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# Reconsidering moras

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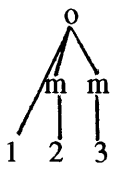
## 1. Introduction

When we assign a specific mora structure to a form, then we make at least the following claims about the segments of that form. Firstly, we claim that the segments linked to a mora determine the heaviness or lightness of their syllable, whereas the remaining segments are inert in this respect. Secondly, we claim that the segments linked to a mora are capable of carrying tone. To see this, consider the schematic example below.

(1)




Segments 2 and 3 add to the weight of the syllable, whereas segment 1 does not. Similarly, segments 2 and 3 are tone bearing units, but segment 1 is not.

In the second section of this paper I demonstrate that in the Limburgian variant of Dutch a conflict arises between these two properties of moraic segments; the moras we postulate to describe syllable structure turn out to be quite disturbing when we look at tone. I argue that an analysis based on the traditional nucleus and rhyme does not create a conflict between tone and weight; the nucleus is the tonal domain, and the rhyme is the domain where weight is defined.

Obviously, a theory that recognizes the existence of nucleus and/or rhyme cannot accept the mora as a viable entity. In a theory of that type the only acceptable unit on the

central line is the X-slot. Meanwhile, in various areas of phonology the mora has acquired a rather dominant position. In particular this is true in the domain of stress, where it plays a crucial role in the formulation of the moraic trochee and the iamb. Therefore, any proposal to replace the mora by the nucleus and the rhyme should also show that the insights behind the moraic trochee and the iamb can be expressed equally well in a theory that does not rely on the mora. An attempt in this direction is done in the third section.

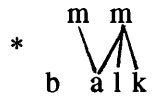
## 2. Quantity relations in Dutch and Limburgian

Let us first consider standard Dutch. It has been observed many times (cf. van der Hulst (1984) for references) that in Dutch a short vowel can be followed by maximally two tautosyllabic consonants, whereas a long vowel can only be followed by at most one tautosyllabic consonant[1]. Here is an example illustrating this phenomenon.

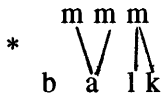
| | | |
|---|---|---|
| (2) a) | short vowel + 1 consonant | b) short vowel + 2 consonants |
| | bak 'tray' | balk 'beam' |
| c) | long vowel + 1 consonants | long vowel + 2 consonants |
| | baal 'bag' | * baalk |

In a mora based analysis this phenomenon can be accounted for in various ways. We can say that the maximal number of moras in a syllable is three and that a mora may contain maximally one segment. Alternatively, we might say that the maximal number of moras is just two, and that every mora can contain maximally two segments. Below both analyses are clarified:

(3) two mora approach




three mora approach




[1]Alveolar obstruents do not participate in this regularity. In this paper they are not taken into consideration.

Dutch has three vowels which are hybrid in the sense that they are phonetically short, but phonologically long. These are the vowels [i], [y], [u]. They must be phonologically long because they may not be followed by more than one consonant in the same syllable. Tautosyllabic sequences of the following type are ill formed:

(4) ill formed sequences in Dutch

[i]lp
[i]lk
[y]lp
[y]lk
[u]lp
[u]lk

This suggests that the hybrid vowels are bimoraic. Since the vowel occupies two moras there is only room for one additional segment in the same syllable.

The Limburgian variant of Dutch is identical to standard Dutch with respect to the quantity laws mentioned above. It is also the case that the three vowels [i], [y] and [u] cannot be followed by more than one segment in the same syllable. Therefore, also in Limburgian they have to be treated as bimoraic.

There are two differences between Limburgian and Dutch that are crucial for the present discussion. Firstly, there is a contrast between the hybrid vowels and the vowels [i:], [y:] and [u:] which are long phonologically as well as phonetically. Examples follow.

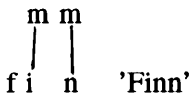
(5)

| hybrid vowels | | unambiguously long vowels | |
|---|---|---|---|
| fin | name | fi:n | 'subtle' |
| z'yl | name | s'y:l | 'to take shelter' |
| pun | 'money' (col.) | pru:m | 'plum' |

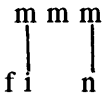
This contrast can only be accounted for by postulating an empty mora in the representation of the hybrid vowels. In this way we can express the difference between truly short vowels[2], hybrid vowels (which are phonetically short but phonologically long) and truly long vowels. I demonstrate this in (6).

[2]Phonetically truly short vowels are lower than long vowels of the same phonological height.

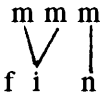
(6) a) truly short b) hybrid c) truly long



'Finn'



name



'subtle'

That fact that we need an empty mora is of crucial importance, for it makes clear that we have to accept three moras as the upper limit in Dutch. The alternative analysis which recognizes a maximal amount of two moras cannot possibly account for the contrast between the short vowels and the hybrid vowels, as is shown here.

(7) a) truly short b) hybrid c) truly long




The second crucial difference between Limburgian and Dutch is that in Limburgian, but not in Dutch, a tone contrast appears in stressed syllables with minimally two sonorants. Syllables of this type either have a falling tone or a so called 'dragging tone'. Before a pause the dragging tone is realized with a falling-rising pitch; in other environments with a level high pitch. Examples of the tone contrast follow (the segments that carry a high tone are underlined).

(8)

| falling tone (HL) | | dragging tone (HH --> HLH) | |
|---|---|---|---|
| k<u>a</u>n | 'jug' | k<u>a</u>n | 'to be able to' |
| w<u>I</u>l | 'will' | w<u>I</u>l | 'to want' |
| dr<u>e</u>j | 'to turn' | dr<u>e</u>j | 'bend' |
| b<u>i</u>: | 'bee' | b<u>i</u>: | 'near' |
| d<u>o</u>:k | 'cloth' | d<u>o</u>:k | 'dived' |

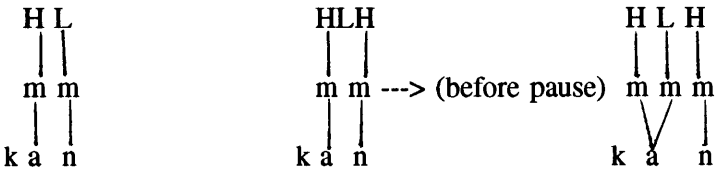
absence of tone contrast

| | |
|---|---|
| b<u>a</u>k | 'tray' |
| w<u>I</u>p | 'seesaw' |
| p<u>o</u>t | 'pot' |

The falling tone is represented as a sequence of two tone segments, H and L. The

dragging tone consists of a sequence of two high tones which are separated by a low tone as a consequence of the OCP. Before a pause the low tone is realized, because in that environment an extra mora is inserted, giving rise to extra length. An illustration of this analysis is given below.

(9) falling tone dragging tone




If we now relate tone with our mora based analysis of quantity, then we are led to predict that a syllable with a hybrid vowel which is followed by a sonorant consonant is capable of supporting a tone contrast. This is a consequence of the fact that a syllable of this type contains three moras, two of which contain sonorants. We have just seen that the presence of two tautosyllabic moraic sonorants is sufficient to realize the tone contrast (cf. (8)). Interestingly, however, this prediction is contradicted by the facts. The hybrid vowels ([i]], [y], [u]) never allow a contrast, not even when they are followed by a sonorant consonant in the same syllable. The examples below are realized with a falling tone. The dragging tone is impossible in words of this type.

(10)

| | |
|---|---|
| f[i̲]n | name |
| mes'[i̲]n | 'maybe' |
| z'[y̲]l | name |
| krep[y̲]l | 'scum' |
| p[u̲]n | 'money' |
| r[u̲]l | name |

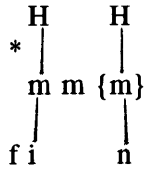
Mapping the two-way tonal contrast onto the three-way length contrast, what we find is not a six-way contrast, but, surprisingly enough, a five-way one. This is illustrated by the following 'minimal quintuplet'.

(11)

| | falling tone | | dragging tone | |
|---|---|---|---|---|
| | | **short vowel** | | |
| | mIn | 'minus' | mIn | 'vile' |
| | | **hybrid vowel** | | |
| | min | name | **GAP !!!** | |
| | | **long vowel** | | |
| | mi:n | 'coal mine' | mi:n | 'my' |

One might think of explaining the gap by marking the final mora extraprosodic. Then, only one moraic sonorant is left. The dragging tone can therefore not be realized, as is shown in (12).

(12)




Phonetically, the third mora is then realized with a low tone, which creates the impression of a falling tone.

This analysis, however, predicts that if the relevant sequence is in non-final position, then the dragging tone cannot appear there. Generally, the quality of tone in non-final syllables is determined by the vowel of the next syllable. One of the rules that regulate the quality of tone inserts a dragging tone in a (stressed) syllable that is followed by a high vowel. This rule is absolutely exceptionless; it always applies, even in the domain of foreign and 'scholarly' words, as the following examples demonstrate.

(13)

| | |
|---|---|
| ra:dio | 'radio' |
| o:lifant | 'elephant' |
| ba:li | 'railing' |
| vero:nica | name |
| reto:rica | 'retorics' |
| impe:rium | 'empire' |
| he:lium | 'helium' |

Given the extreme productivity of this rule we expect that a dragging tone shows up in words where the hybrid vowel is followed by a tautosyllabic sonorant which is followed by a syllable with a high vowel. This is caused by the fact that extraprosodicity is removed, so that the third mora becomes a tone bearing unit. However, the following examples show that the dragging tone does not appear:

| | | |
|---|---|---|
| (14) | l[u]mpia | 'egg-roll' |
| | bur[u]ndi | name of a country |
| | gr[y]ndig | trade name |
| | b[u]rn[u]s | 'burnous' |

Notice, though, that the place of articulation of the postvocalic consonant is determined by the following consonant. One might therefore suggest that a sonorant whose place node is doubly linked cannot carry a high tone. This, however, is not true. In fact, exactly the opposite is true; in Limburgian it is the low tone that cannot be linked to a consonant with a doubly linked place node. Examples illustrating this rule, which is also exceptionless, are given in (15).

| | | | |
|---|---|---|---|
| (15) | laŋk | 'long' | * laŋk |
| | rIŋk | 'ring' | * rIŋk |
| | pomp | 'pump' | * pomp |
| | lamp | 'lamp' | * lamp |

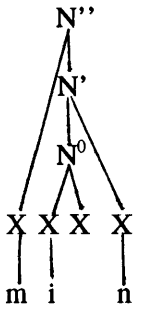
We see, then, that it is impossible to eliminate the third mora as a tone bearing unit. In other words, in a mora based analysis we are unable to explain why a hybrid vowel followed by a tautosyllabic sonorant cannot be realized with a dragging tone.

To solve the problem sketched here in a non-arbitrary way, we should be able to express the fact that, in some way, the third mora has a status which differs from the remaining two moras. This is where we hit the heart of moraic phonology. Precisely this is impossible. It is a fundamental claim of this theory that in a given syllable any mora has exactly the same status as any other mora. It is impossible, for instance, to say that one of the moras is the head and the others are, in some way, dependent of that head. Neither is it possible to maintain that the relation between the third and the second mora differs fundamentally from the relation between the second and the first mora. In moraic phonology it is impossible to express relations of this nature as a matter of principle.

Other theories of the syllable do operate on the assumption that structural relations exist between the elements of the central line. One particularly interesting example is the theory proposed in Levin (1985). According to Levin the syllable node dominates two other nodes: the nucleus and the rhyme. The labeling of these three constituents bears some similarity with consituent structure in syntax. The traditional syllable is seen as a

kind of maximal projection whose category is determined by its head (formerly the rhyme), whose category is in its turn determined by the nucleus (now the $X^0$-head). To illustrate this I present the structure of the example **min**, a form with a hybrid vowel (cf. (11)).

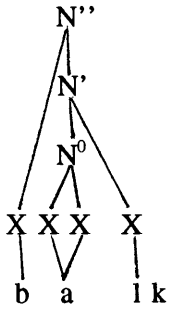
(16)




The hybrid vowel is now represented as a feature matrix which is linked to just one X-slot. The second position of the nucleus is occupied by an empty X-slot.

In a theory of this type it becomes possible to account for the fact that the final X-slot is relevant with respect to quantity, but irrelevant for tone. This slot is not located in the nucleus which makes it structurally different from the preceding two X-slots. We can make use of this difference in our account of the tonal facts. We say that a tone bearing unit must be located in the nucleus. Since the fourth X-slot is not in the domain of the nucleus it cannot carry a tone. From this it follows that a sonorant which follows a hybrid vowel cannot be a tone bearing unit. This explains why hybrid vowels can never receive a dragging tone, not even from absolutely productive rules. On the other hand, we can also refer to the similarity between the fourth X-slot and the preceding two slots. On the basis of this similarity we can explain the quantity law of Dutch and Limburgian. We state that every projection allows at most two heads and that a head is maximally binary branching. It thus becomes impossible to generate two consonants after a long vowel, as is shown with the following representation.

(17)



No room is left for the second postvocalic consonant. In order to syllabify it an extra head must be generated, which is ruled out, or one of the heads must be expanded, which is also ruled out. The two laws mentioned here do not need to be stipulated in the grammar of Dutch/Limburgian. I claim that they govern the structure of syllables in all languages.

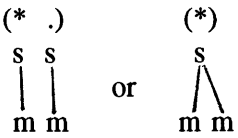
We may conclude that in a mora based analysis it is impossible to explain the tonal properties of the third mora of a syllable, because it is undistinguishable from the preceding (tautosyllabic) moras. In a hierarchical model of the syllable, on the other hand, it is perfectly possible to explain the properties of the fourth X-slot, because this is hierarchically distinguishable from any other X-slot.

If it is true that we should return to a hierarchical theory, then we must answer the question how we can reconcile this with the recent proposals in the theory of stress. In the next section I will present the outlines of a proposal.

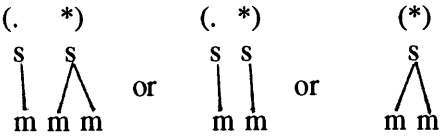
## 3. Stress without moras

In many recent publications it is claimed that the foot inventory provided by universal grammar contains the moraic trochee and the iamb. These constituents are defined in terms of moras and for this reason they seem particularly problematic for a theory that does not recognize the existence of these entities. In Hayes (1989) and McCarthy and Prince (1986) the moraic trochee and the iamb are defined in the following way[3]:

(18) the moraic trochee




the iamb



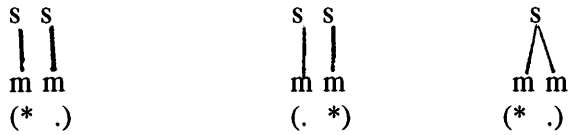

In the domain of the non-prominent syllables there may be maximally one mora. The most

[3]This proposal differs from the inventory of Hayes (1987) in that degenerate feet are not recognized. See especially Kager (1989) for arguments against degenerate feet.

salient feature of the moraic trochee is that quantity is evenly distributed in its domain. If, therefore, the two moras are not located in the same syllable, there may be just one mora in the prominent syllable. The iamb, on the other hand, is typically uneven. In its domain there is a strong tendency to increase the weight of the prominent syllable (cf. also Hayes (1985)). Prince (1991) also recognizes an uneven moraic trochee and an even iamb, but they are evaluated less favourably. Rules tend to map them into their more optimal cognates listed above. Prince shows that in English, for instance, Trisyllabic Shortening is to be interpreted as a rule of this type.

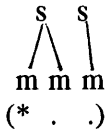
An interesting modification is proposed in Kager (to appear). Kager's first important assumption is that the moraic trochee and the iamb are build directly on the moras, not on syllables. Feet constructed over two moras that are exlusively located in the domain of one syllable must be left dominant. This follows from the fact that within a syllable prominence is (nearly) always on the left side. Kager proposes furthermore that at the level where phonological strings are parsed into stress constituents quantity is evenly distributed in the iamb as well as in the trochee. As a result of these assumptions the moraic trochee and the iamb can only have the following structure at the parsing level:

(19) moraic trochee iamb monosyllabic feet




We see that the position of dominance only contrasts in bisyllabic constituents. Under certain circumstances the feet listed in (19) undergo adjunction. The resulting structures are evaluated by rhythmic principles. According to one of these principles a prosodic domain which contains a lapse is less highly evaluated than a constituent without a lapse. Another principle states that clashes should be avoided. If necessary phonological rules apply to eliminate lapses or clashes. To see how this works, consider a monosyllabic constituent that has undergone adjunction on the right. The resulting representation looks as follows:

(20) moraic trochee



The foot generated by adjunction contains a lapse. This lapse must be removed, which can be done by shortening the vowel.

Kager's theory differs from all previous mora based stress theories in that the typical properties of the trochee and the iamb (even versus uneven duration) are not accounted for by summing them up in the form of a set of templates. Instead of that they are derived from the rhythmic aspects of a given representation. In our non-moraic theory of stress we will adopt these insights.

Our basic assumption is that, in many ways, phonological constituents are similar to syntactic constituents. In particular it is the case that phonological constituents have a head. A head determines the features of the constituent which immediately dominates it. In this view we can interpret the traditional nucleus as the head of the rhyme because it determines its categorial features. In the same way the rhyme can be seen as the head of the traditional syllable. The latter constituent can be interpreted as a maximal projection, because it does not have the capacity of determining the features of an immediately dominating constituent. Formally, we can distinguish heads from maximal projections by means of the feature [proj(ecting)]. Heads are specified as [+proj], maximal projections as [-proj]. A constituent specified as [+proj] requires that the immediately dominating constituent, if present, be categorially identical, as far as that is possible. If a constituent is negatively specified for this feature, then this requirement is not imposed on it.

Although phonological constituents are identical with syntactic constituents in that they have heads, there are also some differences. First of all, recursion is extremely limited, and presumably even ruled out; there are no maximal projections immediately dominating maximal projections of the same category and in each projection there can only be one head which immediately dominates another head. The latter is shown by the fact that, normally, a rhyme cannot contain more than three segments, as I have shown in the second section. Formally we can account for this by saying that in every projection [+proj] may only occur twice and [-proj] only once.

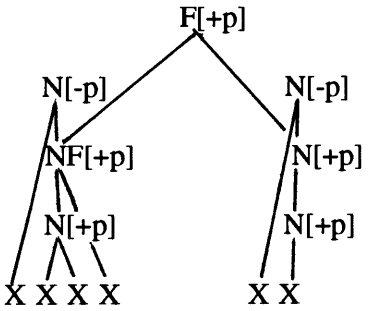
The second difference is that not all projections require the maximal extension. Syllables require it, but feet do not. A parameter that only constrains the shape of maximal projections is boundedness/unboundedness. Syllables are therefore always either unbounded or bounded. In the former case the onset may be infinitely long, although in practice this is restricted to two consonants for reasons having to do with sonority. In the latter case the onset may contain only one consonant. At the foot level the boundedness/unboundedness parameter can only be relevant if a maximal projection is present. Feet of this type can either be unbounded or bounded. In the former case the geometrical analogue of the unbounded syllable is generated, which means that an infinitely long string of syllables may be located to the left of the heads[4]. In the latter case we generate an amphibrach (cf. Halle and Vergnaud (1987) and Rice (1988). This

[4]This allows us to eliminate the iterativity parameter. Like Halle and Vergnaud (1987) we can then assume that all constituents are constructed iteratively. Unbounded feet can also do the work of the End Rule (cf. Prince (1983)).

is a foot which allows only one syllable to the left of its heads[5].

The third difference between phonological and syntactic constituents is the following. In syntax a given constituent can only have one categorial specification; something which is a verb, for instance, cannot also be a noun. In phonology, however, the equivalent of this is possible. A given constituent can carry the features N and F (the categorial specification of a foot) at the same time. I assume that this follows from the fact that the phonological categorial features are monovalued, whereas the syntactic features are binary. Assuming that only [-α] is able to contradict [+α] in the same matrix we get the following result: the specification N can cooccur with F in the same matrix, but the specification [+proj] cannot appear in the same matrix as [-proj]. As a consequence of this, the head of a foot cannot also be the maximal projection of the nucleus. The rhyme, however, can function as the head of a foot, because within its feature matrix there are no contradictions; N does not contradict F, and there is only one specification for [proj], vz. [+proj]. This is illustrated below.

(21)




We see that the rhyme of the first syllable splits into a syllable and a foot. The fact that the head of a foot cannot be a syllable at the same time has an important consequence; consonants in onset position are not dominated by a foot. This explains why they are not able to determine the geometrical structure of a foot.

One of the advantages of an X'-type of notation is that it becomes possible to make use of the notion government in phonology. We say that a head governs a node in the domain of the constituent of which it is the head, unless it dominates that node. In the structure above, the head of the foot governs the rhyme of the second syllable and the nodes dominated by that rhyme. In both syllables the nucleus governs the X-slot in the rhyme which is not located in the nucleus. It is also the case that in both syllables the consonants in onset position are governed by the rhyme. In fact, only two X-slots are ungoverned in the representation above; the two X-slots of the first syllable. Now recall that in Limburgian tone can only appear in the nucleus of a stressed syllable; sonorants in onset position, in non-nuclear rhyme position and sonorants in an unstressed syllable

[5]This parameter does the same work as weak local parsing (cf. Hayes (1991)).

cannot bear contrastive tone. We can treat this set as a natural class if we say that an X-slot in governed position cannot be a tone bearing unit[6]. The fact that this can be expressed only with the help of government is a strong argument in favour of this notion.

By invoking government it becomes possible to work out an alternative for the moraic trochee and the iamb without moras. Let us say that a projection may be subject to what we might call a 'Branchingness Requirement'. Its definition is given in (22).

(22) Branchingness Requirement

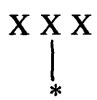
A projection of type P must contain a branching head in ungoverned position and may not contain a branching head in governed position.

If it is specified in the grammar of a given language that the N-projection belongs to type P, then the syllables of that language have a branching nucleus or a branching rhyme. A good example of a language where syllables are constrained in this way is Dutch. In this language every syllable that does not end in a consonant must have a long vowel.

If a foot is subject to the Branchingness Requirement, then either the ungoverned nucleus or the ungoverned rhyme or the foot itself branches. The nucleus and the rhyme in non-dominant position do not branch. The feet thus generated are essentially of the same type as the feet proposed in Prince (1991). In principle, both the moraic throchee and the iamb can be even or uneven. That the trochee and the iamb differ with respect to lengthening and shortening can be explained in the spirit of Kager (to appear). Just like Kager we assume that rhythmic principles apply within the domain of a foot. Also, following Kager we assume that the stress marker, the element that necessarily accompanies a foot, is linked to the first ungoverned X-slot, i.e. the first X-slot of the nucleus. The rhythmic principles governing the structure of a foot are stated in (23).

(23) rhythmically undesirable:

rhythmically desirable



[6]It many languages (Mandarin Chinese, for instance) tone does appear in unstressed syllables. But in these languages stress is assigned postlexically. In Limburgian, on the other hand, stress is cyclic (lexical). The constraint proposed here must therefore be a lexical constraint.

The elements in the domain of a foot are evaluated in terms of the principles in (23). The definition of lapse guarantees that the trochee exhibits a strong tendency towards shortening. The second principle takes care of the fact that in the domain of iambs the stressed syllable is preferably lengthened. Notice now that the consonants in onset position are not located in the domain of a foot, because they are not dominated by it. This explains why they are insignificant with respect to the rhythmic principles listed above.

We may conclude that it is possible to incorporate the basic insights of the moraic stress theory into a hierarchical (or non-autosegmental) model of phonological constituents. Firstly, the X'-notation explains why onsets are irrelevant for the geometrical structure of feet and for the rhythmic principles governing the distribution of quantity in the domain of feet. Secondly, the Branchingness Requirement immitates the basic structure of the moraic trochee and the iamb. Finally, the rhythmic principles explain why the syllables of a trochee tend to have even duration, whereas the syllables of an iamb tend to have uneven duration.

## 4. Summary

I have argued that the facts of tone and quantity in Limburgian Dutch cannot be explained in a non-arbitrary way in moraic phonology. This is a consequence of the fact that the second mora cannot be distinguished from the third. Hierarchical phonology, on the other hand, can explain the facts straightforwardly, because in this model the fourth X-slot is located in the rhyme but not in the nucleus, whereas the third X-slot is located in the rhyme and the nucleus. I have also argued that the recent developments in the theory of stress can easily be incorporated into a hierarchical model of phonology, where notions like 'head' and 'projection' are crucial.

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