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Main stress and secondary stress: two modes of stress assignment

Harry van der Hulst & Jan G. Kooij

0. Background

Standard metrical phonology (e.g. Hayes 1982) develops the following view on the relation between main stress and secondary stress. The full rhythmic organization at the word level is derived by first constructing a layer of left- or right-headed feet and then selecting a peripheral foot to express main stress. This view has been challenged already in van der Hulst (1984), who proposes a "main stress first" approach, where main stress assignment and secondary stress assignment are regarded as separate algorithms. The central goal of this paper is to examine some of the consequences of this dissociation.

We will first repeat the original motivation for the "main stress first" proposal and make the claim more precise by embedding it in a general theory of stress placement, worked out more fully in van der Hulst (1992). Then, we review the ways in which we expect the location of main stress and secondary stress to differ, given their independence. We will, in particular, defend the hypothesis that secondary stress assignment is a late rule. We refer to analyses of languages which bear out these expectations, and also to recent work where the approach we take here is implicitly present. Finally, we briefly indicate some problems that arise, as well as issues for further research.

1. "Main stress first"

The original observation which led to the formulation of the "main stress first" idea was that, in the majority of cases, we can compute the location of main stress with reference to word-edges and weight, without depending on an exhaustive parsing of the word into feet. Only one type of system does not fall under this generalization; we will call them "count systems". An example of a count system is MalakMalak (Goldsmith 1990), which has stress on the first syllable if the number of syllables in a word is even and on the second syllable if the number of syllables is odd. This is the only RL type that we know (i.e. Quantity Insensitive and with left head marking):

```
(1) ER (L)              x
    HM (L, RL)          x         x         x
    even          [  (  σ  σ  )  (  σ  σ  )  (  σ  σ  )  ]

    ER (L)                 x
    HM (L, LR)             x         x
    odd           [  σ  (  σ  σ  )  (  σ  σ  )  ]
    where ER=End Rule (Left), and HM=Head Marking (Left), (Right-to-Left)
```

A slightly more complex system of this type would be Cairene Arabic, where Head Marking is Quantity Sensitive (QS) (Hayes 1991).

In contrast with MalakMalak, in most systems if it is assumed that exhaustive footing always precedes main stress assignment, main stress falls on the first foot that is assigned, i.e. the leftmost foot in a left-to-right system and the rightmost foot in a right-to-left system:

```
(2) a. ER (L)              x
       HM (L, LR)          x          x          x
                      [  (  σ  σ  )  (  σ  σ  )  (  σ  σ  )  .....

    b. ER (R)                                       x
       HM (L, RL)             x          x          x
                      .....  (  σ  σ  )  (  σ  σ  )  (  σ  σ  )  ]
```

Clearly, in cases like in (2), we can compute main stress by a non-iterative procedure applying at the left or right edge, respectively. But if we adopt this viewpoint, we must also assume that secondary stresses, which in the standard view result from exhaustive parsing, instead result from a procedure which applies independently, respecting the position of the main stressed syllable. We will return to this point later. Let us briefly indicate how we derive main stress and secondary stress in the approach that we have in mind. "Main stress first" systems involve the non-iterative *delimitation of a two-syllable stress domain*. We postulate that stress domain delimitation involves a parametric choice forming part of the theory of *Prosodic Circumscription* (PC) as proposed in McCarthy and Prince (1991). Stress systems for which the main stress proposal was originally developed can be characterized as involving the delimitation of *minimal words* on either the right or left edge of the input word:

```
(3)  [ σ .... σ σ σ σ ]    minimal word      → [ σ .... σ σ ( σ σ ) ]
                           formation (mwf)
```


Extrametricality, as McCarthy and Prince argue, can also be seen as a form of PC. Two modes of prosodic circumscription can be compounded, so that a larger part of the word is carved out for assigning stress, i.e. the minimal word plus an extra syllable. In that case, the extrametrical syllable is removed first and the residue after that operation is subjected to carving out the minimal word. The order of these two instantiations of PC is, in fact, a natural application of the Elsewhere Condition:

```
(4)  [  σ .... σ  σ  σ                        σ  ] EM
        residue                           circumscribed

     [  σ .... σ               σ  σ           σ  ] MWF
        residue            circumscribed
```

Let us refer to cases where stress is assigned through a single application of MWF as *peripheral systems*. To explain the existence of *count systems*, we assume that MWF can also apply iteratively. Hence we get a fairly standard derivation in those cases, as in (1).

If MWF does not apply at all and the whole word forms the stress domain, we have an *unbounded system*. For an illustration of the latter, we take the example where stress is assigned to the rightmost heavy syllable, and, if a word has no heavy syllable, to the first syllable:

```
(5) Unbounded: last/first
    ER (R)       x                              x
    HM (L)       x                        *     *
             [   σ  σ  σ  σ  σ  ]     [ l  h  l  h  l  l  l ]
```

2. Secondary stress

For our present purposes, it is important to point out that all these systems are "main stress first". In unbounded systems, after all, stress assignment only produces main stress on the rightmost or leftmost heavy syllable in the word, or the right or leftmost syllable in case there is no heavy syllable. And even in count systems, feet that do not bear main stress do not necessarily express the rhythmic structure (even though it may seem like that in some cases). In count systems like Creek and Cairene, no secondary stresses are reported that would correspond to the foot heads. Thus, in such systems, rhythmic structure apparently results from an independent procedure where main stress is respected as a strong beat in the rhythmic wave.

The view that we will maintain here, is that main stress assignment and assignment of secondary stress are different operations at different levels. The strongest claim, which we will also maintain, is that the difference consists in application at the lexical and at the post-lexical level, respectively, and the domain of application is (again, pushing the hypothesis to the extreme), the difference between the lexical word and the phonological phrase. What we would expect is that the same parameters are involved, but that the two modes of stress assignment can differ in that, for instance, main stress assignment is QS whereas secondary stress assignment is not, or vice versa. Also, the directionality of the assignment of secondary stress can be the opposite of Main Stress ("edge-in" rhythm) or identical ("echo" rhythm).

Consider what English would look like under this approach:

(6) English stress

	lexical	*post-lexical*
EM	yes	no
MW	left, non-iterative	right, iterative
QS	yes	no
HM	left	left

(7)

```
                x                   x
      x         x                   x     x     x
      x x   x   x   x               x     x   x x x x
  f r a t e r n i z a t i o n       s e n s a t i o n a l i t y
  ---------------  ---------        ---------------   ---------
      rhythm          MWF               rhythm          MWF
```

After the location of Main Stress has been established, the secondary stresses fall out from an algorithm that essentially creates an alternating pattern and, in this case, also differs along the directionality parameter. Essentially the same situation obtains in Dutch: Main Stress is QS, secondary stress is not, or only halfway. As is well known from the literature, in both languages variations occur with respect to the location of secondary stresses due to syllable strength, or to position and number of syllables. This is what one would expect: if secondary stress assignment is late, it is variable within limits, whereas main stress will not normally vary.

(8)

```
                                                   (x)
                    x              (x)              x
   x                x               x      x        x
   x    x    x      x               x      x    x   x  x
  s e n s a t i o n e e l          c o n s t a n t i n o p e l
  -----------------  -----         -------------------  -------
       rhythm         MWF               rhythm            MWF
```

With respect to quantity-sensitivity the reverse situation is also attested. In both Finnish and Estonian main stress invariably falls on the first syllable of the word. The pattern of secondary stress may show signs of QS, however. In principle we find an alternating pattern starting on the third syllable, but if the third and fourth syllable are a light–heavy sequence, the first secondary stress appears on the fourth syllable. Several phonologists have analyzed this in terms of QS, in particular in terms of a QS foot type which avoids mismatch (cf. Kager 1991).

A third possibility is that both main stress and secondary stress are QS, but in different ways. We find an example of this is a number of Eskimo languages, which treat both CVV and CVC as heavy for main stress, but only CVV as heavy for secondary stress. In Chugach, for example, main stress is initial if the initial syllable is either CVV or CVC; otherwise main stress is on the second syllable. This shows that CVC is counted as heavy. Yet in the remainder of the word only CVV syllables are treated as heavy.

Chugach is illustrative of yet another difference between main stress and secondary stress. As stated earlier, main stress falls on the first or the second syllable. Hence EM is not involved. The pattern of secondary stress, however, is ternary. If we are correct in claiming that ternary stressing involves EM, the difference is one of parameter setting. In fact, ternarity also plays a role at the foot level in the assignment of secondary stress in Estonian: light syllables can optionally be skipped.

The examples from Dutch and English show, in addition, that there is no need for the cumbersome refooting and restructuring of stress patterns that are assigned in the "one parse" approach in the standard theory. And there are other phenomena that are an embarrassment for the standard theory, and that acquire the status of fulfilled expectations if it is assumed that rhythmic structure is assigned independently. A case in point is the analysis of the Rhythm Rule in Tiberian Hebrew as presented in Churchyard (1992). This rule resolves clashes at the phrasal level in the familiar fashion, but crucially does not refer to positions in the pattern that would have received secondary stresses had the rule of Secondary Stress assignment applied in one block with the Main Stress Rule.

(9)

```
                     x                                     x
              x      x                  x                  x
   x          x      x                  x          x       x
   x     x    x      x   x    *→        x     x    x       x   x
  t e e  ʕ a a z a b  ʔ a a r e ṣ      t e e  ʕ a a z a b  ʔ a a r e ṣ
  'the earth will be abandoned'
```

In a similar vein, Roca (1986) has argued that secondary stress in Spanish must be a late rule since it interacts with other low-level rules of the phonology. It is illustrative to quote his conclusion in full:

> This paper presents empirical arguments to back the claim that secondary stress, in languages like Spanish and Italian, is but a manifestation of phrasal rhythm. [...] Harris [...] unwisely intermixes the algorithms for primary and secondary stress, with the concomitant implicit lexical ordering for the latter. The fact that such ordering can be falsified and that secondary stress grids must be built on primary stressed structures (precisely the contrary result to that presented in Harris (1983)) suggests a dichotomy between lexical and postlexical stress which goes beyond the one embodied in metrical theory to date. Specifically, it seems to point in the direction of freeing lexical stress from the pressures of prosodic rhythm, and postlexical rhythmic stress from the idiosyncrasies of lexical determination. Roca (1986:364)

At this point, we should acknowledge that our proposal regarding what we call peripheral systems is implicit in much recent work. Halle and Kenstowicz (1991:489) state that for English (which in our typology has a peripheral system) "representations of stress emerge from the cyclic rules with just a single metrical constituent at the right edge of the word." This foot is of the quantity sensitive type, since the location of main stress is dependent on the make-up of the right-peripheral syllables. Halle & Kenstowicz propose that secondary stresses arise from a left-to-right iterative assignment of quantity insensitive feet. More explicit examples, besides Roca on Spanish, are Bat-El (1990) on Modern Hebrew, and Bruce (1983) on Swedish, one of the rare studies in which secondary stress patterns have been investigated within larger than word constituents. Bruce reports that, in Swedish, a regular alternating pattern of strong and weak syllables can be found in-between syllables that carry main stress.

> Generally, the unstressed syllables will be alternatively weak and strong starting from the upcoming stress and counting backwards. Bruce (1983:35)

This finding would suggest that rhythmical patterning is phrasal and echoing.

A final advantage of our approach is of a more general nature. If we are right in our claim that main stress assignment precedes secondary stress assignment, we expect that main stress assignment may be sensitive to lexical and morphological information, whereas secondary stress, being post-lexical, cannot refer to such information. We claim that this is exactly what we find. In fact we are so used to the observation that secondary rhythmic structure is blind to anything but phonological information (i.e. weight, and position in the string) that we fail to feel the urge to explain this quite straightforward fact. If "footing" preceded the allocation of main stress in the unmarked case, we would expect to find (1) massive lexicalization of rhythm and therefore (2) all sorts of exceptions, i.e. patterns containing clashes and lapses which could not be explained in phonological terms. While we do not deny that in languages like Dutch and English there is some degree of lexicalization of secondary stresses in morphologically structured words, we agree with Halle and Kenstowicz that this is the exception and not the rule.

3. Conclusion

The central claim we have made in this paper is that secondary stress assignment is an independent phenomenon, perhaps with the exception of count systems, where rhythmic structure may be a reflection of a "deep" exhaustive parsing of the whole word into minimal words. It is tempting to think that Minimal Word Formation is in fact the lexical counterpart of rhythmic footing, assuming that PC

is a computational device which makes use of units which are "inspired" by the lower categories in the prosodic hierarchy. We have suggested that rhythmic alternation holds within prosodic constituents, perhaps typically the phonological phrase. But what about the prosodic word? In fact, in this view so called "strong secondary stresses" located on the edge opposite to where we find main stress, can be seen as boundary effects holding at the level of prosodic words. In Dutch, for example, the prosodic word is formed on the basis of left edges (which is why Dutch has enclitics, but no proclitics) and thus we expect to find initial strong syllables.

A consequence of this view is that languages with completely fixed stress assignment within the prosodic word may be analyzed as having no lexical stress rule at all. Stress assignment in such languages would be done at the level of the prosodic word. If, on the other hand, the domain of stress assignment is not the prosodic word, stress must be computed within a lexical domain, either the grammatical word or a minimal word portion thereof.

We have tried here to point out the consequences of our proposal in its most radical form. This, we feel, is the best way to make the issue quite clear. At the same time, our proposal is open to criticism and counterexamples. For instance, any case where other phonological rules at the lexical level refer to secondary stress would be a problem. While we certainly do not want to explain these cases away, we also want to point out that such counterexamples raise another issue that deserves to be discussed more fully, namely the extent to which secondary stresses in some languages should be regarded as underlying rather than derived by rule. The recent history of the famous *compensation/condensation* pair in the literature would indicate that this issue is far from resolved. We trust that further research on the details of rhythm and secondary stress will at least bear out the fruitfulness of the radical position advocated here.

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Features and gestures in an articulatory speech production model

Bernd J. Kröger & Claudia Opgen-Rhein

1. Introduction

A comprehensive computational articulatory speech production model capable of producing any utterance of standard German has been developed. Two different phonological concepts, *gestures* as defined by Browman & Goldstein (1986) and segmental *features* form the basis for two competitive rule components: a gestural and a segmental one. Both produce articulatory time functions, i.e. they produce or define the movements of all articulators (lips, tongue tip, tongue body, velum, and glottis) for an intended utterance (Figure 1). The time functions produced by both components control the same articulatory-acoustic model, which transforms them into a temporal sequence of vocal tract shapes and subsequently into an acoustic speech signal (Kröger 1990a, 1990b; Kröger & Opgen-Rhein 1990).

Features and gestures seem to be the central concepts in speech production modelling. On the one hand they are basic phonological units, i.e. the basic units for the formulation of phonological rules. On the other hand they have an articulatory and also, in the case of features, an acoustic and auditive basis. While a gestural production model is well described (Browman & Goldstein 1990), no complete and computational feature-based articulatory production model can be

Figure 1. The articulatory production model