Lodewijk Muns

Music, Language, and the Deceptive Charms of Recursive Grammars

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Why should we think of a theory of music as 'grammar'?

One reason could be that there is an obvious analogy between language and music. Both make use of sounds, which also may be represented in writing. In their sonic existence both have a temporal or linear structure.

An important proviso must be made at once: though speech is considered language's default mode, it seems to be non-essential. Gestural languages and writing are fully adequate manifestations of language. In speech as a coupling of sounds and meanings, the sounds are arbitrary signs. Music exists uniquely in and through sound.

If we omit the sonic element from their commonalities, linear structure remains. It is often emphasized that this structure, in both music and language, has hierarchic features – at least in the western tonal music of the past four centuries. 'Grammar' is then taken to mean the description of this hierarchic structure – as a set of rules operating upon discrete elements, which allows us to produce and parse well-formed strings or sentences.

That is a narrow use of the word 'grammar'. Actually, it is syntax.

If we speak of the grammar of language in its traditional broad sense, including phonology, morphology, lexicon, semantics, and possibly pragmatics and discourse, many more interesting things may be said about the analogy between music, in particular classical music, and language.

That is the subject of my book, *Classical Music and the Language Analogy*, which is presently in search of a publisher. I will now focus however on grammar in the narrow sense which has been current in modern linguistics, and in which it has also been applied to music. Most influentially, through the *Generative Theory of Tonal Music* by Fred Lerdahl and Ray Jackendoff, published in 1983.

This theory has met with some strong criticism early on. Even so, it is still widely accepted as a milestone, and a truly thorough critical evaluation is, surprisingly, lacking. For now, I can select only one particular aspect of the theory, which I will relate to a broader historical and ideological context.

In their vision of what a theory of music should be the authors are strongly influenced by Generative Grammar, introduced by Noam Chomsky in the late 1950's.

Language is in Chomsky's view primarily inner language of thought, and only derivatively an instrument of communication. Linguistics should therefore study language as a mental object. This mental object, in turn, is narrowed down to grammar, and grammar involves those aspects that may be optimally formalized, in particular, syntax. Grammar, and hence language, is essentially a computational system within the human brain.

On these premises, Generative Grammar purports to describe what happens in our minds when we speak and understand a language. It does so by stipulating grammaticality conditions for a unit that is both basic and maximal: the sentence.

GTTM attempts to implement a similar model within the domain of music. It describes what happens within a musically competent listener who 'parses' a composition, from eight bar blues to symphonic movement.

The authors defend this transfer of an (in itself controversial) linguistic paradigm to music by transforming their psychological thesis into an ontological one.

> *The present study will justify the view that a*
> *piece of music is a mentally constructed entity,*
> *of which scores and performances are partial*
> *representations by which the piece is*
> *transmitted.*
> GTTM (= Lerdahl and Jackendoff 1983): 2.

The 'work' is in the mind, as a final state of understanding, conceived through a process in time, but idealized as a timeless totality.

Their appeal to the theory as justifying their ontology really turns things upside down. It is this vision of the 'inner work of music' which allows the authors to do psychology with the means of music theory. Without the 'inner work', the theory looses its psychological content.

Their choice of words is remarkable. Though neither scores nor performances can exhaust the 'work' concept, a performance at least is, in common parlance, a 'realization' (even if partial and non-definitive) rather than a

'representation'. The representation is, rather, an ephemeral actuality in the listener's mind.

According to Generative Grammar, the structure of a sentence is the result of a mental computation process. This explains some of the faith Chomsky has put into one aspect of hierarchic structure, recursion. A recursive function or procedure is a procedure which calls upon itself, or in other words, is repeated upon its own output.

Suppose that Rembrandt copied a painting by Rubens, who had copied it from Romano, who in turn had copied Raphael. That would have produced a recursively copied painting, and the sentence that describes it may be thought to have recursive structure.

```
                              S
                         /         \
                      NP            VP
                      |           /    \
                 Rembrandt   copied     NP
                                      /    \
                                    NP      S'
                                    |      /  \
                                 Rubens WHNP   S
                                        |      |
                                       who     VP
                                            /     \
                                        copied     NP
                                                 /    \
                                               NP      S'
                                               |      /  \
                                           Romano  WHNP    S
                                                    |      |
                                                   who     VP
                                                        /     \
                                                    copied     NP
                                                               |
                                                            Raphael
```
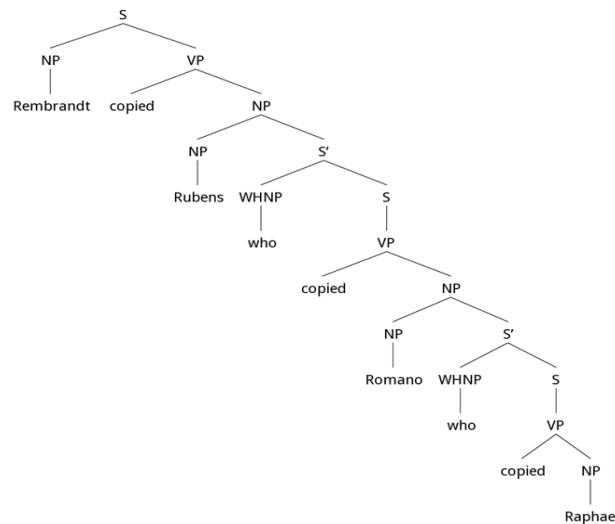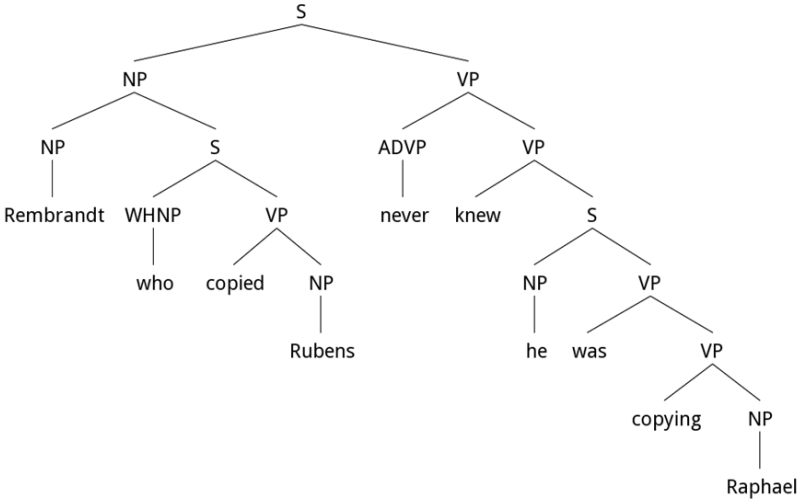
[Rembrandt copied Rubens [who copied Romano [who copied Raphael]]]

Ignoring the actual details of syntax, we might stipulate a recursive rule which allows us to replace the name of a painter with that name plus a relative clause including another name from some lexicon of painters.

However, we might argue that this sentence is simply a concatenation of three sentences, *Rembrandt copied Rubens, Rubens copied Romano, Romano copied Raphael*, with the relative pronoun as a kind of contractive device. It produces tail recursion, in which elements are always added on one end, as visible in the triple bracket on the right. The truly recursive character of such constructions is in doubt, even though conceptually there is a recursive aspect.

More convincing as an instance of syntactic recursion is centre embedding, where there is an interruption in the structure. For instance with an embedded relative clause: *Rembrandt, who copied Rubens, never knew he was copying*

Raphael. It is recursive not just because there is one element inside another, but because there is a similarity or functional equivalence between both elements. Both have sentence structure.

```
                              S
                 ┌────────────┴────────────┐
                NP                         VP
          ┌──────┴──────┐           ┌──────┴──────┐
         NP             S          ADVP           VP
          │        ┌────┴────┐       │       ┌─────┴─────┐
     Rembrandt   WHNP       VP     never    knew         S
                  │      ┌────┴────┐             ┌────────┴────────┐
                 who   copied     NP            NP                VP
                                   │             │          ┌─────┴─────┐
                                 Rubens         he         was          VP
                                                                  ┌──────┴──────┐
                                                               copying         NP
                                                                                │
                                                                             Raphael
```

[Rembrandt [who copied Rubens] never knew [he was copying Raphael]]

The hypothesis of Generative Grammar is that such structures are produced by recursive mental computation. With a limited set of words or lexicon, and a limited set of rules without recursion, there will be an upper limit to the number of permutations allowed or 'generated' by the grammar. Chomsky reasonably assumes that the expressive power of natural language is unbounded. He deduces from this that the generativity of the grammar must be infinite. The clue to this is unbounded recursion. Any sentence generated can be embedded in some other sentence.

The issue has come under particularly intense debate since an article written in 2002 by Chomsky together with biologists Hauser and Fitch. It proposes that there is one component of the mental Faculty of Language which is both uniquely human and specifically linguistic, and that it consists of the capacity for recursive computation.

There are many things that may be said against it. Most importantly, maybe, that the expressive power of language seems not to depend on it. Generative Grammar relies on a strictly synchronic, a-historical view of language, which may well be an unrealistic abstraction.

The self-similarity of recursion may be just an incidental aspect of syntax. A hierarchy is recursive if its levels are generated in a uniform manner. But under

a sufficiently abstract or vague description *any* hierarchy is recursive. Every hierarchy consists of higher and lower levels, or more and less inclusive sets. Speak of 'levels' or 'sets', and we have a uniform aspect.

This is the source of what I have called 'deceptive charms'. The risk is that by excessive abstraction (or just vagueness) a theory may create an appearance of pervasive similarity and connectedness, while all that is done is playing with words. This poses a problem of metatheory, which has kept resurfacing in science and philosophy ever since antiquity.

The article I referred to was inspired by a new turn in Generative Grammar, initiated by Chomsky in the 1990's, the Minimalist Program. In Minimalism, the role of recursion is maximized. Every operation of syntax is explained as the formation of a set of two elements, an operation called Merge. The dominant element or head of this pair is duplicated outside this set and available for Merge at the next level. As represented in one version of minimalist theory (Bare Phrase Structure Grammar), there is no labelled phrase level that marks the interpretation of an element as, say, Noun Phrase. This may then be represented with a tree diagram that shows a dominant branch extending upward directly from the word.

Rembrandt, who copied Rubens, never knew he was copying Raphael.
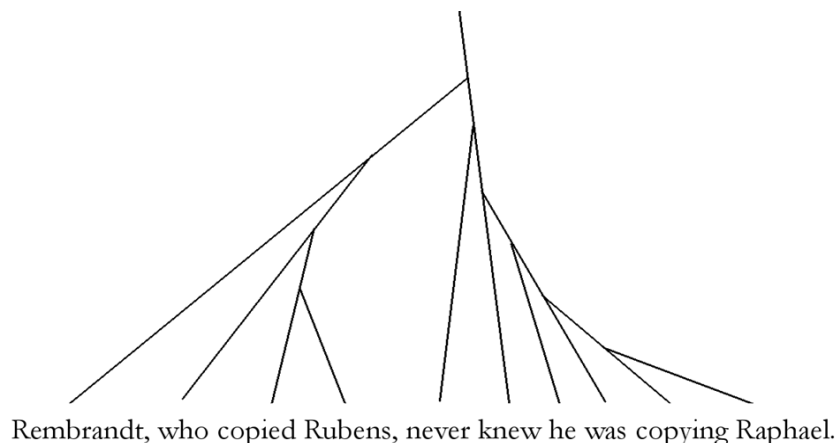
The tree implies uniform relations, all due to recursive Merge, but evidently there are differences to be accounted for *somehow*. The relation between article and noun is not of the same kind as that between verb and direct object.

This example allows me to make a smooth transition back to GTTM. This particular type of tree diagram is familiar to its readers, and was in fact a novelty in the book, which predates Minimalism.

Bach, Matthew Passion Nr. 53, Chorale.
Partial analysis after GTTM fig. 6.12 and 6.25.

This famous figure shows a fragment of a Bach chorale setting, as analyzed by Lerdahl and Jackendoff in what they call Time Span Reduction (TSR). It produces a parsing tree which extends over a whole composition, as if it were a sentence.

The first thing we should notice about this chorale is that it is a melody in the Phrygian mode, with a tonal harmonization. It is uncertain how this setting is perceived as 'tonal music'. As a whole, it seems to me neither directed toward the end, nor dependent on the beginning. It maintains, rather, an unresolved suspense between B minor and D major.

If we look at the details, there are various principles by which one tone or chord may be thought more important than another: suspensions, passing notes,

inversions, harmonic resolution. TSR is based on a notion of structural importance, but this is a rather vague and weakly defined notion embracing, mainly, factors of key definition.

In practice, TSR is a harmonic reduction upon which a metric hierarchy is imposed by picking one chord per time interval. The motivation for this kind of analysis is given in GTTM's *Reduction Hypothesis*, which stipulates an exhaustive "hierarchy of relative importance", with the most important 'events' constituting a kind of skeleton.

> **Reduction Hypothesis.** *The listener attempts to organize all the pitch events of a piece into a single coherent structure, such that they are heard in a hierarchy of relative importance.*
> (GTTM: 106)

This produces successive reductive levels.

Leaving out the passing notes, as at the top right, is uncontroversial, and coincides with a reduction at the quarter note level. Going one step further leaves, at the half note level, two D major triads in bar 1.

The authors speak of these relations in terms of 'elaboration'. I find it hard to give any meaning to the assertion that, for instance, a harmonic degree V generally 'elaborates' I, or that this reduction represents any listener's perception. Evidently, the chord succession allows us to infer that this bar is in D major. That does not mean that at some deeper level there are just D major

triads, or even that these triads 'make' the key. It is the progression that establishes the key. Not every set of scale notes 1, 3 and 5 is a tonic. That interpretation takes place at a higher level of syntactic function, not by filtering out some notes.

This recursive structure, imposed upon the whole piece, therefore derives from a dubious abstraction over a diversity of relations.

I must note that Jackendoff, who is a linguist, is among the strongest critics of Minimalism. It is also true that his own linguistic orientation has developed since the 1980's in a less formalist direction. But this has not led to a significant re-evaluation of GTTM.

The direct inspiration for GTTM's recursive reduction practice is not so much Generative Grammar as *Schenker theory*. The Schenkerian approach entails that a higher hierarchic level is established by residues from surface events, selected notes or pitches, rather than scale degrees or harmonic functions. In both Schenker theory and GTTM, a higher structural level is explained as a direct relation between nonadjacent, concrete moments in the surface.

Schenker has a clear motive for this practice; it is his claim that all levels are governed by voice leading. In GTTM, the motivation is less clear.

Leonard Meyer, who argued against Schenkerism in the 1960's, spoke of "the fallacy of hierarchical uniformity". The fallacy, according to Meyer, is a failure to acknowledge that at different levels of organization different principles are at work. I think Meyer was right.

Such differentiation of functions is evidently not present in all kinds of hierarchy. It is absent from the most simple and static recursive structures, such as a pyramid built out of blocks, or musical metre. But in music, patterns of succession from note to note are not the same as those between chords and between tonal regions.

The confluence of Schenkerism and Generative Grammar is one of history's curious coincidences. It has often been claimed that Schenker anticipated Generative Grammar. According to Schenker, the composition is 'generated', in a loose sense, through transformations from a basic principle, the *Ursatz*, resulting in a quasi-axiomatic recursive-hierarchic structure.

The magic word is 'axiomatic'. In the 1950's it allowed his admirers in the US to praise Schenker in terms very similar to those used for Chomsky's

Syntactic Structures, when it appeared in 1957. It is a strange meeting of mathematical formalism, logical positivism, Cartesian rationalism and German Idealism around one basic intuition, that an infinite variety may be explained through the recursive application of a single principle.

That is almost literally the definition Goethe gave of plant morphology, which he introduced in 1790. He defined it as the attempt "to reduce all manifold, individual phenomena of the world's wonderful garden to one general, simple principle". The key to his vision was self-similarity, as expressed in his famous dictum, "Alles ist Blatt", every part is a leaf. It is likely to have been inspired by certain cactuses.

As is well known, morphology has made a revival through the mathematics of fractals, and in particular so-called Lindenmayer systems, which generate plant forms through recursive algorithms. It is particularly striking that the Lindenmayer formalism is based on the same kind of rewrite rules as Generative Grammar.


```
d                          e                          f
n=7,δ=20°                  n=7,δ=25.7°                n=5,δ=22.5°
X                          X                          X
X→F[+X]F[-X]+X             X→F[+X][-X]FX              X→F-[[X]+X]+F[+FX]-X
F→FF                       F→FF                       F→FF
```
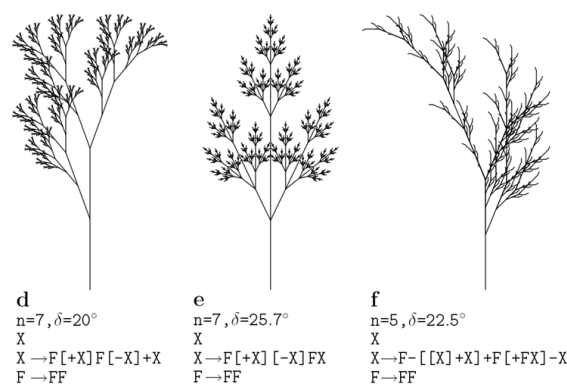
Figure 1.24: Examples of plant-like structures generated by bracketed OL-systems. L-systems (a), (b) and (c) are edge-rewriting, while (d), (e) and (f) are node-rewriting.

P. Prusinkiewicz and A. Lindenmayer. *The Algorithmic Beauty of Plants.* New York: Springer-Verlag, 1990. http://algorithmicbotany.org

More directly, Goethe's morphology has contributed to the rise of organicist aesthetics, which is the framework within which Schenker theory must be understood. For Schenker, the triad is the generative source of the key, the tonal system, and the composition. His attempt to reduce the musical manifold to one general, simple principle was made in opposition to the tendencies of his time, the early 20th century. It expresses not merely a reactionary, but a nostalgically utopian stance.

The same can be said even of the earlier theory of Moritz Hauptmann, who published his *Natur der Harmonik und der Metrik* in 1853. This book decisively influenced Hugo Riemann. Hauptmann's conceptual apparatus was the dialectic of German Idealist philosophy, blended with Goethean organicism.

For Hauptmann, the general formative principle is a dialectical progression from 'direct unity', embodied in the octave, through 'division', or the fifth, to 'indirect unity', the third – recursively repeated at several levels. The key is explained as an 'exponentiation' of the triad so constituted. 'Exponentiation', or *Potenzierung*, is probably the most simple example of recursion in arithmetic.

We find this idea of recursive 'exponentiation' again in Hugo Riemann's article and dissertation *Musikalische Logik* of 1872 and '73. Riemann applies the dialectical threestep of thesis-antithesis-synthesis first to the cadence, with Tonic, Subdominant and Dominant, then reapplies it to structural levels both lower and higher, from individual notes to phrases.

Beethoven, Sonata op. 2 nr. 1/2; analysis after Riemann [1872] 1895 vol. 3: 7-8.

This Beethoven example represents an incomplete and somewhat obscure schematic analysis. We see cadential degrees assigned even to the non-written notes of the turn in bar 1. Proceeding recursively to the higher levels of harmonic areas, Riemann arrives at what he calls an "exponentiation" of "cadences within a cadence".

This example may illustrate what I consider recursion's deceptive charms. The cases of Hauptmann, Riemann and Schenker also show how a sideline of the famous Cartesian ancestry of Generative Grammar went through a romantic phase, which allowed it to bond with the aesthetics of so-called 'absolute music'.

It is striking that recent arguments for linguistic Minimalism often appeal to aesthetics. The central place given to recursion primarily satisfies a demand of computational efficiency. In the metatheory of Minimalism, efficiency makes place for 'simplicity', simplicity for 'perfection', and perfection for 'beauty'. Chomsky and some of his followers have argued that it is an ideal of beauty that has guided the search for natural laws by great scientists from Galileo to Steven Weinberg.

Nobody, I think, will deny that a sense of beauty has some relevance in the creation of scientific theories. But beauty cannot be a criterion established in advance. The Copernican heliocentric model simplified planetary orbits, but until Kepler it was assumed that these *must* be circles, since the circle is incontestably, in the Pythagorean paradigm, the most simple, perfect and beautiful form.

Pre-established ideas of simplicity, naturalness, beauty and purity have often shaped conservatively utopian, irrational theories – those of Hauptmann and Schenker being particularly striking examples. What they have in common is a tendency to drift away from the empirical world and develop into ethereally abstract chimeras.

It is maybe not so surprising, therefore, that the ontological thesis I quoted earlier reflects a vision of music which, despite its professed affinity to cognitive science, is strongly conditioned by an idealist inheritance, including the idea of absolute music.

In my abstract I promised an alternative. There is too little time to elaborate on that. Instead of giving a full sketch, I will therefore briefly conclude with two theses and leave them open for discussion.

First, there is no need to assume that in the various ways in which we speak of a 'work of music' *x* there is a single, ontologically stable *x*. In practice, we refer to different selections from a broad range of historical and psychological *facts*.

Second, since music is art and imaginative play, its strongest language-likeness may lie within the realm of *discourse* rather than in its basic grammatical structure.

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