanssen 1959 and chapter VI of Fischer-Jørgensen 1952), and it has both statistical, psychological, and, above all, purely phonological aspects of the sort discussed in section 4.3 below. E.g., a Danish word like lingvist [leŋvíːsd] should be syllabified before /gv/ despite the non-occurrence of word-initial /gv/, [g] being the syllable-initial allophone of /g/. That the non-occurrence of word-initial /gv/ may be regarded as accidental is seen from the existence of word-initial [sgv] as found in skvat [sgvad], etc. (the interpretation of [sg-] as /sk-,/ suggested by Uldall 1936 and taken over by Vestergaard 1968, is not only far-fetched phonetically, but also at variance with the unanimously accepted interpretation of [sv-] as /sv-/ and not /sf-/).

There are at least two principal difficulties which arise when we try to evaluate the importance of the syllabificational
criterion under discussion here. First: we argue for a certain intra-word syllable boundary by saying that alternative locations of it would lead to a syllable-initial (or -final) cluster which is structurally impossible as a word-initial (or -final) cluster. However, it will in general be possible to get (roughly) the same results by defining the location of the syllable boundary in terms of the sequence of intervocalic consonants instead, without reference to the set of structurally possible clusters in the word. This difficulty arises in Danish, and it will therefore be discussed in section 3.4.1 below.

The other principal difficulty is the following: When a certain constraint is valid both for syllable-initial (or -final) clusters within the word and for word-initial (or -final) clusters, then it is no simple matter to decide which constraint is the basic one and which is the derived one, if they are not both consequences of a more general principle. It is rather evident that the set of word-initial and word-final clusters are primary data in a way in which intra-word (phonological) syllable boundaries are not, and in the language analysis the word-initial and -final clusters have therefore generally been taken as primary, and the intra-word syllable-initial and -final clusters as secondary. But in the final language description model (in the synthesis, if you like), it is not so clear what to do. Within the descriptive framework advocated in section 4 below, according to which most phono-tactic information can be derived from a general model of "maximal syllabic structure", the constraints for word-initial and word-final consonant clusters are a consequence of the fact that these clusters are by necessity also initial, respectively final, in the syllable.

(An approach to syllabificational phenomena relying heavily on the relation to initial and final clusters is found in Anderson and Jones 1974.)
Sensitivity of syllable boundaries to stress. As already mentioned, Hoard 1971 contains a detailed discussion of the influence of stress in English on the occurrence of syllable boundaries (see the beginning of this section). The general principle seems to be that a stressed syllable attracts a maximum number of segments to it.

In Danish, this principle is not very important for the phonological syllabification (but the unstressed vowel shwa plays a great role, see section 3.4.1 below). I shall, however, mention one type of example where its influence can be clearly seen. A word like eskorte is nearly always pronounced with an unaspirated [g]: [εsgʊ:da]. The derived verb eskortere, on the other hand, is often pronounced with an aspirated [kʰ], i.e. with the /k/ in syllable-initial position not occurring after a homosyllabic /s/: [ɛskʰɒtɛ:ʔ]/ɛsgɒtɛ:ʔ]. The only relevant difference between the two occurrences of /s/ + velar stop is that in eskortere, both surrounding vowels are unstressed, whereas in eskorte, the following vowel is stressed and it thus obligatorily attracts both preceding obstruents to it.

Sensitivity of syllable boundaries to the surrounding vowels. It has been pointed out in Basbøll 1972a that the distinction between the shwa-vowel and all other vowels (i.e. "full vowels") plays a major role for phonological syllabification in Danish; e.g. a single intervocalic consonant, as well as a /g/ preceded by a sonorant, belongs to the preceding syllable if the following vowel is shwa, but to the following syllable if its vowel is a "full vowel". It is of course not accidental that it is exactly the vowel shwa which occupies such a unique place with regard to syllabification: The distinction between shwa and full vowels is also essential to the description of stress (cf. Rischel 1970b), of the Danish "word types" (Poul Andersen 1955 and later works), and of the creation of
syllabic consonants and other assimilatory phenomena in un-
stressed syllables (see section 4.6 below).

The importance of the vowel shwa for syllabificational
phenomena is also suggested by the fact that the "consonant
gradation"-phenomena (section 2.2 above), i.e. the consonant
weakening in syllable-final position, are peculiar to Danish
as opposed to e.g. Swedish, in which there is a contrast
/a:/ /e/ in unstressed position, corresponding to the one Danish
vowel shwa' (cf. Danish gade, Swedish gata [gæːøe, gãːta]
'street').

Finally, it is interesting to notice that the unstressed
vowel shwa in French plays a role for phonological syllabifica-
tion very much as in Danish. For example, an intervocalic
consonant as well as an obstruent-liquid cluster belongs to
the following syllable if its vowel is a "full vowel" (this
term denoting all other vowels than shwa, as well as the under-
lying shwas which receive the word stress, e.g. appel [apɛl]
/#apɛl#/}, cf. appeler [apɛl] /#apɛl+e+r#/), but to the
preceding syllable if its vowel is a full vowel and the follow-
ing vowel is an unstressed shwa. If both surrounding vowels
are unstressed shwas, then the preceding syllable is open
unless there is a morpheme boundary between the post-vocalic
consonant and the following shwa (cf. genevois, appellerons
[ʒœnvwa, apɛlɔ̃] /#ʒœnv+uaz#, #apɛl+e+r+oN# z#/) as men-
tioned above in the present section. Also in French there is,
of course, ample evidence for the special phonological role
played by the unstressed shwa, both with regard to the word
stress-rule (a word-final shwa in a polysyllable being the
only final vowel which does not bear the word stress) and to
the vowel deletion rules (where unstressed shwas regularly drop
in most contexts, as opposed to all other vowels with a couple
of quite isolated exceptions like the /a/ of /la/).
Sensitivity of syllable boundaries to the sequences of consonants. It is a well-known fact that different types of consonant clusters can have different effects on syllabification. E.g., in many languages, like Latin, Italian, and French, and to some degree also in Germanic languages, a sequence obstruent-liquid "counts as" one single consonant with regard to the principles of syllabification (it should be added, however, that in the Romance languages mentioned above it is a condition that the obstruent be non-sibilant). Also the clusters of /s/ plus a stop can in certain cases in Germanic languages, but generally not in Romance, act as single consonants with respect to syllabification (see Davidsen-Nielsen 1974 for a phonetic analysis of some English material in this respect). Since this type of conditioning on syllabification has been discussed extensively by others, e.g. Hooper 1972, I shall limit myself to the above remarks on this matter.

3.4.1 Some principles of phonological syllabification in Danish

As an illustrative appendix to the more general discussion in the preceding section, I shall here briefly survey some principles which seem, by and large, to account for the phonological syllabification in Danish (I have discussed these principles in greater detail in the notes mentioned in footnote 1 on page 42).

It is probably superfluous to emphasize that the principles to be presented below constitute only one out of several possible ways to account for the phonological syllabification in Danish, and that the formulations are highly sketchy. As pointed out above, it is very difficult to determine the interaction between two of the principles to be mentioned below, namely (ii) (on the relation between clusters in the syllable and in the word), and
(iii) (on the sensitivity of syllable boundaries to the surrounding segments), and it is not even certain that principle (ii) will be indispensable in the final analysis. The following section should thus be taken as exemplifying the preceding discussion rather than explaining the location of every phonological syllable boundary in Danish.

The practical difficulties in effectively testing such principles (as well as phonological rules in general) for observational adequacy should be evident. I would therefore like to mention that Kjeld Kristensen and the author of these lines are at present engaged in computer testing of a part of a Danish phonology which includes a phonological syllabification of Danish words, as well as a number of phonological rules (both categorial and variable). This work in progress is planned to be reported in the forthcoming volume of ARIPUC.

I shall now discuss one model for determining the place of the phonological syllable boundaries in Danish, containing the following three types of factors (it should be borne in mind that (ii) below may turn out to be dispensable in the final analysis, presupposing a certain elaboration of (iii)): (i) grammatical boundaries, (ii) the relation between initial and final consonant combinations in the syllable and in the word, and (iii) the sequences of segments in question (both concerning vowels and consonants). The principles apply in a hierarchical fashion so that (ii) only applies if (i) has not decided the location of the syllable boundary, and (iii) only if (ii) has not (i.e., the principles (i)-(ii)-(iii) are disjunctively ordered). It is presupposed that the chain of segments to be syllabified is fully specified as to the feature [syllabic], i.e. it is known which segments form a syllabic peak and which do not ("vowels" and "consonants", respectively, in a somewhat loose terminology, see below), cf. sections 4.1 and 4.5 below.

1) A preliminary account is given in the present volume of ARIPUC.
The function of the principles can be illustrated by means of the following (somewhat metaphorical) description: The first time a phonological string is input to a rule which either has the syllable as its domain or which mentions a syllable boundary in its structural description, it is syllabified. Every boundary of a certain "rank" occurring between two [+syllabic]-segments is concurrent with a syllable boundary (see below). In the cases where there is no such boundary between two [+syllabic]-segments (possibly with intervening [-syllabic]-segments), all the places a syllable boundary can occur without giving rise to a syllable-final cluster which is impossible word-finally, or a syllable-initial cluster which is impossible word-initially, are marked off (ii). If there is only one such place, then the syllable boundary occurs there (there will always be at least one). If there are several such places, then the syllable boundary is placed at one of these, according to the principles (iii) which are sensitive to sequences of segments.

(i) The syllable boundary coincides with certain grammatical boundaries. This seems true of the boundaries between words, the intra-word boundaries before stems, and the boundaries before stressed native suffixes like -inde and -agtig. It thus seems possible to define the occurrence of these grammatical boundaries only in terms of what follows; viz. if what follows is a word, a stem (i.e., roughly, a major lexical category: N, V or A), or a stressed native suffix, or if nothing follows, then the grammatical boundary is obligatorily a syllable boundary too. Notice that both words, stems, and native stressed suffixes contain at least one [+syllabic]-segment, i.e. the principle suggested above can give rise to at most one syllable boundary between two [+syllabic]-segments (which is, of course, necessary in order for the definition "to work").
I leave the question open whether the syllable boundaries in these cases could or should be defined by means of junctures, or whether they have to refer directly to notions like "stem", "suffix", etc.

Concerning the grammatical boundary before stems, it will place the correct syllable boundaries between prefixes or "small words" (prepositions etc.) and stems, e.g. medgørlig [mɛdɡørlι], as well as between stems, i.e. between the two parts of a compound, e.g. mados [mæð(?)ø:s] (in this connection it may be interesting to notice that in French as well, the grammatical boundaries before stems are always syllable boundaries too, which is not the case for all grammatical boundaries after stems, cf. Basbøll, forthcoming).

Concerning the syllable boundary before native stressed suffixes like -inde, -agtig, -dom, -hed, it should be emphasized that "stressed" covers main stress as well as the reduced main stress typically found in second parts of compounds (e.g. violinistinde, barnagtig, sølvagtig, guddom, guddommelig, godhed [violinisdënø, bɑ:nɑɡdi, sølɑɡdi, gʊdɒm?øli, gʊdɒhɛð?]). (To account for the distribution of main vs. reduced stresses is in many cases difficult, and non-pertinent for our purpose.)

The qualification "native" of the stressed suffixes in question is necessary in view of the many foreign (Greek-Latin type) stressed suffixes like -at, -ist, -i, -isse which are preceded by syllable-initial consonant allophones (e.g. doktorat, kontorist, perfidi, abbedisse [dɔktɔsɔːd, kɔntɔsɔːsd, pɛrfiːdɪ:, abedɪsə], cf. doktor, kontor, perfid, abbed [dɔtɔ, kɔntɔ, pɛrfiːd, ɛbɛ]). Another fact which points to the foreignness of these suffixes, as opposed to -agtig, -dom, etc., is that they have never reduced main stress which is in general characteristic of typically native formations.
The special role of the boundary before stressed native suffixes agrees well with the vague hypothesis advanced in Basbøll 1972a (p. 194) that the intuitively transparent morpheme boundaries are also syllable boundaries. This amounts to postulating that native derivative formations like professorinde are more easily analysable for the native speaker than learned forms like professorat.

Finally it should be said that morphemically complex words can be lexicalized in the sense that their internal (phonologically relevant) grammatical boundaries are erased, with the consequence that they are treated phonologically as if they were monomorphemic. E.g. when the word rødpætte \([\text{\$\text{\$\text{\$\text{\$}}}]}\) is pronounced without \([\delta]\), it is in accordance with the general constriction on monomorphemic words that \([\delta]\) does not occur before \([s]\) (which it does in compounds etc.). This agrees well with the semantics of the word in question, which means 'plaice', whereas its second "constituent" in isolation can only mean 'woodpecker' (cf. Basbøll 1973, p. 122ff). Similarly, several names of Danish islands ending in \(-\text{\$}\) ('island') are pronounced as if they were not compounded: Erø, Thurø \([\text{\$\text{\$\text{\$\text{\$illary}}]}\) (cf. Færøerne \([\text{\$\text{\$\text{\$\text{\$illary}}]}\)), while others have alternating pronunciations corresponding to forms with and without the grammatical boundary (e.g. Rømø, Femø \([\text{\$\text{\$\text{\$\text{\$illary}}]}\) and \([\text{\$\text{\$\text{\$\text{\$illary}}]}\)).

(ii) The location of syllable boundaries as decided by the possibility of word-final and word-initial clusters. As already mentioned, phonological syllable boundaries in Danish, as well as in many other languages (not in all, e.g. not in Classical Greek), can always be - and, in fact, also are - placed in such a way that the syllable-final cluster does not violate any general restrictions holding for word-final clusters, and so that the syllable-initial cluster does not violate any general restrictions holding for word-initial clusters.
(I deliberately avoid the formulation that "syllable-final clusters should also occur word-finally" or the like, in order to stress the fact that the issue concerns structurally possible clusters, see above).

Examples which clearly demonstrate the necessity of having recourse to such a principle for the location of phonological syllable boundaries in Danish are not easy to find. One could mention words like angre(r), buldre(r) [æŋrə, bulə], where the manifestation of /r/ is the one elsewhere found in syllable-initial position, but what these examples in fact show is only that the morpheme boundary and the syllable boundary need not coincide (in both words the morpheme boundary occurs after /r/). Whether the explanation for this syllabification is that neither /ŋr/ nor /lr/ are structurally possible word-final consonant clusters, or that the syllable boundary in an intervocalic sequence of two sonorant consonants always separates these consonants, is an open question.

The use of this criterion in the present model for phonological syllabification in Danish depends on a previous phonotactic description allowing one to distinguish between (structurally) excluded and accidentally non-occurring clusters in the beginning and end of the word (cf. Basbøll 1973). This criterion has been used here in order to permit as simple and general a formulation of principle (iii) below as possible.

(iii) The location of syllable boundaries as a function of the sequence of segments. When the location of a syllable boundary between two syllabic peaks with intervening [-syllabic]-segments must be determined by principle (iii), the primary distinction is whether the following syllabic peak is a "full vowel" or a "weak syllabic peak". The basic generalization is, then, that the syllable border is situated in the leftmost position indicated by principle (ii) if the following syllabic
peak is a full vowel, otherwise in the rightmost position with one reservation (see below). In other (and vaguer) words: the "stronger" of the two syllabic peaks attracts the conso-
nants (cf. the influence of stress briefly mentioned in the preceding section), but when the vowels are of equal "strength" (i.e. with respect to the distinction full vowel:weak syllabic peak), then the following syllabic peak is the decisive one (thus the syllable boundary goes "to the left" between two full vowels, but "to the right" between two weak syllabic peaks).

First, let us define the distinction between full vowels and weak syllabic peaks on the phonetic surface (but it should be remembered that it is used at an earlier point of the deri-
vation, cf. below). The latter comprise all occurrences of the vowel [ə] and of all syllabic consonants (i.e. [ʰ, l, m, n, γ], of which [m, n] only occur after labials and velars, respectively, where they are in free variation with [η], see Basbøll 1969, p. 44f). Certain occurrences of the unstressed vowels [i, e, ʌ] are weak syllabic peaks, too. This is always true for the vowels of the (unstressed native) derivational suffixes ing, ing (and the rare ik), e.g. dydig, madding, maddin ([dɔːi], mæðeŋ, [maðiŋ]). Also all unstressed ʌs which are derived from one of the sequences /ər, rər, rə/ or from /ə/ preceded by /r/ (e.g. kuer=kurer=kure, angre [kʌə, angrə], cf. Rischel 1969, p. 196ff) count as weak syllabic peaks. The vowel of the derivational suffix isk in some words counts as a weak syllabic peak (e.g. metodisk, pædagogisk [metsemi, pæda- goː?(y)isg]), in others as a full vowel (erotisk, parodisk [eːdsemi, pærədsemi, pærədsemi], cf. Rischel 1970b, p. 133f. All other syllabic peaks are full vowels (i.e. all stressed vowels, all unstressed vowels different from [i, e, ʌ, ə], and all instances of unstressed [i, e, ʌ] which do not satisfy the (mainly non-phonological) conditions stated above).

1) I here follow the traditional use of the term "consonant", but in section 4.2 below [ð] will be defined as a vocoid.
When viewed on the phonetic level, the distinction between full vowels and weak syllabic peaks may look cumbersome and unnatural. But it should be remembered that the phonological syllabification under discussion takes place at an intermediate level of the phonological component, and on that level the distinction turns out to be much more natural.

First of all, the phonological processes deriving unstressed [ɔ] from a number of different inputs all containing shwa (discussed by Rischel 1969, p. 196ff) have not yet applied, and all syllables with a weak syllabic peak and which phonetically contain [ɔ] thus have shwa as their vowel when the phonological syllabification applies. Furthermore, syllabic consonants are generally created by a process of shwa-assimilation (see section 4.6 below) which is a late one and thus applies after phonological syllabification (it will be considered in section 4.5 below whether underlying syllabic consonants should be postulated, but at any event there is a general relation of equivalence between pronunciations with [ə] and a non-syllabic

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1) My transcription differs from most of the earlier IPA-transcriptions of Standard Danish used in ARIPUC in that I identify the unstressed vowel derived from /e/ in certain /r/-contexts with the stressed vowel in kom! [kʰʌm], and not with (the quality of) the stressed vowel in hård [hɔːr]. From a purely phonetic (in the sense of 'non-phonemic') point of view the former identification is clearly superior to the latter for the majority of Standard Danish usages; but if each phonetic symbol is taken to represent a certain range of different pronunciations within the norm, then a new symbol (i.e. a symbol not identical with any stressed Danish vowel symbol) is probably needed for this unstressed vowel: the unstressed vowel in damers can be identical to that of Amos, but also less rounded; the unstressed vowel of Amors, on the other hand, can be identical to that of Amos (and thus also to that of one of the possible pronunciations of damers), but also more rounded and back/low. All these pronunciations can even occur in the speech of one individual (e.g. my own).
consonant (in more formal styles etc.), and pronunciations with syllabic consonants). Finally, an assimilation rule has been proposed with the effect of raising a /æ/ in /æng, øg, øk (øsk)/ to i (Basbøll 1972a, p. 201):

\[ \varepsilon \rightarrow [+\text{high}]/\text{---} \]

thus accounting for the fact that the vowels of the derivational suffixes ing (where i is regularly lowered before a nasal), ig, ik (and possibly, for purely descriptive reasons, certain occurrences of isk, namely those which seem to have a weak syllabic peak) count as weak syllabic peaks, the reason being that their vowel is an underlying shwa. With the possible exception of the derivational suffix isk, the set of syllables with weak syllabic peaks is thus identical to the set of syllables whose vowel is shwa at the point of the derivation where phonological syllabification applies.

There is one exception to the general principle that the syllable boundary goes to the left before a full vowel but to the right before a shwa, viz. when a consonant cluster which contains a stop other than /g/ preceded by either a (underlyingly) voiced continuant or a nasal occurs before shwa. In that case the syllable boundary goes before the stop (see section 2.2 above):

- kan$tre, an$dre  [(k^h\text{enty}^y/)/k^h\text{endy}^y, \text{en}(.)dy^y];
- lam$pe, jam$be  [(lom^h^o/)/lom^be, jom(.)be];
- vär$ten, ver$den  [(vær^t^s^en/)/vær^d^en, vær(.)den];
- mal$ke, alg$e  [(malk^h^e)/mal^e, al(.)ye];
- vär$ke, var$ge, arg$re  [(vær^k^h^e/)/vær^ge, vær(.)ye, ær(.)y^y].
There is overwhelming evidence that a single intervocalic consonant before a shwa belongs to the preceding syllable (Bassbøll 1972a), e.g. bade, koge [bæ:ðə, kɔ:ɣə]. Examples showing the location of the syllable boundary before full vowels are ek$stra, a$ttrap, O$ta [ɛgsdɔa, atsɔb, ɔ:tɔa] (that /s/ belongs to the preceding syllable in eksport [ɛgspʰɔ:d] is in accordance with principle (i) above since its stem is port, cf. import [empʰɔ:d]). As already mentioned, the location of the syllable boundary can be dependent on stress as shown by certain clusters of /s/ plus stop.

1) I thus no longer believe (as in Bassbøll 1972a, p. 199) that the syllable boundary in /CVndə, CVldə/ regularly goes to the right of the /d/, cf. bande (sb.) and see section 2.2 above. (The fact that /d/ is deleted (possibly via a lenition to ɔ) in vande, skylde, jorde, etc., is thus not a consequence of the location of the syllable boundary, but of an earlier rule which seems to obey the proposed universal condition (Kiparsky 1973, p. 65ff) that (non-automatic?) neutralization processes only apply to derived forms (i.e. not to the underlying form of one morpheme); the underlying logic is, not surprisingly, that if they applied to the non-derived forms, too, a word like bande (sb.) could then have no possible use for its underlying /d/ since it would be deleted in all contexts.) This change in the earlier syllabification principles has the desirable consequence of turning the class of "exceptions" (1972a, p. 201f) vandig, skyldig, etc., into regular consequences of the principles. The main argument for the location of the syllable boundaries proposed here is that they permit the most general statement possible on the manifestation of /p t k/ vs. /b d g/: the distinction is one of aspiration when they occur initially in a syllable with a full vowel, the distinction is most often neutralized, in favour of the unaspirated stops, when they occur initially in a syllable with a weak syllabic peak (whereas Conservative usages in that position can make a distinction in the length of the preceding consonant), and /d g/ are regularly manifested as voiced continuants when they occur syllable finally (for details, see my notes referred to above).
4. The structure of the syllable and the hierarchy of distinctive features

The theoretical framework used in the preceding sections was that of (non-orthodox) generative phonology. In this section we shall take a more general view of the phonological syllable. It is, of course, impossible here to survey all the different theories of the syllable which have been proposed in the literature (Kloster Jensen 1963 gives a good overview of the subject; cf. also Malmberg 1965). Our main concern will be to discuss the sonority structure of the syllable in terms of currently used phonological distinctive features and to define a syllabic hierarchy of these features (sections 4.2 - 4.4).

Before this central part of section 4 (on the structure of the syllable), a word will be said on how to define the phonological syllable (i.e. on the nature of the syllable) (section 4.1), and we will conclude by discussing the feature [syllabic] (section 4.5) and a rule which changes the coefficient for this feature (section 4.6).

1) It should be emphasized that I consider this generative framework a purely descriptive model (which, in my view, is a useful complementary tool to structuralist methods of analysis emphasizing the notions of contrast etc. (cf. also Rischel 1974)), and I thus do not share the commonly held belief among generativists that their phonologies are (ideally) models of the psychological language mechanism of the (ideal) speaker-hearer. See Linell 1974 and (particularly) Derwing 1973 for recent critical discussions of the psychological implications of generative phonology and syntax.
4.1 On the nature of the phonological syllable

Hooper (1972, p. 537) defines the syllable (S) in the following way:

\[ X \rightarrow S / \$ \quad \$ \]

Condition: X contains no \$. I.e., according to Hooper, a syllable is defined as the maximal string between two consecutive syllable boundaries ($). This seems to me a poor definition. It is well known that the number of syllables as well as the location of their peaks can very often be indicated - by the native speaker as well as by the linguist - even in cases where the precise location of their borders is indeterminate. Hooper's definition makes it impossible to speak about e.g. bisyllabic words without being able to indicate the precise location of the border between the syllables. This is to me suggestive of a weakness in her theory (recall that I do not agree with Hooper's claim that phonological syllable boundaries (as opposed to phonetic ones) are always, by necessity, uniquely defined, cf. section 3.4 above).

It is, of course, true that if the location of all syllable boundaries in a given phonological string is known, then the extension of each syllable of that string is, ipso facto, also known; but the peaks of each syllable are not determined by the boundaries. If the location of all syllabic peaks in a given phonological string are known, on the other hand, then the number of syllables is also known, but not the location of their boundaries. Thus the syllabic peaks give some information on the syllable that cannot be derived from the location of the syllable boundaries, and vice versa. This means that the syllable is crucially characterized by both of these concepts, and a satisfactory general definition of the syllable ought thus to include both types of information, cf. Kloster Jensen's conclusion (1963, p. 34): "Es ist dringend notwendig, dass man sich klar macht,
was für eine Hybride die Silbe ist. Sie hat einen phonetischen Kern und phonemisch und distributionell bestimmte Grenzen".

In the following we shall briefly survey a couple of definitions which in different ways make reference to the "phonetic kernel" of the syllable.

One such approach to defining the phonological syllable is that exemplified by Haugen 1956 (cf. also O'Connor and Trim 1953), who defines the syllable as "the smallest unit of recurrent phonemic sequences. We will then have to include not only the segmental phonemes, but also the prosodic ones like stress, tone, length, and juncture. Any or all of these occur in sequence with each other, and the syllable is that stretch of phonemes which makes it possible to state their relative distribution most economically" (p. 216). Haugen thus indirectly refers to both the peak and the boundaries of the syllable: the peak is characterized by means of "prosodic phonemes" like stress and tone, the boundaries by the segmental phonemes. This certainly makes sense as an operational definition within phonemic theory, but from our point of view the definition is not entirely satisfactory. For one thing, it is not quite clear that the meaning of the phrase "to state their relative distribution [i.e. of the phonemes] most economically" can be made explicit, and if so, there is no reason to believe that the syllable is in all languages the most satisfactory frame of reference for the phonotactic description (for some evidence bearing on this question, see Pike 1947, e.g. p. 144ff, 174ff; Basbøll 1974 argues that the word is the preferable frame of reference for the distributional description of Italian consonants). It is also problematic in Haugen's definition what "recurrent phonemic sequences" means in cases where there are great differences between the phonemic inventory and/or structure of e.g. "stressed and unstressed syllables" (cf. Fischer-Jørgensen 1952, p. 17).
I thus see Haugen's definition as a practical way of trying to solve the problem of the (phonemic) syllable within an American structuralist framework, but with results which are not quite satisfactory from other points of view.

The difficulty met with above, i.e. that two types of syllables (e.g. "strong" and "weak", of which only the "strong" ones occur as one-syllable utterances) may differ structurally, also shows up in Eli Fischer-Jørgensen's definition (1952, p. 16ff) as she herself notes. She defines the "syllabic base" as "the class of the smallest units, of which each (in connection with stress, tone, and intonation, if such units are distinctive in the language in question) is capable of constituting an utterance by itself" (my italics). The difficulty in question cannot, of course, be avoided by changing "each" to "some" in the definition, since segments (i.e. vowels and consonants) will then fulfil this definition in a language in which a vowel alone can form a "strong" syllable and thus also an utterance.

To Hjelmslev (1939), the essential feature of the syllable is its being a unit consisting both of a syllabic theme and a distinctive accent. This leads to the well known terminological absurdities that French does not have syllables, and that Finnish vocoids and contoids are not vowels and consonants, respectively, in the structural sense, cf. Fischer-Jørgensen ibid. (Hjelmslev therefore defines the notion pseudo-syllable, which is a unit consisting of a pseudo-vowel (capable of constituting an utterance by itself) and pseudo-consonants, to be applied in languages without distinctive accent, e.g. French; the pseudo-syllable is close to Fischer-Jørgensen's definition of the syllabic theme.) According to Hjelmslev, the vowels (in the structural sense) are presupposed by the consonants (this idea has recently been developed within the framework of dependency grammar, see Anderson and Jones 1974). The difficulty of working with Hjelmslev's definitions is that they are made without regard to the phonetic
substance, and what appears to be basically the same unit in different languages, viz. the syllable, will therefore be given a number of quite different structural interpretations within Hjelmslev's framework (cf. Fischer-Jørgensen: "The most suitable method will probably be to choose the structural unit presenting the closest affinity to the phonetic syllable", but this unit: "will hardly be structurally the same in different languages" (1952, p. 16; my italics)). This is in fact to deny the very existence of a universally defined phonological syllable.

But does such a universally defined phonological syllable in fact exist? What I mean by "phonological" in this context is simply that it is more abstract than "phonetic". But it is a consequence of the claims made in section 3.4 above that we should expect a universal definition of the phonological syllable to apply at a level of representation not very distant from the phonetic surface. And the characterization of the phonological syllable to be given in the following sections in fact applies at such a level (see section 4.2 below). However, it should be emphasized that within generative phonology the distinction between phonological (as used here) and phonetic (e.g. syllable) is a matter of degree, not of principle.

It is a common feature of most definitions of the phonological syllable that they only make reference to one aspect of the problem of the syllable, either to its boundaries, or to its peak, or to the fact that it is the bearer of prosodic entities, or to its capability of occurring as an utterance. These definitions all have a certain value within given methodological frameworks, but they are far from giving an adequate picture of the nature of the syllable. A more insightful characterization of the syllable can be given, I think, if we go back to Jespersen's (1897-99) theory of the syllable as a top of sonority. The idea that each syllable consists of exactly one relative sonority maximum (the peak), that the least sonorous segments occur
farthest off the peak, etc., is a way of condensing information concerning several aspects of the nature of the syllable: the syllabic peak is defined by the syllabic sonority structure, the syllable boundaries can be defined as the relative sonority minima in the cases where they are not determined by grammatical boundaries (see section 3.4 above), the voiced part of the syllable (which is also defined by the syllabic structure) is phonetically the bearer of tone, the non-consonantal part of the syllable is "the nucleus", etc. In the following sections we shall try to develop Jespersen's general theory of the syllable within the framework of modern phonological theory, i.e. to make the content of the sonority hierarchy precise, defined with currently used phonological distinctive features. We shall also state some limitations of this general theory (it goes without saying that not every part of Jespersen's syllabic theory can - or ought to - be redefined within a quite different conceptual framework from his of the late nineteenth century).

4.2 The distribution of distinctive features around the syllabic peak

In Basbøll 1973 (p. 106ff) I argued that it is an empirical problem at what level phonotactic restrictions in a given language are best described. I also claimed that the most general distributional statements of Danish vowels and consonants can be given at an intermediate level of the phonological component, defined by the fact that the diphthongization of short vowels plus homosyllabic voiced continuants has been applied, but neither the rule which devoices continuants after aspirates, nor the rule which deletes [ʔ] after low back vowels. Furthermore, the variable rule which shortens long vowels before homosyllabic voiced (non-lateral) continuants ought not to be applied.
At this intermediate level the inventory of non-syllabic segments (i.e. the inventory of segments which can occur outside the syllabic peak; under a vowel symbol indicates that the vocoid in question does not form the syllabic peak, see below) is the following:

\[ptkbdsfhvyn\bar{omn}\bar{n}_{1}\bar{v}n_{i}].\]

Words like skærv, lav (adj.), ud, bor, var, hagl, elv, talg, plaske, sjæl at this level consist of the following sequences of segments: [sgærv, læ:v, u:v, bo:v, var, ha:yl, el:y, tal:y, plasge, sjæ:l].

At this level of description I postulate that syllables containing a full vowel (see section 3.4.1 above) have the following hierarchical structure (cf. Basbøll 1973, p. 130ff):

\[\text{Fig. 1}\]

The distinctive features are used in accordance with the principles of Ladefoged 1971. I shall briefly comment on each of the hierarchical features.
syllabic means "constitutes the peak of a syllable". When a Danish syllable contains several vocoids, it is clear from an auditory point of view that exactly one of these constitutes the syllabic peak. E.g. the first syllable of ivrig and juridisk both contain the sequence of segments [iu], but in the former word [i] constitutes the syllabic peak, whereas it is [u] in the latter. I follow the traditional transcription in writing a [\] under a vowel symbol which does not constitute the syllabic peak: ivrig, juridisk [i\u, \u\disg] (more examples of this sort are given in section 4.5 below). However, since the articulatory and acoustic correlates of the feature [syllabic] are largely unknown, there are evidently great difficulties in defining it (see Ladefoged 1971, p. 81f). Nevertheless, I do not think it is logically circular to include this feature in the syllabic hierarchy, since its placement at the top of that hierarchy reflects the observation that when the syllable contains one or more vocoids (i.e. non-consonantal segments, see below), then its peak falls in a vocoid. But it is undeniable that the feature [syllabic] has another status in the syllabic hierarchy than the other features since it is not defined by any inherent quality of the segment in question (thus each of the pairs [i] and [\i], [\i] and [l], etc., are in a sense the same segment type), but only in a given context within the syllable. On the special status of this feature within the present model, see section 4.5 below.

consonantal is, according to Ladefoged, a cover feature "in that it can be defined only in terms of the intersection of classes already defined by other features. Thus non-consonantal sounds are non-lateral and sonorant. They correspond largely to what Pike (1943) called vocoids, which he defined as central, resonant orals" (1971, p. 91). I here use [\-consonantal] as

1) In Basbøll 1973 I used a terminology which I now think should be abandoned: I then used [+syllabic] roughly for what is here called [\-consonantal], and for the syllabic peak I employed the label vowel (which then, in fact, had to be taken as a distinctive feature).
equivalent to [+sonorant, +continuant, -lateral] (it must be a lapse (which is, however, repeated on p. 108) in Ladefoged's formulation that he does not include "continuant" (in the sense of SPE) or "non-stop" (in his own terminology) in his characterization of non-consonantal sounds). According to this definition, the class of consonants is the union of the class of obstruents (i.e. [-sonorant]), the class of nasals (i.e. [+sonorant, -continuant]), and the class of laterals (i.e. [+lateral]). According to the syllabic hierarchy, all syllabic segments found at the present level are non-consonantal. Of the non-syllabic segments found at this level, only [i u y ø] are non-consonantal. 1

sonorants have "a comparatively large amount of acoustic energy within a clearly defined formant structure" (Ladefoged 1971, p. 58). It is a consequence of this definition that voiceless sounds are always obstruents. All non-consonantal segments are sonorants. Of the consonantal segments found at the present level, [p t k b d g s f h v y ø] are obstruents, [m n ø l] sonorants. 2

1) It is a consequence of the definition of [-consonantal] adopted here that [ø] must be classified as a vocoid (in disagreement with Basbøll 1973), since it is (at the level used throughout the present discussion) a sonorant and neither a nasal nor a lateral. This is in accordance with Heger's classification (forthcoming), which is purely phonetically based.

2) It is also a consequence of the definitions that [ø] must be classified as an obstruent (and not as a consonantal sonorant as in Basbøll 1973), just like [v] ([ø] is neither a vocoid nor a nasal nor a lateral). Also this is in agreement with Heger's phonetic classification (as well as with the phonetic classification of Eli Fischer-Jørgensen, personal communication), and since I have argued elsewhere that the Danish /r/ is an underlying obstruent, the so-called "consonantal r" must be [-sonorant] throughout the derivation.
voiced is used here as a binary feature defined by the vibration of the vocal cords during the articulation. All sonorants are voiced. Of the obstruents found at the present level, \([p \ k \ b \ d \ g \ s \ f \ h]\) are voiceless, \([v \ y \ s]\) voiced.

Those are the features which define the syllabic hierarchy of Danish. There are, of course, other distinctive features too (see section 4.4 below).

Fig. 1 should be read as follows: the syllabic peak together with possible adjacent glides (i.e. \([-\text{syllabic}, -\text{consonantal}]\)) constitute the non-consonantal part of the syllable, often called the "nucleus". The non-consonantal part together with possible sonorant consonants constitute the sonorant part of the syllable. The sonorant part together with possible adjacent voiced obstruents constitute the voiced part of the syllable. The voiced part together with possible adjacent voiceless segments constitute the syllable (or syllabic theme, in Hjelmslev's terminology).

Thus the following "implication chains" hold true without exception:

\[
[+\text{syllabic}] \supseteq [-\text{consonantal}] \supseteq [+\text{sonorant}] \supseteq [+\text{voiced}]
\]

and:

\[
[-\text{voiced}] \supseteq [-\text{sonorant}] \supseteq [+\text{consonantal}] \supseteq [-\text{syllabic}].
\]

(The two implication chains are notational variants in a system where all the features are binary.)

These implication chains predict the systematic non-occurrence of certain combinations of distinctive features, viz.

\([+\text{syllabic}, +\text{consonantal}], [-\text{consonantal}, -\text{sonorant}], [+\text{sonorant}, -\text{voiced}], [+\text{syllabic}, -\text{sonorant}], [+\text{syllabic}, -\text{voiced}], [-\text{consonantal}, -\text{voiced}]\). That only vocoids can be syllabic is a trivial consequence of the fact that the present model only concerns syllables with a full vowel as peak (in syllables with a weak syllabic peak, also consonantal sonorants can be syllabic, at least at the phonetic level, see below). That only consonantal
sounds can be obstruents is a consequence of our definition of [-consonantal] as equivalent to [+sonorant, +continuant, -lateral]. That only obstruents can be voiceless is an empirical consequence of the definition of [sonorant] (by "empirical (consequence)" I mean that it does not follow from the formulation of the definition itself). That the last three combinations mentioned are excluded follows from the systematic non-occurrence of the first three, mentioned in the beginning of the paragraph.

However, the important point in this connection is not only to what degree the implication chains are based on observable facts on (Danish) syllable structure (see the following section), on the nature of the human speech and hearing apparatus, or on the formal definition of the distinctive features used. But it is in itself significant that exactly these features can be arranged into a syllabic hierarchy. It should be emphasized that all the features used here are well motivated in phonological theory, and that their definitions have not been given with the syllabic hierarchy in mind (as a matter of fact, such considerations are not included in Ladefoged's treatment of the distinctive features at all). Furthermore, all the hierarchical features except [syllabic] have well-defined articulatory and/or acoustic correlates. As mentioned above, the acoustic and articulatory correlates of the auditive feature [syllabic] are largely unknown, cf. sections 4.5 and 4.6 below.

One possible interpretation of the model is that the hierarchical features do not "belong to" one segment at a time, but that they characterize the "central part" of the syllable as a whole (where this part has a different extension for different features).

It can be shown that each of the hierarchical features has its function in the syllabic hierarchy, i.e. the removal of any
of these features will cause a decrease in the explanatory value of the model (see the following section). But it is clear that in many concrete cases, the extent of several hierarchical features will be identical: e.g. in a monosyllable like *tak*, the syllabic part, the non-consonantal part, the sonorant part, and the voiced part of the syllable all equal the vowel \( \ddot{a} \).

The feature hierarchy for syllables with a weak syllabic peak is a strict subset of the feature hierarchy for syllables with a full vowel as peak, viz. that given in fig. 2.

The "implication chains" which can be read from fig. 2 are the following:

\[
[+\text{syl}] \supseteq [+\text{voiced}]
\]

and

\[
[-\text{voiced}] \supseteq [-\text{syl}]
\]

(i.e., \([-\text{voi}]-\text{segments are never } [+\text{syl}]; \text{ this has the status of an empirical finding}).

Within this weak syllabic hierarchy there is thus no motivation for a distinction between the non-consonantal and the sonorant part of the syllable, nor for a distinction between the sonorant and the voiced part of the syllable (see below).
4.3 Ordering relations in Danish as explained by the proposed feature hierarchy

Fig. 3, which in all relevant respects is a notational variant of fig. 1, expresses the order relations holding between segments within the same syllable more directly (in fig. 3 I only write the features which cannot be deduced from the implication chains).

Fig. 3 correctly predicts the order of any permitted (unordered) set of either initial or final segments, together with the following additional restrictions: In the initial part of the syllable, s precedes plosives and v precedes w; in the final part of the syllable, oral sonorants precede nasals (see the following section), and sequences of non-sibilant obstruents end in a dental. Furthermore, all the "boxes" of fig. 3 can be descriptively motivated as "order classes" (cf. Sigurd 1965, Vestergaard 1968) for the phonotactic description of Danish (see Basbøll 1973). This highly general model of the syllabic hierarchy, defined in terms of phonologically well motivated distinctive features, thus explains a very large part of the phonotactic structure in Danish.

Fig. 4 is the similar "linearization" of fig. 2, i.e. it should predict the combinatory possibilities and order in syllables with a weak syllabic peak. (Included in fig. 4 are only segments which can occur in such weak syllables, cf. Basbøll 1973, p. 134ff. The syllable boundaries are supposed to be in accordance with the principles of section 3.4.1 above. p t k are only found initially in weak syllables in certain pronunciations, cf. section 3.4.1 above.)

Examples showing the structure of weak syllables in this respect are andre, ellers, himlens [ɛndɪə], el?as, hemlens], which are, at the level used throughout this discussion, $ɛn$ɪə$, $ɛl?as$, $hemlens$. 
Fig. 3

Fig. 4
A reasonable question to ask at this point is the following: Since phonotactics plays a crucial role as evidence for the syllabic hierarchy according to our model, and since the phonotactics of different languages can be highly diverse, can this model in any sense be a candidate for a phonological universal?

First of all, the fact that some of the "boxes" (i.e. of the features in the hierarchy) have no descriptive justification in a given language, does in itself not prove that the model is not universal. As long as a language (with a less rich range of possible consonant combinations than e.g. Danish) does not offer counter-examples to the orderings predicted by the general model, then it is in accordance with the model in the sense that a strict subset of the hierarchical features in the same order will be a relevant model for its syllabic structure (just as the model in fig. 2 is no counter-example of the validity of the model in fig. 1 for Danish).

But cases like initial [ŋk-, mb-] in many African languages and [mgl-, lg-] in Russian are more serious to the hypothesis. However, [ŋk-, mb-] can be considered counter-examples only if [ŋ, m] in these clusters are voiced and the "clusters" in fact function as such, i.e. only if [ŋk-, mb-] do not function as unit phonemes (as "prenasalized stops" or the like). And in the cases where /ŋk-/ etc. are true combinations and thus apparent counter-examples to the hypothesis, it is a question whether the nasal does not constitute a syllabic peak (or a "mora") of its own (as could be shown in a tone language if /ŋkə/ may have different tones on /ŋ/ and /ə/). In all probability, however, there will turn out to be some real counter-examples to the hierarchy (cf. the description of the Mazateco syllable by Pike and Pike 1947). In that case, the syllabic hierarchy might be considered the maximally "natural" or "unmarked" arrangement of distinctive features in the syllable.
(a universal tendency, if you like), but not a universal law without exceptions.

As for the Russian examples, the violation of the model in fig. 1 is clear. But notice that fig. 1 will apply to Russian if the feature \([\text{sonorant}]\) is removed from the model. And notice, furthermore, that it is not possible to reverse any of the hierarchical features if the model is still to be consistent with the data. I.e., it is not true in Russian that sonorant consonants cannot be nearer to the syllabic peak than voiced obstruents (e.g. \([\text{gl-}, \text{br-}]\)). This may lead to the following hypothesis concerning the universality of fig. 1: The hierarchical features are \([+\text{syllabic}, -\text{consonantal}, +\text{sonorant}, +\text{voiced}]\). Each language takes all of these features or any subset of them in the order given to form its syllabic hierarchy. Viewed from this angle the hypothesis predicts that the syllabic hierarchy for a given language will always be a strict (ordered) subset (in the sense in which fig. 2 is a strict subset of fig. 1) of the universal hierarchy. I.e., if a certain universally hierarchical feature plays a role for the syllabic hierarchy of a given language, then its place in that language-specific hierarchy is predictable from the universal hierarchy.

It is clear that the explanatory force of the model for a given language increases when the proportion of mirror-image ordering relations which are accounted for by the model (see the following section) increases. If this proportion is small, then the model is unsuccessful with respect to the language in question. And since a hierarchy must contain at least two units, it will be nonsense to speak about \([\text{syllabic}]\) as the only feature involved in the syllabic hierarchy in a given language (phonologically speaking, this would only amount to saying that the syllabic peak occurs within the syllable). In languages with no hierarchical features the predictive value of the model is, of course, nil. And languages which use two or more of the hierarchical
features in their syllabic hierarchy, but in the reverse order of that predicted here, will be counter-examples to the hypothesis suggested above.

The feature hierarchy proposed here agrees well with the psycho-linguistic test results reported by Pertz and Bever (1973). These authors tested a number of the markedness relations among different consonant clusters postulated, mainly on the basis of typological evidence, by Greenberg 1965 and Cairns 1969 (of the type 'initial cluster AB is more marked than initial cluster CD'). A number of monolingual English-speaking persons, both adolescents and children, were asked which cluster was likely to be found in the largest number of languages, and their responses agreed (with one exception, see below) with the postulated markedness relations (so that the less marked cluster was supposed by the test subjects to occur in more languages). The exception was that the sequence liquid-nasal seemed to be less marked than liquid-voiced obstruent, in disagreement with Greenberg and Cairns (who did, in fact, not distinguish between voiced and voiceless liquids; this is, of course, an error, cf. Pertz and Bever 1973, p. 72).

The feature hierarchy proposed here in fact explains all the test results of Pertz and Bever, in connection with the following two very natural axioms: (i) a cluster which violates the hierarchy is more marked than one which does not, and (ii) if two clusters both violate the hierarchy, and if they both begin with a certain hierarchical feature, then the cluster which violates the hierarchy "with more steps" is the more marked one (e.g. liquid-nasal is less marked than liquid-voiced obstruent, and nasal-voiced obstruent less marked than nasal-voiceless obstruent).

Notice that this explanation of their results does not depend on the universality of the syllabic hierarchy proposed here: it only presupposes that the syllabic hierarchy is valid
for the language of the test subjects, i.e. English (which it
clearly is). As a matter of fact, I am anything but convinced
by Pertz and Bever's general line of reasoning that if English-
speaking test subjects can react differently to clusters which
do not occur in English, and which have the same "Distance from
English" in the sense of Greenberg and Jenkins 1964, then they
must have internalized a universal hierarchy of clusters. They
do not at all consider the possibility that the internalized
hierarchy may be relevant only to English and more or less
"English-like" languages.

4.4 Hierarchical, semi-hierarchical, and cross-classificatory
features

According to the hypothesis sketched here, the following
features in the order given constitute the "syllabic hierarchy":
[+syllabic, -consonantal, +sonorant, +voiced]. Of these
features, [syllabic] differs from the others in that its pho-
netic correlates are undefined. The content of this feature
label will be discussed in the following section.

Other distinctive features are not hierarchical, but
cross-classificatory (cf. the distinction between a hierarchical

1) Or [ αsyllabic, -αconsonantal, αsonorant, αvoiced] (cf.
the implication chains of section 4.2 above). The reason why
we need to write a coefficient together with the feature dimen-

sion is, of course, that [consonantal] always has the opposite
coefficient of the other hierarchical features. This is due to
the fact that we have chosen (like Ladefoged 1971, p. 108) not to
deviate unnecessarily from the usual feature labels. But it
would have been more satisfactory to call the feature [vocoid]
(in the sense of Pike 1943), not only because it is [+vocoid]
(but [-consonantal]) which is defined by a configuration (as
opposed to a disjunction) of distinctive features (cf. Ladefoged
ibid.), but also because it is [+vocoid] which plays a part in
the syllabic hierarchy like the positive values of the other
hierarchical features.
(McCawley) and a cross-classificatory (SPE) conception of grammatical boundaries, discussed in section 3.3 above). This is true of the feature or features accounting for different places of articulation (cf. section 3.2 above), the features accounting for differences of vowel quality, and for further features characterizing different "articulation modes" of consonants (like the features characterizing sibilance, stridency, aspiration, etc.; I shall not commit myself as to what the exact inventory of such features is).

It is an important characteristic of most cross-classificatory features that they are not involved in ordering relations, whereas they are sometimes essential for the statement of other distributional restrictions like "aspirates do not combine", "labials do not combine". However, some cross-classificatory features can, in fact, be involved in ordering relations, but then these ordering relations are not mirror-image-like. E.g. s and the plosives in Danish are not distinguished by any hierarchical feature. Nevertheless, the ordering relation obtains in the initial part of the syllable that s precedes a plosive, but it is well known that the inverse relation does not hold in the final part of the syllable (e.g. aks, ask, cf. Vestergaard 1968, p. 64f). Similarly, it is a general ordering restriction in the final part of the syllable that sequences of non-sibilant obstruents end in a dental (Basbøll 1973, p. 127). But the inverse relation does not hold in the initial part of the syllable, etc.

1) Jørgen Rischel suggests (personal communication) that the ordering relations which are here called "mirror-image-like" should be termed "distance relations" instead, since they refer to the (relative) distance (of non-syllabic segments) from the syllabic peak. According to this terminology, cross-classificatory features are not involved in distance relations (whereas they can be involved in other ordering relations). I entirely agree with this suggestion.
There is at least one phonological feature in Danish which is neither hierarchical nor cross-classificatory in the above-mentioned sense, viz. [continuant]. Within the sonorant part of the syllable this feature seems to be hierarchical (see fig. 5):

![Diagram](image)

Fig. 5

1) By different linguists the nasal consonants have been defined either as [+continuant], viz. if the definitions are acoustically/auditorily based (e.g. Jakobson, Fant and Halle 1952), or as [-continuant], viz. if the definitions are articulatorily based (e.g. SPE and Ladefoged 1971, who uses [α stop] as equivalent to [-α continuant] in SPE). I follow the latter definition which seems to me to fit well into the general framework of distinctive features: The nasals in a given language regularly follow the same pattern as the stops (as opposed to the fricatives) with regard to place of articulation. Furthermore, the natural class consisting of vocoids, laterals, and nasals is already defined by the feature [+sonorant] (it is, of course, due to the nature of the human speech apparatus that a sonorant with no passage of air through the mouth must be a nasal). The most important argument for the classification of nasal consonants as [-continuant] within the present framework is, however, the fact that it permits the class of vocoids (i.e. the [-consonantal] segments) to be defined as the segments which are [+sonorant, +continuant, -lateral]. And there seems to be no way of defining this natural class (which includes, of course, the nasalized vocoids) as equivalent to a configuration of already established distinctive features if the nasal consonants are [+continuant], i.e. [-consonantal] will not be a cover feature in the sense of Ladefoged 1971. This seems to me a serious drawback of this alternative definition of [continuant].
The following implication chains hold in Danish syllables with a full vowel as peak:

\[ [+\text{syllabic}] \supseteq [-\text{consonantal}] \supseteq [+\text{continuant}] \]

and:

\[ [-\text{continuant}] \supseteq [+\text{consonantal}] \supseteq [-\text{syllabic}] \]

But notice that it is not true that \([+\text{continuant}] \supseteq [+\text{sonorant}]\), or \([-\text{sonorant}] \supseteq [-\text{continuant}]\), since fricatives are \([+\text{continuant}, -\text{sonorant}]\). I.e., the feature \([\text{continuant}]\) cannot be included in the syllabic hierarchy. On the other hand, the feature \([\text{continuant}]\) can play a crucial role in mirror-image ordering relations (or distance relations), since nasals (i.e. \([+\text{sonorant}, -\text{continuant}]\)) generally occur in greater distance from the syllabic peak than laterals (which are \([+\text{consonantal}, +\text{sonorant}, +\text{continuant}]\) within the present framework). I therefore use the label "semi-hierarchical" for a feature like \([\text{continuant}]\).

I have not used the feature \([\text{nasal}]\) in the discussion for two reasons. First, this feature is not hierarchical within the sonorant part of the syllable in languages with a contrast between oral and nasalized vowels (like French), whereas it follows from our definitions that \([\text{continuant}]\) will always be "semi-hierarchical" (since \([-\text{consonantal}]\) always equals \([+\text{sonorant}, +\text{continuant}, -\text{lateral}]\), and since the relation between (sonorant) laterals and (sonorant) nasals seems universally to be that indicated here, cf. Jespersen 1897-99, p. 523ff). Second, in languages like Danish which do not have phonologically relevant nasalized vowels, \([+\text{nasal}]\) can, in the phonology, be used as a cover feature which is always equal to \([+\text{sonorant}, -\text{continuant}]\). It is thus completely redundant in the phonology of e.g. Danish (just as \([-\text{consonantal}]\) is completely redundant since \([-\text{consonantal}]\) always equals \([+\text{sonorant}, +\text{continuant}, -\text{lateral}]\); but it may very well, of course, be economical to include redundant features in the phonological description).
I have not included the feature [lateral] in the discussion for a similar reason. It follows from our definitions that the class of sonorant laterals (that is, all the laterals which exist in Danish at the level under discussion here, viz. $l$) can be defined as $[+consonantal, +sonorant, +continuant]$. This means that the class of (sonorant) laterals equals the class of consonantal sonorants minus the nasals. I.e., the place of the feature $[-lateral]$ in that part of the syllabic hierarchy which only comprises the continuant sonorants would necessarily be equal to the place of $[-consonantal]$ and thus completely redundant. All this is, of course, a consequence of the fact that we do not recognize the existence of any consonantal sonorants which are not laterals or nasals. (In languages with a contrast between sonorant and obstruent laterals, the feature [lateral] will be cross-classificatory.)

4.5 The feature [syllabic]

In section 4.2 above we said that the feature [syllabic] indicates that the segment in question constitutes the peak of its syllable. It was also emphasized that the articulatory and acoustic correlates of this (auditorily defined) feature are largely unknown.

In this section we shall briefly examine two questions: (i) is the feature [syllabic] redundant at the systematic phonetic level, i.e. can the occurrence of the syllabic peak in a syllable be predicted from the occurrence of other distinctive features in the chain of segments which constitutes the syllable? and (ii) which role does the feature [syllabic] play in a generative phonology of Danish, i.e. must it be specified in the phonological representations in the lexicon, can the coefficients of this feature change in phonological derivations, etc.?
The features involved in the syllabic hierarchy in Danish except \([+\text{syllabic}]\), i.e. \([-\text{consonantal}, +\text{sonorant}, +\text{voiced}]\), together with the semi-hierarchical feature \([+\text{continuant}]\) define the following syllabic hierarchy of segment types:

- **vocoids** (i.e. \([-\text{consonantal}] \equiv [+\text{sonorant}, +\text{continuant}, -\text{lateral}])
- **lateral**s (i.e. \([+\text{lateral}]\) or \([+\text{consonantal}, +\text{sonorant}, +\text{continuant}]\)
- **nasals** (i.e. \([+\text{sonorant}, -\text{continuant}]\))
- **voiced obstruents** (i.e. \([-\text{sonorant}, +\text{voiced}]\); they are in Danish always \([+\text{continuant}]\) too)
- **unvoiced segments** (i.e. \([-\text{voiced}]\)).

In the spirit of Jespersen (1897-99, p. 525, also 1926, p. 112)\(^1\), we shall (in fig. 6) give a graphical illustration of the "sonority relations" in a number of segment sequences on the systematic phonetic level:

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1) I differ from Jespersen in that I do not distinguish between voiceless stops and fricatives (his groups la and lb, 1897-99, p. 523f, and 1926, p. 191), and between sonorant \(r\)-sounds (i.e. the "syllable final /r/") and vocoids, nor between vocoids of different height (i.e. his groups 4-8). However, in order not to get a high number of counter-examples to his scheme, viz. all the initial clusters of \(s\) plus a stop, Jespersen in the graph considers la, lb as one group. Within his framework, this is nothing but a trick; within our model, however, this is due to the fact that no feature(s) distinguishing between \(s\) and the stops can be arranged into the syllabic hierarchy, quite apart from any ordering considerations (e.g. it is the very existence of the class of fricatives that makes it impossible to include \([\text{continuant}]\) into the syllabic hierarchy, see the preceding section).
vocoids

laterals

nasals

voiced obstruents

unvoiced segments

u !? v s g e !? n v e g l

Fig. 6

The relative maximum is the syllabic peak. [u!?v] is a normal monosyllabic word with [u] as its peak (notice that stød is not considered a segment in this connection). The imperatives skeln and vikl both exhibit word-final consonant clusters which do not occur outside imperative forms. However, skeln is always pronounced as a normal monosyllable, and it is clear from the graph that it does not violate any systematic order restriction based upon the syllabic hierarchy (i.e. distance relation-restrictions). vikl, on the other hand, will, according to our model, have two syllabic peaks if it is pronounced with a fully voiced
[1] (and this violates the general principle that imperatives of verbs whose infinitives end in shwa are shorter by one syllable than the infinitive form); however, if they are pronounced with an unvoiced [ɬ] instead (the dotted line in fig. 6), the number of syllables will be respected according to the model (cf. Basbøll 1970, p. 21ff). Whether the syllabic peaks predicted by the model are in fact also heard as syllabic peaks (e.g. whether vikl pronounced with a voiced [ɬ] is a perfect rhyme word to Mikkel pronounced without the vocoid [ə]) ought to be systematically tested.

It should be emphasized, however, that the location of the syllabic peaks is not always predictable from the sequence of segments (defined by their distinctive features, except the feature [syllabic]), neither at the phonetic surface nor at the level of description which has been used throughout the present discussion. For example, a narrow unrounded palatal vocoid followed by a narrow rounded velar vocoid can be realized as [iu] (e.g. in just [iust]) or as [iʊ] (e.g. in ivrig [iʊʁi]). Similarly, there is a possible contrast between [ɪp] or [ɪʌ] (e.g. in hjort, j [ɪpːd, ɪʌð]) and [ɪʁ] = [iʌ] (e.g. in ir [ɪʁ, iʌ]; the transcriptions with [ʊ, ʌ] are mere notational variants), cf. French examples like houille, oui [uʁi, ʊi] (in pays, paye [pɛi, pɛj] there is also a distinction in the number of syllables). Examples with consonants (which differ as to number of syllables) are skeln, ellen [sgɛl̩n, eɬ̩n = eɬ̩n = eɬ̩n] and vidn, bidden [við?n, bið?n = bið?n = bið?n] (the latter transcriptions, i.e. [eɬ̩n, bið?n], are probably the most phonetically correct ones in such contexts, at least in younger Danish standards, if one is forced to make a segmental distinction between the forms, see the following section; it may, however, be better to say that the sequence of segments are identical in

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1) Danish examples like naivist vs. nej vist! are also distinguished by their number of syllables (in addition to vowel quality distinctions): [naivɪs'd, naivɛs'd].
the mono- and bisyllabic forms, and that the distinction in syllabicity is (phonetically) prosodic\(^1\).

Although the location of the syllabic peaks in the majority of cases can be predicted from the sequence of segments (defined by their distinctive features except the feature [syllabic]) occurring at the phonetic surface or at the level of description which has been used throughout the present discussion, this is thus clearly not always feasible. The conclusion is, within a generative framework, that the feature [syllabic] must be present in underlying forms. The coefficient for this feature is only changed by the rule shwa-assimilation, to be discussed in the following section, and maybe by some very late reduction processes. But apart from these exceptions, the feature [syllabic] is unchanged throughout the derivation: e.g. when underlying postvocalic voiced obstruents are turned into vocoids (viz. /γ, v, r/ → [\(\alpha/\gamma, \upsilon, \eta\)]) those vocoids are non-syllabic, i.e. glides; and when adjacent vocoids are completely assimilated (see the following section), e.g. /diːə/ → [diːi], the number of syllables is generally kept constant.

In other words: the coefficients for the feature [syllabic] (which is redundant in the phonological representation, i.e. each underlying segment has its "natural" value for this feature, see below) are kept constant throughout the phonological rules (excluding, of course, morphological rules), apart from the rule of shwa-assimilation; this is true even when segments are changed

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1) This agrees well with Rischel (1970c) who has found that \(F_0\) seems to be an important cue for syllabicity in Danish. This fact may also help explain why voiceless segments generally do not qualify as syllabic peaks (see the following section). Rischel (1964) also gives an interesting account of syllabicity as a level of culminative contrast below the stress levels.
in such a way that their coefficient for [syllabic] is no
longer the natural one for the derived segment in the context
in question. This agrees well with the idea (cf. Rischel
1970c) expressed in the preceding footnote, viz. that the
feature [syllabic] is phonetically prosodic.

Hjelmslev (1951) proposed that words like fadder, vammel
[faδʔə, vamʔɛ] should be derived from monosyllables: /fadər,
vaml/, thus explaining the obligatory occurrence of stød (the
final consonant clusters have stød-basis, since they begin with
a voiced consonant). It is uncertain whether such monosyllabic
underlying forms for disyllabic phonetic forms should be postu­
lated in a generative phonology of Danish (cf. Basbøll 1972b,
p. 13, 23ff). If they are, the syllabic hierarchy predicts
that /r, l/ of /fadər, vaml/ will form a syllabic peak, pre­
supposing that the final /r/ has already, at this point of the
derivation, been changed to the corresponding (pharyngeal)
vocoid. The underlying non-syllabic /r, l/ can thus be re­
written as the corresponding syllabic segments. Another pos­
sibility is that a rule which is sensitive to the syllabic
hierarchy inserts a shwa to break up the non-permissible final
cluster. (Under the presupposition that the final /r/ is a
vocoid at that point of the derivation, the syllabic hierarchy
explains why final clusters like /lr, qr/ mentioned under prin­
ciple (ii) in section 3.4.1 above are systematically excluded,
viz. excluded by virtue of the distance relation-restrictions.)
Both possibilities permit the preservation of the redundancy
constraint on phonological information in the lexicon that all
consonantal segments are non-syllabic and vice versa, which, of
of course, also applies if fadder, vammel etc. end in /ər, əl/ in
their most underlying forms.
As already mentioned, the feature [syllabic] is redundant in phonological representations since its coefficient is always the opposite of the coefficient for [consonantal]; i.e., all segments in the fully specified phonological representations will be [ +syllabic, -consonantal]. (I do not claim that the feature [syllabic] is redundant in the phonological representations of all languages, only that it is redundant in Danish.) An economical way of doing this seems to be the following: All segments which in the incompletely specified distinctive feature matrix are [-consonantal] will get the redundant specifications [+syllabic, +sonorant, +continuant, -lateral] (and probably others as well, like [-sibilant]); all segments which in the incompletely specified distinctive feature matrix have at least one of the following specifications: [-sonorant], [-continuant], or [+lateral], will get the redundant specifications [-syllabic, +consonantal] (and probably others as well, like [-round]).

4.6 Shwa-assimilation

It is well known among students of Danish phonetics and phonology that shwa can be "assimilated" in different ways to neighbouring sounds.¹ There is no general agreement on how to transcribe the results of the shwa-assimilation, however, and this is probably due to the fact that the acoustic and articulatory correlates of syllabicity in Danish are largely unknown; in fact only one very preliminary investigation of this subject has been published, viz. Rischel 1970c. According to Rischel², 

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2) Rischel emphasizes (personal communication) the highly preliminary nature of his report, particularly concerning the perceptual aspect. It is also true that the number of persons investigated is small. The investigations are planned to be continued.
some speakers of standard Danish have a consistent difference in quantity and $F_0$ in assimilated words of the type hårde, hårder (\([hn:v, hn:vn]\) or the like), and a pilot experiment with a synthetic stimulus suggested that the word types can be identified correctly when the only difference in the stimuli is in $F_0$. All this points towards a prosodic function of syllabicity (somewhat resembling that between accent 1 and accent 2 in Swedish and Norwegian, so that Danish $C_0 VC_o a$ words correspond to accent 1, and $C_o VC_o aC_o a$ to accent 2). A transcription indicating the location of the assimilated shwas by a hyphen seems to be rather satisfactory from this point of view, in comparison with transcriptions indicating syllabicity as occurring in one segment only: skeln, vidn, ellen, bidden [sgel?n, við?n, el?-n, bið?-n].

Recently Brink and Lund (forthcoming) have given an alternative treatment of shwa-assimilation. They suggest roughly the following: It is an option for the speaker to retain the shwa or not. If shwa is not retained, it depends on the sonority of its neighbouring segments whether it is assimilated or deleted (sonority is understood basically as in Jespersen 1897-99). If the most sonorous neighbouring segment to shwa is a voiceless obstruent, then shwa drops without leaving any trace behind (e.g. passe [pase, pas] where the second pronunciation is also that of pas [pas]). If the most sonorous neighbouring segment to shwa is a sonorant, shwa assimilates to that sonorant (in such a way that shwa either assimilates completely to the sonorant in question with the reservation that the assimilated segment is always syllabic, e.g. koen, ballen \([k^h:o:?:on, balln]\), or in such a way that shwa is elided while making the sonorant in question syllabic, e.g. gode, pæne, tale \([go:?:, p^h:e:n, t^s:a:?:]\). Brink and Lund set up a number of principles which they claim predict which type of assimilation will be chosen in a certain context).
If there can really be given substance to the claim that shwa is assimilated to its most sonorous neighbouring segment, then data from the treatment of shwa in different contexts can give independent evidence for the sonority hierarchy, suggesting that sonority may be an independently needed auditory dimension (a multivalued linearly ordered distinctive feature), although it can be defined by distinctive features that are needed in the phonology for independent reasons. And I see no reason, after all, why a prosodic treatment of syllabicity, and a treatment in terms of a sonority hierarchy which has independent motivations, should in principle be incompatible.
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