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Achim Barsch

TRENDS IN RHYTHMICS – LANGUAGE, LITERATURE, AND MUSIC

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TRENDS IN RHYTHMICS - LANGUAGE, LITERATURE, AND MUSIC

Summary

The aim of this paper is twofold. First of all I want to give a somewhat rough overview concerning generative theories recently developed in phonology, metrics, and musicology. Additionally, I want to sketch some inner relations between these theories as far as possible.
Secondly, there are pointed out some problems and research questions involved with the above-mentioned theories concerning aspects of cognitive psychology.

Zusammenfassung

Zwei Ziele sind mit dieser Arbeit verbunden. Einmal möchte ich einen kurzen Überblick geben über die Entwicklung neuerer generativer Theorien in Phonologie, Metrik und Musiktheorie. Überdies möchte ich auf einige innere Beziehungen dieser Theorien zu sprechen kommen - soweit das in diesem Rahmen möglich ist.
Zweitens soll auf Probleme und Forschungsfragen hingewiesen werden, die an die genannten Theorien anschließen und u.a. Aspekte der kognitiven Psychologie betreffen.

TRENDS IN RHYTHMICS - LANGUAGE, LITERATURE, AND MUSIC

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0. Overview on developments in phonology, metrics, and musicology

Starting my overview of generative theories recently developed in phonology, metrics, and musicology with phonology has three reasons. First, there is the problem of representation; it appears easier to me to discuss some phonological concepts and their use in other disciplines first than vice versa. A second point is related to the first one: In my opinion metrical theorizing cannot be done without considering phonological results and phonological theories. The third argument is a historical one: the new developments being presented here have first been formulated in phonology (Liberman 1975).

1. Metrical phonology

I restrict myself to a slightly modified version of the theory of Liberman & Prince which has recently been carried on[1] and which is called with a general term 'metrical phonolgy'[2].
Metrical phonology has brought a fundamental change in phonological research. Up to this new development Chomsky & Halle's "The Sound Pattern of English" (abbrev. SPE) was the only paradigm in generative phonology. The SPE theory focused on the form and function of phonological rules as for example the principle of disjunctive ordering of adjacent rules. The conceptions of phonological representation in the SPE model are mainly based on the theory of distinctive features. Utterances and their underlying representations are thought of as being made up of matrices of distinctive features. Each column of the matrix corresponds to a single segment. The underlying representations consist of segments which are built up of bundles of unordered features bearing binary values. Utterances are ordered

lists of segments including numerical values for the distinctive features. These segments must also include prosodic categories as tone, stress, and syllabification.

So metrical phonology and autosegmental phonology, which will not be discussed here, serve as departure from the SPE model of phonological representation. In the alternative model utterances consist of several kinds of simultaneous levels (utterance, intonational phrase, phonological phrase, etc.). Each of the levels is ordered independently of the other levels, but is also related to them.

Some of the phenomena metrical phonology deals with are stress and syllabification. Relative prominence between adjacent prosodic units and the notion of relations of constituency are used to explain these phenomena. The main characteristics of metrical phonology are hierarchical relations, namely non-overlapping binary-branching trees and the notion of a metrical grid, which are combined with the notions of relative prominence and linguistic rhythm, respectively. All these notions will be presented in the following chapter.

1.1 Relative prominence based on constituent structure

First let us regard some data of English compounds:

(1)

(a) $((\overset{1}{\text{highway}})_N(\overset{2}{\text{patrol}})_N)_N$

(b) $(((\overset{1}{\text{highway}})_N(\overset{2}{\text{patrol}})_N)_N(\overset{3}{\text{commander}})_N)_N$

(c) $((\overset{2}{\text{patrol}})_N((\overset{1}{\text{station}})_N(\overset{3}{\text{commander}})_N)_N)_N$

(d) $(((\overset{2}{\text{highway}})_N(\overset{3}{\text{patrol}})_N)_N((\overset{1}{\text{station}})_N(\overset{3}{\text{commander}})_N)_N)_N$

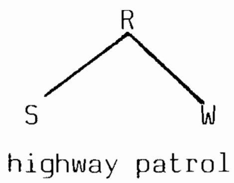
The numbers indicate stress according to the notation of SPE.

Examples (1a) to (d) show that English compounds have either main stress on their left member, as in cases (1a) and (b), or on the left member of a branching right member, as in cases (1c) and (d). If stress is considered not to be a segmental but rather a relational phenomenon, then we can explain the examples above in the following way: each compound has a more prominent right member, if it is branching, otherwise the left member is the more prominent one. Liberman & Prince capture this observation in their Lexical Category Prominence Rule (LCPR):

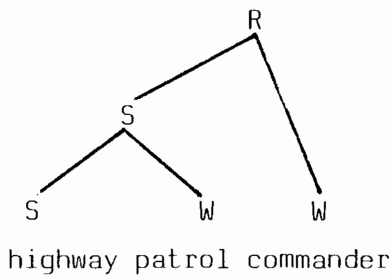
(2) In the configuration $(N_1 N_2)$, N_2 is strong iff it branches.

N_1 and N_2 are sister nodes of a binary-branching tree which are always complementary labelled S for strong and W for weak. That means single Ss or single Ws are not defined within this theory. Applying the LCPR to the compounds above, we obtain the following results:

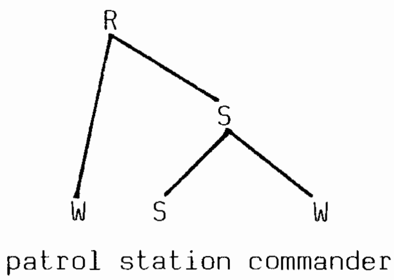
(3) (a)



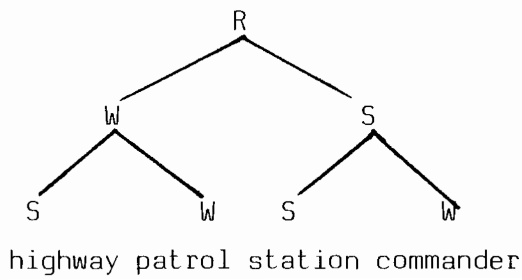
(b)



(c)

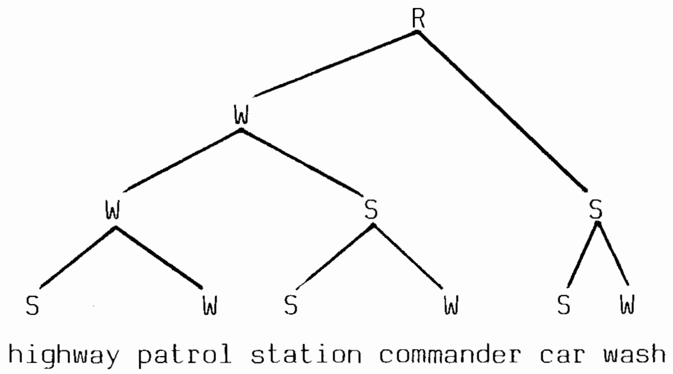


(d)



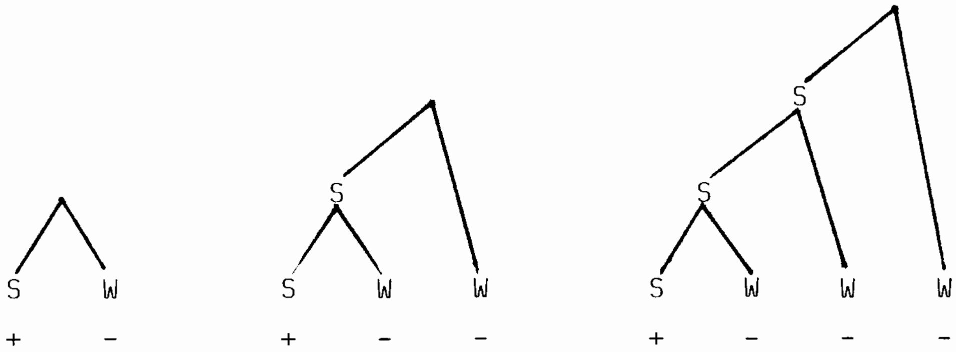
The LCPR also accounts for the natural stressing of strange compounds such as:

(4)

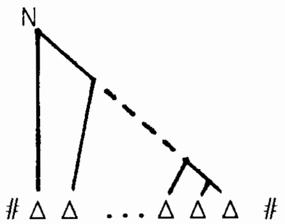


The most prominent element in a tree is called 'designated terminal element'. It is that node which is dominated only by S labels and the root and which indicates primary stress. Since each W node is relatively less prominent than its sister, degrees of secondary stress are also indicated by the labeled tree.
Actually the LCPR also accounts for English nuclear stress, because if N_1N_2 are building a phrasal category, N_2 is always prominent, i.e. N_2 is labeled S and treated like a branching lexical category.
Affecting phrasal stress and compound stress the tree structure is already given by syntactical or morphological rules. For English word stress the situation is somewhat different, because the metrical trees for words must first be erected. Liberman & Prince give a description of this procedure presupposing the value marks (+ and -) of the segmental feature ($\pm$) *(stress)*:

(5) "a. Every sequence of syllables +-, +--, +---, etc., forms a metrical tree. Because of the condition limiting (-stress) to weak positions, and because of the bivalent (binary-branching) character of metrical trees, the structure and labelling of the sequences is uniquely determined. We have, necessarily, left-branching trees, looking like this:



b. The syllable-dominating trees of provision (a) are organized into a right-branching tree whose root is associated with the syntactic mode immediately dominating the entire word. The arrangement will look like this:

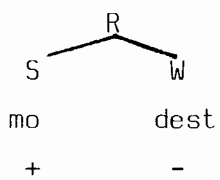


(Liberman & Prince 1977, 266)

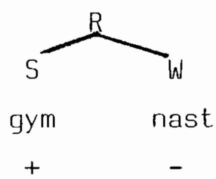
The method for developing these patterns "is to start at the end of the word and work leftward, stopping at each (+stress) to build up as much of the tree as possible" (Liberman & Prince 1977, 267). The final trees[3] are then labeled according to the LCPR, which therefore is sufficient for all lexical categories, namely words and compounds.

The rule assigning *(+stress)* to words proposed by Liberman & Prince is very cumbersome and keeps mainly the traditional view of the SPE model, that is a segmental stress rule assigning stress features to vowels. Fortunately, this problem has been surmounted by proposals of Kiparsky (1979) and Selkirk (1980) for instance. Both argue for the foot as a separate, labeled prosodic category. I take up an example of Selkirk. The Liberman & Prince representation of words like "modest" and "gymnast" is as follows:

(6) (a)



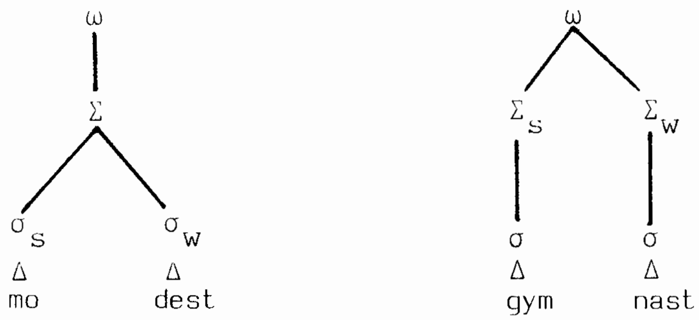
(b)



The constituent structure serves to define degrees of stress or relations of relative prominence. The marks (+ and -) determine the presence or absence of the feature *(stress)* of a vowel.

In the representation of Selkirk the feature *($\pm$ stress)* can be dispensed with. She assumes the existence of a set of prosodic categories, namely the categories syllable, stress foot, and prosodic word, which have the symbols σ, Σ , and ω respectively. These prosodic categories have corresponding labels at the appropriate nodes of the tree. Selkirk also allows for the possibility that nodes with different prosodic category labels may be interpreted differently by phonological processes. In the case of "modest" and "gymnast" Selkirk proposes the following solution:

(7) (a) (b)

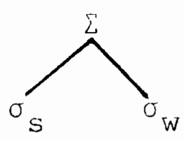


Selkirk assumes two basic types of stress feet; they are already implemented in (7), one is the monosyllabic type:

(8)

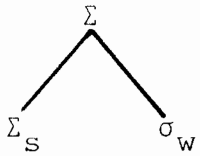
the other one is the bisyllabic:

(9)



Additionally a third type is introduced, the stress superfoot:

(10)



The fundamental idea of Selkirk's solution is the organization of syllables into stress feet[4], which accounts for the presence or absence of stress. Though a syllable which is a stress foot is never a weak syllable. To be a stress foot always implies some degree of stress, even when the stress foot is weak like the syllable "nast" of example (7b). Correspondingly, a syllable which is not a stress foot is treated as stressless like "dest" of "modest".
The prosodic categories are an enrichment of the theory of Liberman & Prince which exceeds the scope of this paper. Just let me mention two points which go beyond the Liberman & Prince theory. First, the foot-level provides a rather natural explanation of the problem of vowel reduction. Secondly, Selkirk assumes that the traditional differentiation in "stress-timed" and "syllable-timed" languages has to do with the two basic types of stress feet, monosyllabic and bisyllabic. This point could be of interest, because other linguists deny this distinction completely.

1.2 The metrical grid

I now turn to the second new idea of Liberman & Prince, the notion of the metrical grid which involves aspects of linguistic rhythm. Tacitly there has been presupposed up to now that relative prominence or degrees of stress are preserved under embedding, one can compare for instance the examples in (3). But there is a set of cases in which relative prominence is not preserved under embedding. Classical examples are:

```
 3 1          2 4   1 3    1         3     4    1     3    1
thirteen, but thirteen men; achromatic, but achromatic lens; Tennessee, but

 2    4 1
Tennessee air.
```

Such changes of stress cannot only be stated for English, but for other languages as well (among them Hebrew and German). The common explanation for this phenomenon is referring to a concept of 'rhythm' and to the desire to maintain an alternating pattern avoiding 'clashing' stresses. The domain of this 'rhythm rule' are patterns of secondary stresses of compounds, phrasal collocations, and words. Because of the differences in different languages the rhythm rule cannot be thought of as a phonetic universal. Therefore, one must look for a general description of this phenomenon which allows the implementation of language-specific differences.

For this purpose Liberman & Prince developed the concept of the metrical grid. The grids do not contain the rhythm rule itself; they only produce pressure for stress-retraction, if there is a certain configuration of stresses, namely 'clashing' stresses. 'Clashing', 'adjacent', and 'alternating' stresses are defined in terms of their new representation of stress patterns. Then the rhythm rule is formulated in terms of the hierarchies of relative prominence relations represented above, i.e. prosodic constituent structure.

Liberman & Prince devise grids as rows of abstract elements ordered in columns above each syllable. The relative prominence of each syllable is indicated by the height of its column. Grids are erected in the following way:

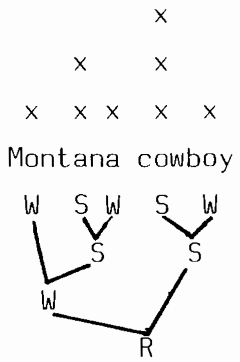
On the first level of the grid each syllable receives a mark as a place marker. On the next levels sufficient marks are added so that the Relative Prominence Projection Rule (RPPR) is not violated:

"In any constituent on which the strong-weak relation is defined, the designated terminal element of its strong subconstituent is metrically stronger than the designated terminal element of its weak subconstituent". (Liberman & Prince 1977, 316)

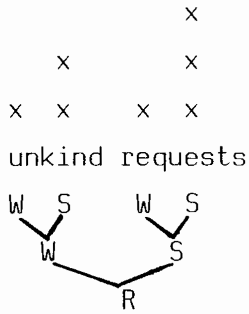
Producing grids for

```
 4 2   1            3      1
Montana cowboy and unkind requests we get:
```

(11) a)



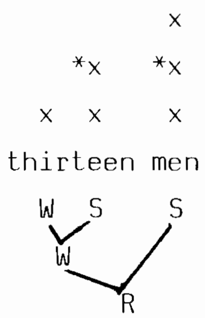
b)



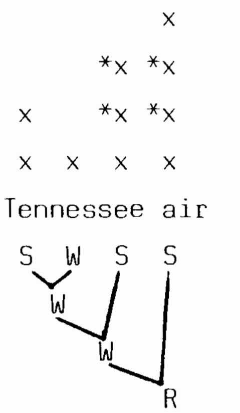
4 2 1 4 2 1

For illformed cases like *thirteen men* and *Tennessee air* we get:

(12) a)



b)

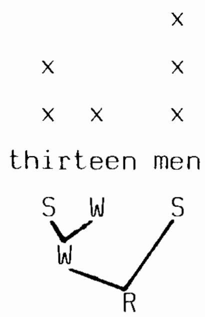


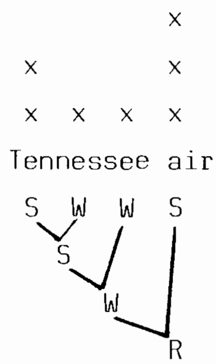
Terms like 'adjacent', 'alternating', and 'clashing' can now be defined in the following way: "Elements are metrically <u>adjacent</u> if they are on the same level and no other elements of that level intervene between them; adjacent elements are metrically <u>alternating</u> if, in the next lower level, the elements corresponding to them (if any) are not adjacent; adjacent elements are metrically <u>clashing</u> if their counterparts one level down are adjacent" (Liberman & Prince 1977, 314).

In (12 a) and (12 b) the stress clashes are marked with asterics. In (11 a + b) there are no stress clashes at all. Following Liberman & Prince the stress clashes found in the metrical grid produce the pressure for the application of the rhythm rule. We can see this if we build the grids for the well-formed cases of

2 4 1 2 4 1
thirteen men and *Tennessee air* where no stress clashes appear:

(13) a) b)





Up to now I have discussed the descriptional frame of stress-retraction. Let us come to the rhythm rule itself. Liberman & Prince formulate a rule specific to English:

(14) Iambic Reversal (optional)

$$\underset{1}{W}\ \underset{2}{S} \Rightarrow \underset{1}{S}\ \underset{2}{W}$$

Conditions: 1. Constituent (2) does not contain in the designated terminal element of an intonational phrase.
2. Constituent (1) is not an unstressed syllable.

(Liberman & Prince 1977, 319)

The role of the rhythm rule can be shown very easily if we take (12 a + b) as the input and (13 a + b) as the output scansions, respectively. It can be seen that the rhythm rule operates on the prosodic constituent structure, changing the strong-weak relation within one of its constituents so that stress clashes in the grid are avoided. It is this combination of relative prominence pattern and grid which led Liberman & Prince to call their phonological theory "metrical".

2. Metrics

In case of metrics the use of Liberman & Prince's phonological theory has been different. I will outline the sketches of Kiparsky (1977) and Hayes (1983), who take advantage of metrical trees and grids, respectively, but I will not take them into critical consideration here.[5]

2.1 Kiparsky's concept

As is usual in generative metrics[6] Kiparsky regards a metrical system to be a set of rules which decides whether a certain linguistic phrase is an acceptable realization of a particular abstract metrical pattern or not. Those rules which link linguistic strings to abstract metrical patterns are called correspondence rules. Additionally, metricists have to take into account a criterion for the determination of metrical complexity. Metrical complexity gives a measure how far a line of verse deviates from a one-to-one correspondence to the metrical pattern, whereas the correspondence or metrical rules determine whether a linguistic string is metrical or not. The variation of these metrical rules also takes care of what is called a 'metrical ideolect' which means the individual style of a poet. Kiparsky formulates metrical rules for Milton and Shakespeare for example. But as we are dealing with general problems of rhythm in this article I will not concern myself with problems of style. Therefore, I will discuss Kiparsky's general theoretical frame.
To formulate metrical patterns and metrical rules he takes up Liberman & Prince's tree-representation of stress. In case of iambic pentameter he sets up as the basic metrical pattern five simple trees, branching W S as shown in

(15)


The determination of the metricality of a line is carried out by a matching of two tree patterns, one representing its linguistic stress and the other representing an abstract metrical pattern. I give an example of the simplest case, where the two trees are identical:

(16)

W S	W S	W S	W S	W S	stress pattern
Of hand,	of foot,	of lips,	of eye,	of brow	Shakes. Son. 106
W S	W S	W S	W S	W S	metrical pattern

Normally, the stress pattern of a line of verse is more complex than in the case above (16). Moreover in many lines there exist mismatches between the two tree patterns. It is the function of the metrical or correspondence rules to determine those mismatches which are excluded as non-metrical. Kiparsky gives the following conditions for metricality (Kiparsky 1977, 195):

(17) "A line L is <u>metrical</u> with respect to the meter M if and only if the stress pattern of L corresponds to M as follows:

a. Terminal nodes correspond one-to-one.

b. There is no correspondence of the form $\begin{smallmatrix}S\\ \Updownarrow\\ W\end{smallmatrix}$, where S is a lexical stress."

A stress is lexical, if its sister is in the same word. The main effect of the metrical rules is to forbid a linguistic S to appear in a metrical W position as in

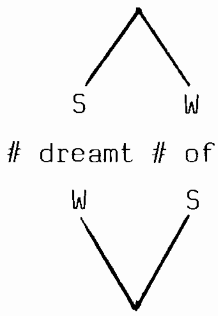
(18)

S W	stress pattern
modest	
W S	metrical pattern

Other mismatches are permissible.

Kiparsky tries to capture the individual "metrical style" of poets by modifying metrical rules. But this does not affect us here. I have just said that mismatches which do not violate the metrical rules are permissible. Kiparsky distinguishes two typs of mismatches, labeling mismatches like

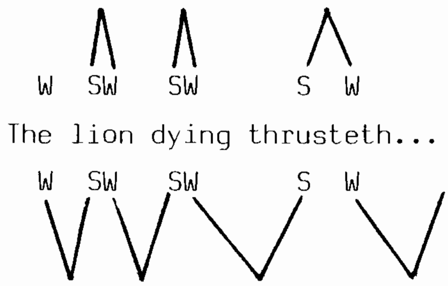
(19)



(Kiparsky 1977, 196)[7]

and bracketing mismatches like:

(20)

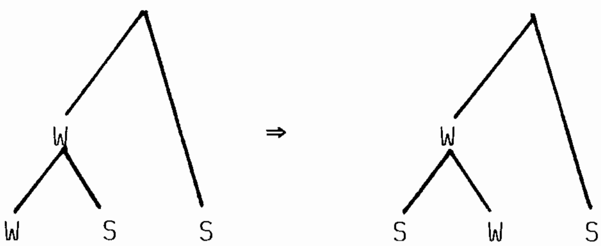


(ibid.)[8]

Having defined these kinds of mismatches a very simple characterization of metrical complexity is possible: "The complexity of a line is measured by the number of mismatches in it" (Kiparsky 1977, 195). The measurement of complexity is identically characterized for all poets. "Metrical ideolects" are formulated in terms of metrical rules only.

Kiparsky also considers the problem of linguistic rhythm and the rhythm rule. But he avoids dealing with grids in taking up the rhythm rule as follows:

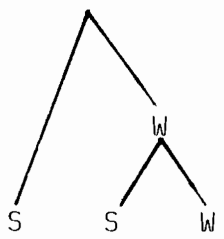
(21)



(Kiparsky 1977, 218)

with the constraints that terminal W must be *(+stress)* and that no pattern like (22) is produced:

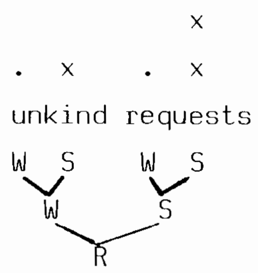
(22)



2.2 Hayes' concept

In contrast to Kiparsky Hayes (1983) does not use prosodic constituent structure in his theory of metre but instead of metrical trees uses metrical grids. In fact, he slightly modifies the Liberman & Prince notion of grids by deleting its bottom level. Missing grid columns above syllables are then marked with a dot. So from (11 b) <u>unkind requests</u> we obtain:

(23)



Hayes refers to syllables still bearing marks on higher levels of the grid as 'grid-marked'. He has phonological and metrical arguments for introducing this kind of grids. On the one hand, revised grids express the "natural classes" of metrical phonology, i.e. only grid-marked syllables may occur in stress clashes. On the other hand, the distinction of metrically relevant secondary stresses and metrically irrelevant secondary stresses is related to grid-markedness. At this point Hayes carries on a lot of verbal display to emphasize that content words, that means lexical monosyllables must be grid-marked.

I will not repeat Hayes' arguments against Kiparsky's system here, but restrict myself to a brief sketch of his metrical theory. Three basic ideas are involved with Hayes' grid-based theory. First he introduces the well-known and very general principle: "Correspondence to a metrical pattern tends to be lax at the beginnings of units; strict at the ends" (Hayes 1983, 373).

This principle is used as a substitute for bracketing, because in the grid-based metrical analysis information on prosodic constituent structure, i.e. the form of the trees, is missing. Secondly he makes use of the principle of locality: "the metrical evaluation of a stressed syllable can be made by comparing its stress level with that of its immediate neighbors" (Hayes 1983, 375). The third point is the assignment of "domains" to metrical filters, where metrical filters must be viewed as the correspondence or metrical rules: "the filters may only analyze metrical lying within a specified domain, such as the word or the phonological phrase" (Hayes 1983, 376).

In order to formulate metrical filters Hayes using the principle of locality introduces the terms 'stress peak' which can be 'falling' or 'rising' and 'stress valley'. A stress peak is defined "as a syllable whose grid column is higher than that of at least one of its neighbors" (Hayes 1983, 376). Stress valley is defined analogously as a column having at least one higher neighbour. Rising and falling peaks are shown in (24) respectively:

(24) a) Rising Peaks

$$\begin{array}{cccc} & x & & x \\ .\underline{x} & .\underline{xx} & .\underline{x}. & x\underline{x}x \end{array}$$

b) Falling peaks

$$\begin{array}{cccc} & x & & x \\ \underline{x}. & \underline{xx}. & .\underline{x}. & x\underline{x}x \end{array}$$

(Hayes 1983, 376)[9]

Hayes is now in the position to define metrical patterns as being grids themselves. The metrical pattern for iambic pentameter is as follows:

(25) . x . x . x . x . x

Still two things are left: metrical or correspondence rules and measurement of complexity. Instead of metrical rules Hayes speaks of metrical filters and proposes for them a general frame:

(26)
$$\begin{array}{lll} \text{Meter:} & & \text{Valley} \\ & & \updownarrow \\ \text{Line:} & {}^{*}\left[\begin{Bmatrix}\text{rising}\\ \text{falling}\end{Bmatrix}\right] & \text{Peak} / \{ \dots (\psi) \_\_ (\rho) \;\; (\dots)\}_{\alpha} \end{array}$$

where ψ, ρ may be specified as grid-marked or not, and $\propto$ is a phonological domain. (Hayes 1983, 376)

The effect of this frame is to rule out a linguistic stress peak in a metrical stress valley. Additional constraints for the individual metrical style of authors can be made up according to "(a) the domain of the filter, (b) whether the offending cadence is phrase-final, and (c) the presence of adjacent grid-marked or non-grid-marked positions" (Hayes 1983, 377). A metrical filter for Milton, called Milton I, is (27) where the phrase-final cadence is crucial:

(27) Milton I

*Peak / { ... __ }phrase (Hayes 1983, 377).

Applying this filter to some lines (linguistic grids are marked above the line, the grid of the meter below) Hayes gets the following unmetrical and metrical cadences:

(28) a) unmetrical cadences

```
                         x
     . x   .      x      x
   { Resembling strong youth }  in his middle age
     . x   .      x      .     x   .  x   . x
```

b) metrical cadences (peak is not phrase-final)

```
        x
  .  .  x  x
{On a Sunbeam}, swift as a shooting star
  .  x  .  x      .   x  .   x  .    x
```

```
               x
  .    .   x   x
{And his Son Herod} plac'd on Juda's Throne
  .    x   .   x .    x    .   x .    x
```

(Hayes 1983, 377)

More complex filters can be elaborated by making use of the constraints mentioned above. Finally I will give Hayes' proposal of measuring complexity. According to a certain metrical pattern he says a line is metrically complex to the extent that the one-to-one correspondence of peaks and peaks and valleys and valleys is not reached. For a line in iambic pentameter that means it is complex when its grid shows not the alternating sequence of five rising and four falling peaks.

3. Musicology - A formal theory of tonal music

Now I come to the discussion of new developments in musical theory, which is the most difficult task for me, because I am not a musician nor a musicologist[10]. First I will give a short overview of the theory of Lerdahl & Jackendoff. Then I will try to describe some connections between their musical theory and metrical phonology.
Lerdahl & Jackendoff call their theory a formal or generative theory of tonal music[11] because they are working with generative grammars restricted to tonal music. They are not the first ones who tried to do this[12], but they are the first who do not look for a mere one-to-one correspondence to Chomsky's generative grammar, i.e. looking for deep structures, transformations or semantics in music or generating pieces of music. Instead they see the significant parallel between generative linguistics and musical theory

in the combination of psychological concerns and in the formal nature of the theory. This should become clear in the following remarks.
The goal of a generative theory of music for Lerdahl & Jackendoff is "a formal description of the musical intuitions of an educated listener" (Lerdahl & Jackendoff 1977, 111), that implies to provide an account of the musical intuitions of a listener familiar with a particular tonal musical idiom. By 'musical intuitions' they mean "the largely unconscious knowledge which a listener brings to music and which allows him to organize musical sounds into coherent patterns" (ibid.). Therefore their goal implies the "understanding of the mental process of musical perception" (Lerdahl & Jackendoff 1977, 114), comparable to the linguistic aim to understand the linguistic competence of an idealized speaker-hearer. Both are psychological phenomena, which is the first parallel between musical theory and linguistics.
The second parallel is that Lerdahl & Jackendoff try "to develop an explicit formal MUSICAL GRAMMAR that models the listener's connection between the presented musical surface and the organization or organizations he attributes to the music. The grammar takes the form of a SYSTEM OF RULES which assigns analyses to pieces" (Lerdahl & Jackendoff 1982, 83/84). In their conception of generative grammar structural considerations are basic: they are not dealing with generating or composing new pieces of music but with assigning structural descriptions to already existing pieces.
But there are also differences between musical and linguistic grammars[13]. For instance musical theory distinguishes between well-formedness conditions and preference rules. The well-formedness conditions specify possible structural descriptions, i.e., "a specification of all the structure which the educated listener infers in his perception of the piece" (Lerdahl & Jackendoff 1977, 113). The preference rules designate those structural descriptions out of the mere possible ones that "correspond to the educated listener's hearing of any particular piece" (ibid.). The reason for preference rules is that music is pure structure and potentially vastly ambiguous. There is no unambiguous way to hear a piece of music. Therefore one can only be occupied with the most coherent or preferred way to hear a piece. Musical grammar has to account for the hearer's preferences among structural descriptions.
"Under our conception of music theory, then, the understanding of a piece of music by the idealized listener consists in his finding the maximally

coherent structural description or descriptions which can be associated with the piece's sequence of pitch-time events" (Lerdahl & Jackendoff 1977, 115).

Lerdahl & Jackendoff deal with hierarchical aspects of musical structure. In the structural description of a passage of music they distinguish not less than four independent hierarchical structures, which are simultaneously mapped on that passage. The four domains of analysis are: grouping structure, metrical structure, time-span reduction, and prolongational reduction. In short, grouping structure describes the division of a piece of music into motives, phrases, and sections. Metrical structure describes the hierarchy of strong and weak beats which the listener assigns to the piece. The two types of reduction assign degrees of relative prominence to all pitch events of the piece. "The <u>time-span reduction</u> designates 'structural beginnings' and 'structural endings' of groups, and assigns to the pitches a hierarchy which relates them to the grouping and metrical structures. The <u>prolongational reduction</u> assigns to the pitches a hierarchy which expresses harmonic and melodic continuity and progression" (ibid.).

These four structures have some abstract properties in common. First, each structure divides a passage of music into descrete units which are hierarchically organized in such a way that one unit may enclose other units, but is not permitted to overlap with other units. "Another property common to these domains is that the processes of organization are essentially the same at all hierarchic levels. A related point is that the processes of organization of these domains are recursive, i.e., capable of indefinite elaboration by the same rules" (Lerdahl & Jackendoff 1977, 116). Lastly, for each structure, rules assigning structural descriptions are distinguished in well-formedness rules and preference rules. Additionally, transformational rules are introduced which change structures into other structures. They are used for special cases not produced by the well-formedness rules. In contrast to linguistic theory, especially generative grammar, transformational rules have a minor role in the formal theory of music.

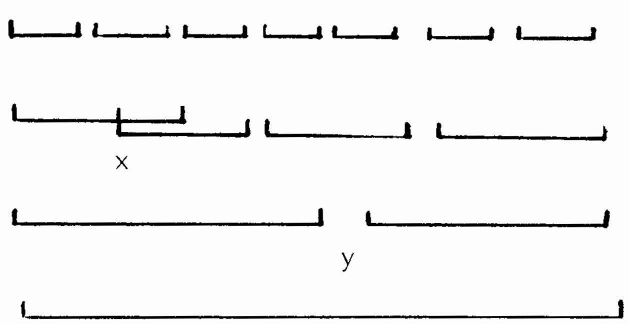
Let us now come to a closer description of the four structural domains. I will characterize each of them according to its well-formedness conditions and its preference rules. I shall start with the rhythmic structure and then come to pitch reduction.

3.1 Rhythmic structure

3.1.1 Grouping structure

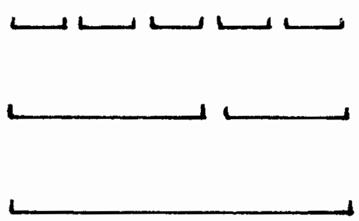
The fundamental notion in grouping structure is 'group'. Groups are units such as motives, themes, phrases, periods, theme-groups, etc. The listener hearing a piece of tonal music naturally builds up such groups. In the structural description of the piece groups are indicated by slurs beneath the musical notation. The well-formedness conditions for the hierarchic grouping structures forbid the overlapping of groups such as at x and y in

(29) 1) 2) 3) 4)



although (29) is a possible grouping structure.
The grouping preference rules pick out the actually heard grouping(s) from the mere possible ones. They are classified "according to principles of (a) articulation of boundaries, (b) parallelism in structure, and (c) symmetry" (Lerdahl & Jackendoff 1977, 118). An example of a well-formed and preferred grouping structure is

(30) 1) 2) 3)



If grouping overlaps occur, for instance if a pitch-event is at the same time the ending of a group and the beginning of another group, then the well-formedness conditions of hierarchic organization are violated and grouping transformational rules are needed. "The transformational rule relates well-formed underlying groupings to the musical surface, thereby preserving the sense that overlaps are variations on normal hierarchic grouping" (ibid.).

3.1.2 Metrical structure

The second part of rhythmic structure is metrical structure, which is independent of grouping structure but related to it. Normally the listener of a piece attributes a regular, hierarchic pattern of beats to that piece. In the structural description such a pattern of beats is indicated by dots beneath the musical notation and above the grouping slurs. "A dot at a particular level represents a judgement that that moment in the music is a beat at that level. If a beat at a particular level is felt to be 'strong', or 'down', it is a beat at the next larger level and receives an additional dot" (Lerdahl & Jackendoff 1977, 120). The description very closely resembles the representation of relative prominence in the metrical grid.
Metrical well-formedness rules must fullfill the hierarchic condition that a beat at a particular level must also be a beat at all lower levels. "Characteristics of metrical well-formedness in classical tonal music include the equal spacing of beats and the provision that at each successive level the distance between beats must be either two or three times that of the immediately lower level" (ibid.).
The metrical preference rules select from the many well-formed and possible metrical structures applicable to a piece of music the actually heard metrical structure(s). The metrical preference rules are categorized according to principles of "(a) cues for strong beats, (b) parallelism with grouping structure, and (c) regularity of pattern" (Lerdahl & Jackendoff 1977, 122).
A metrical transformation rule is required for metrical overlaps, "in which a shift in the metrical structure occurs in such a way that the same moment in a piece serves a double metrical function. The transformational rule deletes one set of dots in favor of the other at the musical surface" (ibid.).
Beats are thought of as having no duration, as merely points in time, in contrast to groups which have duration. Therefore the metrical analysis assigns metrical stress to beats within groups but not to groups itself. "Just as groups as such do not receive metrical stress, metrical structure

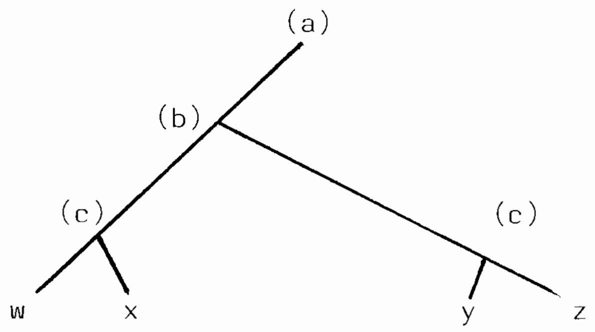
as such does not posess any inherent grouping" (Lerdahl & Jackendoff 1977, 123).

3.2 Pitch reduction

3.2.1 Time-span reduction

Time-span reduction is the first of the two types of pitch reduction. The two reductions assign relations of relative prominence to all the pitch events in a piece. In the structural description the two reductions are represented by different kinds of trees. "The fundamental relationship which they express is that of a sequence of pitch events as being an elaboration of a single pitch event. The dominating event, that of which a sequence of events is an elaboration, is always one of the events in the sequence; the remaining, subordinate events in the sequence are heard as relatively ornamental. 'Reduction' - the process of recursively substituting single events for sequences of events - can be thought of as the inverse of elaboration" (Lerdahl & Jackendoff 1977, 129).
In the tree notation for the time-span reduction, Lerdahl & Jackendoff distinguish "right" and "left" branches. A right branch indicates the subordination of an event to the preceding event within that region at that level. Correspondingly, a left branch indicates the subordination of an event to the following event within that region at that level. If we look at

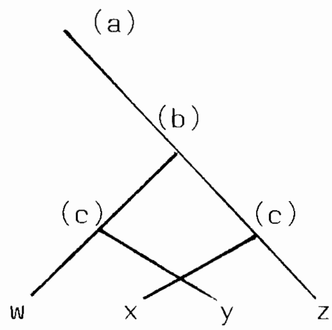
(31)

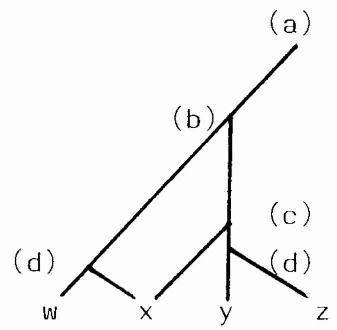


w and x build a right branch, y and z a left branch. Additionally, the subordinated event of a branch is called 'ornament' or 'elaboration', whereas the structurally more important event is called the 'head' of the branch. In (31) z is the head of y and z, and w is the head of w and x and at the

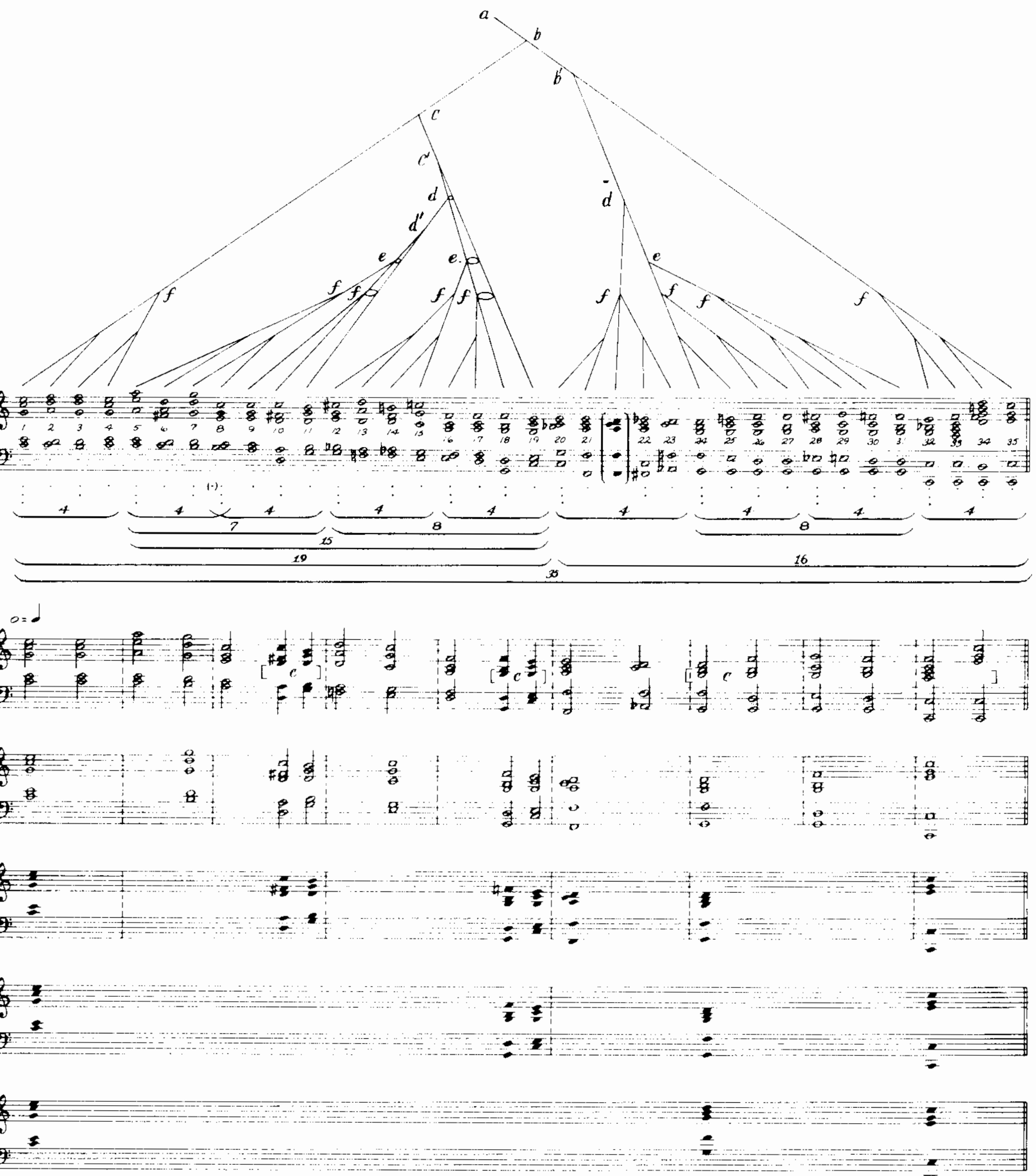
same time the head of the passage w, x, y, and z, with x, y, and z as an elaboration of w.
The well-formedness conditions for these trees forbid the crossing of branches and the assignment of more than one line of the tree to the same event, as is shown in (32 a + b), respectively:

(32) a) b)





Elaboration in the time-span reduction is "elaboration at successive levels within more or less equally spaced, discrete time-spans. Within each time-span, or region, a dominating event must be found; that is, all other events in the region are elaborations of that event" (Lerdahl & Jackendoff 1977, 129/130); as is the cas in (31).
In relation to grouping structure and metrical structure regions of application are selected at every hierarchic level in order to erect tree structures. When the regions of application are given, the preference rules for the time-span reduction select the syntactically most coherent reduction(s) of a set of pitch events from all the possible ones. Syntactic coherence is here thought of in terms of stability. "These preference rules are classified as (a) those which ascertain the most stable structure (the tonic), and (b) those which establish the hierarchy of relative stability in relation to the most stable structure" (ibid.). Globally the preference rules select the dominating pitch event in a given region.
Furthermore Lerdahl & Jackendoff introduce conceptions of 'structural beginning', 'structural ending', and 'cadence' of a group. These notions do not concern us here. In (33) we have the complete structural description of a passage for the three hierarchic structures discussed up to now:



Lerdahl & Jackendoff 1983, 262

"The relation of pitch structure to metrical structure is expressed by the placement of the syntactically most significant event within a bracketing on the strongest beat within that bracketing" (Lerdahl & Jackendoff 1977, 131). Beneath the musical notation there appears a notation formally equivalent to the tree of time-span reduction. Lerdahl & Jackendoff retain both representations to the time-span reduction, because one is useful in bearing any particular hierarchic level, while the other one gives a picture of all the levels in relation to one another.

3.2.2 Prologational Reduction

The second part of pitch reduction is the prolongational reduction. On this structural level events are not measured according to some metrical conception like time-span reduction, but events come before or after other events. Elaboration in the prolongational reduction is "elaboration by harmonic and melodic connection" (Lerdahl & Jackendoff 1977, 140).
There are two kinds of elaboration involved with the prolongational reduction: prolongation and contrast. In <u>prolongation</u> a pitch event is elaborated into two or more copies of itself. In the structural description prolongation is represented by two branches extending from a small circular node. None of the events has hierarchical priority; "rather, both events are thought of as an extension over time of what at a deeper level is the same event" (ibid.). On the other hand, <u>contrast</u> appears as an additional different, relatively ornamental, pitch event. Like in the time-span reduction, <u>contrast</u> designates a hierarchic subordination by means of right and left branching. But, "whereas in the time-span reduction these branchings only indicate the subordination of one event to another, in the prolongational reduction they receive a further interpretation. A right branch signifies <u>progression</u> in a piece, whether at a local level (...) or at a large structural level. A left branch is utilized only at local levels and signifies <u>delay</u> in relation to the bass" (ibid.).
The well-formedness conditions and the preference rules for time-span reduction and prolongational reduction are similar. The well-formedness conditions for the prolongational reduction forbid the crossing of branches and the connection of more than one branch to the same event. "Given a sequence of pitch events, the preference rules select a hierarchy according to principles of stability largely resembling those for the time-span re-

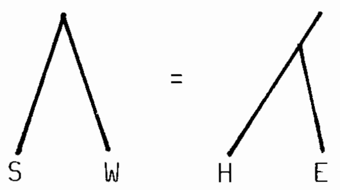
duction (...). At any given level down to the phrase level, the sequence of events available to the preference rules for the prolongational reduction is precisely the same sequence as at the equivalent level in the time-span reduction" (Lerdahl & Jackendoff 1977, 142). But that does not imply that one of the reductions can be dispensed with or that with two kinds of reduction a piece is structurally ambiguous. "The two reductions represent different aspects of one understanding of the piece, i.e., different aspects of a single structural description. Ambiguity arises only when a piece can be assigned more than one complete structural description (...). The time-span reduction accounts for pitch structure as heard in the actual flow of time, partitioned into approximately even spans in a hierarchic fashion by grouping structure and metrical structure (...). The prolongational reduction accounts for pitch structure as heard, insofar as possible, in terms of its internal organization, without respect to other parameters" (Lerdahl & Jackendoff 1977, 146).

3.3 Metrical phonology and the formal theory of tonal music

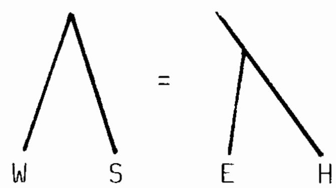
In their article "A grammatical parallel between music and language", Lerdahl & Jackendoff work out in detail the relationship between metrical phonology and their formal theory of tonal music. The grammatical parallel is carried out for one of their hierarchic structures, the time-span reduction, and the prosodic constituent structure. I will summarize some of their results here.

The first astonishing point is that the formalisms, i.e. the trees, used in the time-span reduction and in the prosodic structure are notational variants. In both representations we have branching trees that are classified according to a binary opposition: head vs. elaboration in the tree of the time-span reduction and strong vs. weak in the prosodic tree. (Although ternary branching is permitted in the time-span reduction). Taking HEAD as parallel to STRONG, the equivalence of the tree structures can be established as shown in

(34) a)



b)



The designated terminal element, that is to say the element only dominated by S's, in metrical phonology can be translated into the notation of the time-span reduction as the HEAD, that is that unit from which all others branch.

But that is not the only observation. Time-span reduction and prosodic structure are both the products of formal grammars "that carry out formally parallel operations on musical and phonological strings. In each case, the string is segmented into a layered hierarchy, in which each layer provides at least one exhaustive segmentation. A set of possible tree structures is defined in precisely parallel fashion over the segmentations; and preference rules or prominence rules determine which of the possible trees is the correct one" (Lerdahl & Jackendoff 1982, 111).

The interesting problem arising here is that two theories, developed independently to deal with totally dissimilar phenomena have reached equivalent notations to express their analyses and whether this fact has something to do with rhythmic universals.

4. Concluding remarks

This point tries to describe some problems arising with the theories outlined above. Looking at the developments discussed in phonology, metrics, and musicology, especially under the aspects of formal theories and formal grammars, one can assume the existence of an abstract rhythmical grammar. A related point is whether such a rhythmical grammar can account for rhythmical universals, if one actually can suppose rhythmical universals. Turner & Pöppel (1983) go even further, they assert: "Metrical poetry is a highly complex activity which is culturally universal" (285). For them, the correspondence between poets and metered poetry in widely different cultures "points to an identical neurophysiological mechanism" (ibid.). Sloboda (1985) discusses the problem of musical universals[14] in connection with the dimensions of pitch and time. Both, Turner & Pöppel (1983) and Sloboda (1985) deal with hierarchical structures[15], as the above sketched theories do. Is it therefore reasonable to assume a hierarchical organization of rhythm rather than a linear one? To answer this question and the question of rhythmical universals one has to study other human abilities showing this principles of organization, i.e. temporally structured cognitive capacities. Psychological theories of temporal organization seem to be crucial in this context.

Looking back at the theories sketched out above there arise problems related to the used formalisms. First one can ask whether the time-span reduction in musicology gives evidence for retaining the tree conception in phonology and metrics. Are there psychological and other empirical arguments in favor of metrical trees or metrical grids, or are there even other possibilities? Related to the notion of trees the problem exists if it is possible to retain the principle of binary organization. Slododa (1985) gives a further argument in favor of binary branching: "rhythmic asymmetries are often constructed on a principle of binary subdivision of the metrical unit" (259). Concerning the hierarchical structure of the different formal grammars one can ask for their relationship: does, for instance, the metrical grouping structure in musicology bring evidence for the prosodic foot level?

Notes

[1]Cf. Giegerich 1983a, 1983b, 1985, Hayes 1981, Kiparsky 1979, Prince 1980, Selkirk 1980, 1984, Dogil 1985.

[2]Metrical phonology is one part of a new development in phonology which is called 'Non-linear Phonology'. The other part, called 'Autosegmental Phonology', will not be discussed here. For an overview on both parts see van der Hulst & Smith 1982.

[3]A note beside: Liberman & Prince call the trees in (5a) 'feet', but the notion 'foot' is not explicitly defined in their system and plays no role there.

[4]A similar idea is carried out by Hayes (1981) who distinguishes bound and unbound feet and also beteen binary and ternary feet.

[5]Another concept of generative metrics developed in the paradigm of metrical phonology is Koster 1984.

[6]Cf. Barsch & Schmidt 1981, Küper 1986.

[7]This mismatching is allowed because the S in the W position is no lexical stress.

[8](19) and (20) are Kiparsky's examples.

[9]Hayes does not discuss the question whether stress peaks that are also stress valleys bear problems.

[10]This is the reason why I used a lot of quotations in this chapter.

[11]Cf. Lerdahl & Jackendoff 1977, 1983.

[12]Cf. Bernstein 1976, Sundberg & Lindblom 1970, 1976.

[13]Lerdahl & Jackendoff 1977 they had not got acquainted with the phonological theory of Liberman & Prince. Later on they worked out the parallels and differences between music and language (Lerdahl & Jackendoff 1982).

[14]Sloboda 1985, 253ff.

[15]See also Pöppel 1986.

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