# Art. 154: Semiotic Aspects of Musicology: **Semiotics of Music**

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# 1 PRELMINARIES

## 1.1 Topography of Music

### 1.1.1 The Ontological Topography of Music

The role of semiotic aspects in musicology is best described from the complex ontological topography of music. We start this article from the fundamental description [70], stating that “music is communication, has meaning and mediates on the physical level between its mental and psychic levels”. This fact suggests that three ontological dimensions: reality, communication and sign are described to locate facts that deal with music. It turns out that each dimension specifies three aspects, corresponding to three coordinate values on the cube of musical topography, see Figure 1. For the relation of this scheme to the generic model of semiosis (5.1.2 of this handbook), see 1.1.1.3 and 1.1.3.

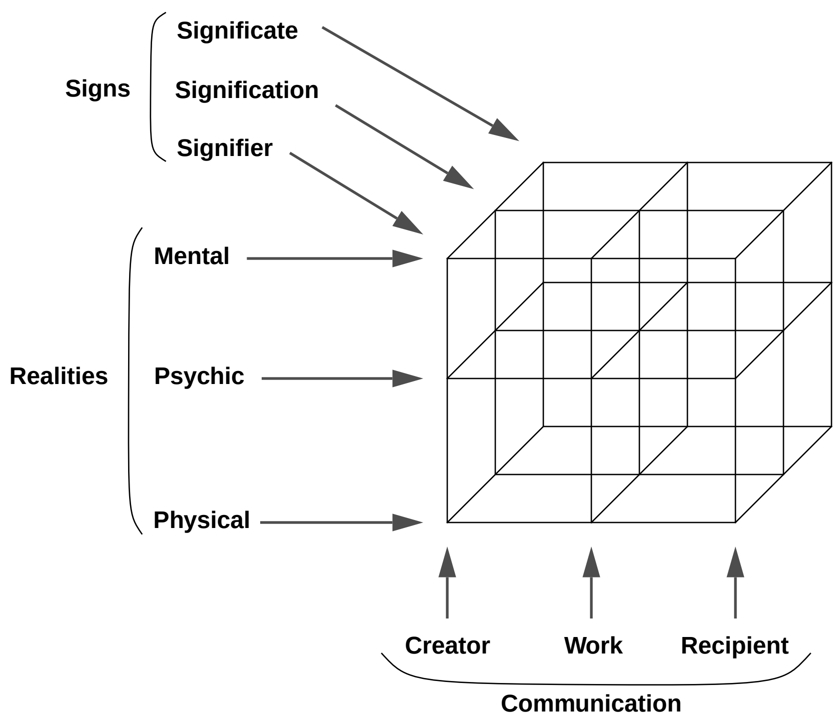



Figure 1. The cube of musical topography

This preliminary investigation makes evident that the study of music is not reducible to the 'dimension' of semiotics, but that the latter is one of three pillars of musical ontology.

*1.1.1.1 Levels of Reality*

Music takes place on a wide range of realities. They may be grouped into the physical, the mental and the psychic level. Differentiation of realities is crucial for avoiding widespread misunderstandings about the nature of musical facts.

A representative example of this problem is Fourier’s theorem roughly stating that every periodic function is a unique sum of sinoidal components. Its a priori status is a mental one, a theorem of pure mathematics. In musical acoustics it is often claimed that—according to Fourier’s theorem—a sound “is” composed of “pure” sinoidal partials. However, there is no physical law to support this claim. Without a specific link to physics, Fourier’s statement is just one of an infinity of mathematically equivalent orthonormal decompositions based on “pure” functions of completely general character, see [27], chapter VI. To give the claim a physical status, it is necessary to refer to a concrete dynamical system, such as the cochlea of the inner ear, which is physically sensitive to partials in Fourier’s sense.

Methodologically, there is no reason nor is it possible to reduce one reality to the others. Rather, the problem is to describe the transformation rules from the manifestation of a phenomenom in one reality to its correspondencies within the others.

We now give an overview of the three fundamental topoi of reality and their specific characters.

*1.1.1.1.1 Physical Reality*

Music is essentially manifested as an acoustical phenomenon, made through special instruments and listened to by humans. Nonetheless, its acoustical characteristics are less—if at all—condensed within an objective physical sound quality than in the physical input-output systems for sound management. Musical sounds are above all signals within a semiotic system. Their use is a function of very special devices for synthesis and analysis of physical sounds. To this date, there is no generally accepted classification method of musical sounds. This is not due to missing synthesis or analysis methods and techniques. The problem is rather that classification of musical sounds is arbitrary without reference to their semantic potential. As physical events, musical sounds are always natural, be they produced by a live violin performance, a computer driven synthesizer via loudspeakers or by the tape patchwork of musique concrète. The physical reality of music is only relevant as an interface between 'expressive' and 'impressive' dynamical systems. Besides classical analog sound synthesis methods as they are realized on musical instruments, there are various digital sound synthesis methods [97].

On the other hand, the central receptive system for music is the human auditory system: Peripherical and inner ear, auditory nerve, its path through multiple relays stations of the brain stem, the neo- and archicortical centers for auditory processing and memory, such as Heschl's gyrus and the hippocampal formation [12], [70]. This extremely complex physiological system is far from being understood. Eventhough some insights into the dynamics of the cochlear subsystem do exist, it is not known which analysis of the musical sounds takes place on the higher cortical levels. In particular, it is not clear how the elementary pitch property of an ordinary tone is recognized [12]. This means that on the cognitive level human sound analysis is not yet understood. Therefore, recurrence to particular sound representation models are good for synthesis options, and for speculative models of cognitive science [62], but not as a firm reference to human sound processing. With these restrictions im mind, we shall give a description of common sound parameters in 1.1.3.

##### *1.1.1.1.2 Mental Reality*

Just like mathematical, logical and poetical constructions, musical creations are autonomous mental entities. It is a common misunderstanding that musical notation is an awkward form to designate physical sound entities. Being a trace of intrinsically human activity, the phenomenological surface of music is linked to mental schemes which we call scores: oral or written text frames of extra-physical specification. Scores are mental guidelines to an ensemble of musical objects. They reflect the fact that music is composed as well as analyzed on a purely mental level. Obvisously, scores do point at physical realization, but only as a projection of a mental stratum into physical reality. A fact of harmony or of counterpoint is an abstractum much the same as an ideal triangle in geometry. In this sense, playing a chord on a piano corresponds to drawing a triangle on a sheet of paper.

##### *1.1.1.1.3 Psychic Reality*

Besides its physical manifestation and its mental framework, music fundamentally expresses emotional states of its creators and emotionally affects its listeners. This was already known to Pythagoreans [119] and defined as a central issue of music by Descartes [26], see [21]. Such an emotional reality of music is neither subordinate nor abusive, for the emotion of the music lover is even its dominant aspect. Like other realities of music, this psychic dimension cannot be reduced to others, it is irreducible. In fact, one and the same mental and physical specification may relate to completely different emotional states of either musicians or listeners, i.e. the psychic emanation of music is not covered by its mental and physical specifications.

#### *1.1.1.2 Music as Communication*

Following Molino [82] and Valéry [115] we describe the tripartite communicative character of music which is visualized in the *communication axis* of the topographical cube in Figure 1. Without specifiying their communicative coordinates, musical objects are not fully represented and the discourse risks to fall short. Here are these coordinates in the sense of Molino; an example will follow their description.

##### *1.1.1.2.1 Poietic Niveau*

This niveau describes the sender instance of the message, classically realized by the composer. According to the Greek etymology, “poietic” relates to the one who *makes* the work of art. In specific cultural contexts or in a more refined discourse about art production this instance may also be the musician or the performing artist. In jazz, for example, the improvisational aspect is a genuine making of the music, and the performance of a classical piece of music in any culture is a creational act. The criterion to decide whether an instance of music production is poietic is that it has to fit into a communication scheme *as* a sender with regard to a receiver.

##### *1.1.1.2.2 Neutral Niveau*

This is the medium of information transfer, classically realized by the score. Relating to the poietic niveau, it is the object that has been made by that instance, and which is to be communicated to a receiver. But it is not a pure signal in the sense of mathematical information theory [106]. The neutral niveau is the sum of objective data related to a musical work. Its identification depends upon the contract of sender and receiver on the common object of consideration. We refer to chapter 3.1.2 for a detailed discussion of this concept.

##### *1.1.1.2.3 Esthesic Niveau*

This niveau describes the receiver instance of the message, classically realized by the listener. According to Valéry [115], the concept of esthesis has been created as a distinction from classical aesthetics which is the theory of beauty. The Greek etymology should stress the role of the receiver who perceives the work of art and evaluates it according to his or her particular coordinate system of values.

Exemple. The problem of symmetries in music offers a good illustration of the communication-sensitive aspect of music. A classical conflict concerning the role of the retrograde in music arises from the observation that this construction “cannot be heard and thus is a problematic feature”. Using communication coordinates, this discussion becomes more transparent: The retrograde construction as a poietic technique is a common compositional tool. It fits into the toolkit of contrapuntal constructs for organizing the compositional corpus. On the other hand, the esthesic perspective of the retrograde is concerned with the question whether and how clearly such a construct can be decoded by the listener. This latter question is a completely different topic and cannot be identified with the former. More preciesly, the role of the retrograde as an organizational instance is not a function of its perceptibility as a isoltated structure. The psychological question of whether a retrograde can be perceived is rather this:"Can a retrograde be distinguished from random?" Finally, retrograde structures may be recognized as objective facts within the neutral niveau of the score without being either constructed be the composer or conciously perceived by the listener. Summarizing, the communicative coordinates help localizing and thereby making more precise the musicological discourse.

#### *1.1.1.3 The Musical Sign System*

By use of a highly developed textuality of musical notation as well as by the very intention of musical expression, music is structured as a complex system of signs. This is not only a marginal aspect: Music is one of the most developed non-linguistic systems of signs. As we are really dealing with this subject in this article, the following subsection are merely a first inspection of the fact that music essentially and irreducibly deals with signs.

Notice that we do not make use of the full catalogue of elements of semiosis as presented in 5.1.2.1 of this handbook. In fact, our approach is based on an abstraction relating to the three Saussurean sign components signifiant/signification/signifié according to [6], [15], [102]. In the generic model of semiosis of this handbook, they would correspond to the trias signifier/interpretant/signified. However, we refrain from attributing to the sign structure an explicit psychological or cognitive status since this question is fully accounted on the axis of psychological, mental, and physical realities. To stress this abstraction, we shall always apply the trias signifier/signification/significate in this article. See 1.1.3 for substantial arguments in favor of this abstraction.

##### *1.1.1.3.1 Expressions*

Already the earliest medieval music notation is motivated by the very nature of the graphical neumes: etymologically as well as substantially they are gestural hints pointing at movements in pitch and rhythm. This coincides with the latin etymology of sign: signare = to point at, give a hint. Beyond musical notation, music is often viewed as an expression of emotions, spiritual contents or gestural units. In any case, music has a phenomenological surface that is organized in a spatio-temporal syntax. Albeit more complex than linguistic syntax, the musical syntax shares some of its characteristics, see 2.3.1.

##### *1.1.1.3.2 Content*

According to the famous dictum of Hanslick [42], "the content of music are sounding forms in movement" ("tönend bewegte Formen"). This evidences that the notated complex of musical graphems is not the content but points at some kind of *sounding* content: they mean something. Hanslick's characterization is a minimal semantic setup but at least, some kind of content can be identified. To start with, this type of sign can be taken as a denotative basis for producing different connotative levels of meaning, to be differentiated according to the musical levels of reality discussed in 1.1.1.1, as well as to the communicative dimension discussed in 1.1.1.2.

The remarkable aspect of Hanslick's approach is that it associates musical content with mathematical content. As a matter of fact, a triangle is a mathematical object that essentially reduces to form. But mathematicians do associate it with a content, usually with a platonic entity pointed at by abstract symbols or by drawings with precise quantifications. We come back to this subject in 2.5.2.2.1.

*1.1.1.3.3 The Process of Signification*

Signification is the most important instance for the realization of a sign. It is responsible for the transformation from the signifier to the significate. For musical signs, this semiotic process bears a highly differentiated structure which is sensitive to Saussure's dichotomy arbitraire/motivé [102] and to the dichotomy of lexemata and shifters. We should stress that shifters constitute an important and extended part of musical signs. Without extensive shifter constructs, musicology cannot claim to grasp the core of music, a kernel often invoked when speaking of the magic of musical performance, see 3.2.4.

Music shares a complex interlocking of denotation/connotation layers. This articulation into subsystems of relatively autonomous sign types makes motivation mechanisms crucial constructs in the system of music, see 1.2.2 for an overview.

### 1.1.2 The Local and Recursive Character of the Ontological Topography

Observe that the topographic specification of a fact of music is a local resp. recursive one in the following sense: Parts of a sign may be entire signs of their own right. For example, the significate of a sign in a metalanguage—by definition—is an entire sign of the object language. Also, in the communication chain, the performing artist is a creator for the auditory, but he/she includes an entire communication process, starting from the composer, and being communicted through the score. Third, Regarding levels of reality, an acoustic sound is essentially a physical entity, but its description refers to mental instances, such as real numbers for parameter values.

In other words, the topographical cube yields a local conceptual orientation, and by recursive regression, the topographical description of a fact of music may refer to a complex tree of ramifications, each knot being loaded by a localization within the cube. Supposedly, there is no consistent ontology without such a selfreferential regression.

In particular, it is not necessary to introduce such a thing as a "topographical metacube" for the description of metamusical facts (e.g. harmony syntactics) since a metalanguage precisely means recursiveness on the level of the significate.

### 1.1.3 The Abstraction Principle of the Ontological Topography

Compared to the generic model of semiosis as described in 5.1.2.1 of this handbook, the ontological determinants of music and its semiosis semiosis are separated into three autonomous dimensions within the cube of musical topography. This non-behavioristic abstraction helps putting into evidence constitutional factors in music semiotics. And it is a *substantial* procedure since complex connotational and metasystemic phenomena are described in a canonical way by means of the topographical cube's recursive nature (1.1.2).

### 1.1.4 Parameter Spaces for Musical Objects

This section presents an overview of some representative types of parameter spaces for music. It is a technical tool to be referenced at the occasion of specific discussions.

#### *1.1.4.1 Physical Spaces*

These spaces are the direct acoustical description of sound parameters, such as frequency, loudness, onset time, partial tones etc. Note as a rule that these parameters are not objective and unique data but do only make sense in connection with a synthesis or analysis procedure where they are defined [70]. A well-known elementary but oversimplified representation of a special class of sounds is the Fourier&Envelope approach. The pressure function p(t) of physical time t has the shape

$$p(t) = H_T(t) \cdot F(t)$$

with

a) an envelope function $H_T$ which depends on the triple T = (e,d,A) and on a normed envelope function H (continuous, non-negative time-function, its support is the unit interval [0, 1], and max(H) = 1), see Figure 2.

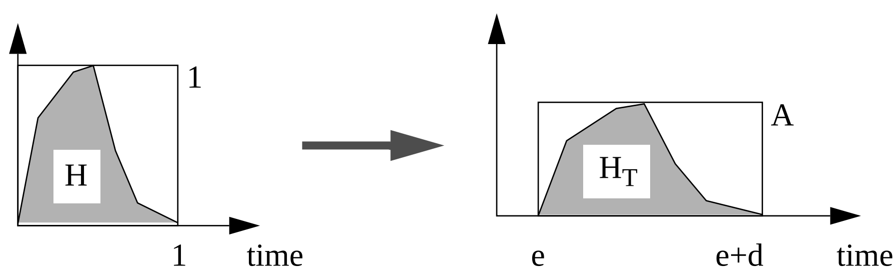



Figure 2. Normed and linearly deformed envelope curve as a function of onset e, duration d and intensity A.

b) a periodic function

$$F(t) = a_0 + \sum_{r=1}^{\infty} a_r \cdot \sin(2\pi r f t + d_r)$$

with frequency f, a normed amplitude spectrum $(a_r)$ and a phase spectrum $(d_r)$.

The *geometric* coordinates are e = (physical) onset, d = (physical) duration, f = frequency or physical pitch, A = intensity (physical dynamics). They project the sound event into a four-dimensional real vector space. The *color* coordinates H, $(a_r)$, and $(d_r)$ are an infinite collection of real numbers and define the sound 'color' as an infinite-dimensional vector, in such a way creating one of the deep problems of classification of sound colors.

There is an *infinity* of other synthesis procedures to define acoustic events, for further details, see [97]. We only mention some well-known types, such as FM synthesis (frequency modulation), wavelet synthesis or physical modeling. Some of these synthesis approaches are also used to analyze sounds by use of corresponding technology. To a limited extent (up to eights partials), the cochlear analysis (but not the cortical analysis) is known to correspond to the above Fourier synthesis [12].

*1.1.4.2 Interpretative Spaces*

Some spaces are not directly physical but they are isomorphic descriptions of physical coordinates. An important example of this type of “interpretative” parametrization is pitch, when defined as pitch ~ log(frequency). This one is measured in [Cent], one [Cent] being 1/1200 of the logarithm of an octave. Interpretative spaces are often motivated by physiological laws, such as Ohms law [22] in the case of pitch.

*1.1.4.3 Mental Spaces*

This type of spaces expresses mental perspectives of music and typically appears in score notation, and in music theory such as harmony or counterpoint; mathematical music theory uses a wide range of such spaces [70].

The most important space parametrizes pitch. For elementary considerations in well-tempered contexts, it is sufficient to define pitch to be a real number $H \in \mathbf{R}$, usually measured in units [semitone] of semitones. For more sophisticated tuning considerations, it is necessary to work in a more generic space, the Euler module. In the most common form, this module is a three-dimensional vector space over the real numbers **R**. So its elements are triples **e** = (o, f, t) of so-called octave, fifth and third components [70]. In a physical interpretation of this formalism, a triple **e** is associated with frequency $f(\mathbf{e}) = f_0 \cdot 2^{o-f-2t} \cdot 3^f \cdot 5^t$, $f_0$ being a reference frequency, usually the frequency of the concert pitch. In the Euler representation, the well-tempered pitches are given by integer multiples of the well-tempered semitone s = (1/12, 0, 0) in the octave direction. Depending on the theoretical context, the numbers are also restricted to rationals or integers. The relation between plain representation of pitch on the reals and the Euler representation is the linear map $p(e) = \log(2) \cdot (o-f-2t) + \log(3) \cdot f + \log(5) \cdot t$, centered around $\log(f_0)$. On the rationals, this is a one-to-one correspondence. Relative pitch such as glissandi or intervals are measured in the same units.

On the time axis, the onset E and the duration D can be measured in [Beat] units. So, a quarter note has duration D = 0.25[Beat]. If we define the start of the first bar of a 3/4 measure composition to stay at E = 0, the onset of a note at the beginning of the third bar has E = 1.5. Here too, the usual values are often limited to particular rationals, such as 1/8, 3/4, as they appear in classical European literature.

For absolute dynamics, the discrete series *ppppp, mpppp, pppp,...p, mf, f, mff,..., fffff* can be gauged by a sequence of successive integers -9, -8,..., -1, 0, 1, ..., 8, 9, centered around *mf* ~ 0, and measured by a score-oriented unit [Dynamic]. Again, this discrete series is embedded in the real axis. Relative dynamics such as crescendo or diminuendo are measured in the same unit.

For mathematical calculations with pitch classes, the Euler module may be reduced modulo selected submodules to quotient modules. In the most common case of pitch classes modulo octaves [70], [84], the octave axis is reduced modulo $\mathbf{Z}\cdot(1, 0, 0)$, and the well-tempered pitches reduce to integers modulo 12.

*1.1.4.4 Technological Spaces*

The physical input/ouput of sounds may be transformed into data formats determined by technological tools. Accordingly, specific spaces are available, for instance MIDI - or FM spaces. In general, these formats are not identical with physical data. For example, the MIDI format for dynamics is [Velocity]. It takes integer values from 0 to 127 and is a data of purely technological significance. Its physical correlate depends upon several gauging presets. Technological spaces may be thought of as being an intermediate construct between physical and mental spaces. The key number on a traditional keyboard such as a piano or a harpsichord is an early version of a technological parametrization of pitch. Only tuning specifications can associate a physical pitch to such a 'symbolic' key data.

*1.1.4.5 Psychological Spaces*

Physical or physiologically motivated spaces are not sufficient to describe effects of music to humans. Psychometric investigations or psychologically motivated music theories deal with psychologically defined parameters for musical objects. For example, loudness which is measured in [Dezibel] in physical contexts is not adequate for psychological purposes, the human perception needs a non-linear transformation from [Dezibel] to [Phon] and then to [Sone], see [98].

## 1.2 Articulation of Music

### 1.2.1 Necessity for Differentiated Systematization

Musicology has to cope with an extremely complex organism built and grown from a cultural tradition on dispersed levels from instrumental technology to philosophy, from music in medicine to mathematical tools for musical composition. The extent of the musicological phenomenon requires a compartmentalization according to specific strata of meaning. Hence musicology cannot survive without differentiating between distinguished levels of sign subsystems in the spirit of Hjelmslev glossematics [45]. This will be explicated with reference to the topographical ontology, above all sections 1.1.1.1 and 1.1.1.2.

### 1.2.2 Overview of the Articulation in Music

This section gives an overview of a Hjelmslev-type articulation in music according to the scheme shown in Figure 3.

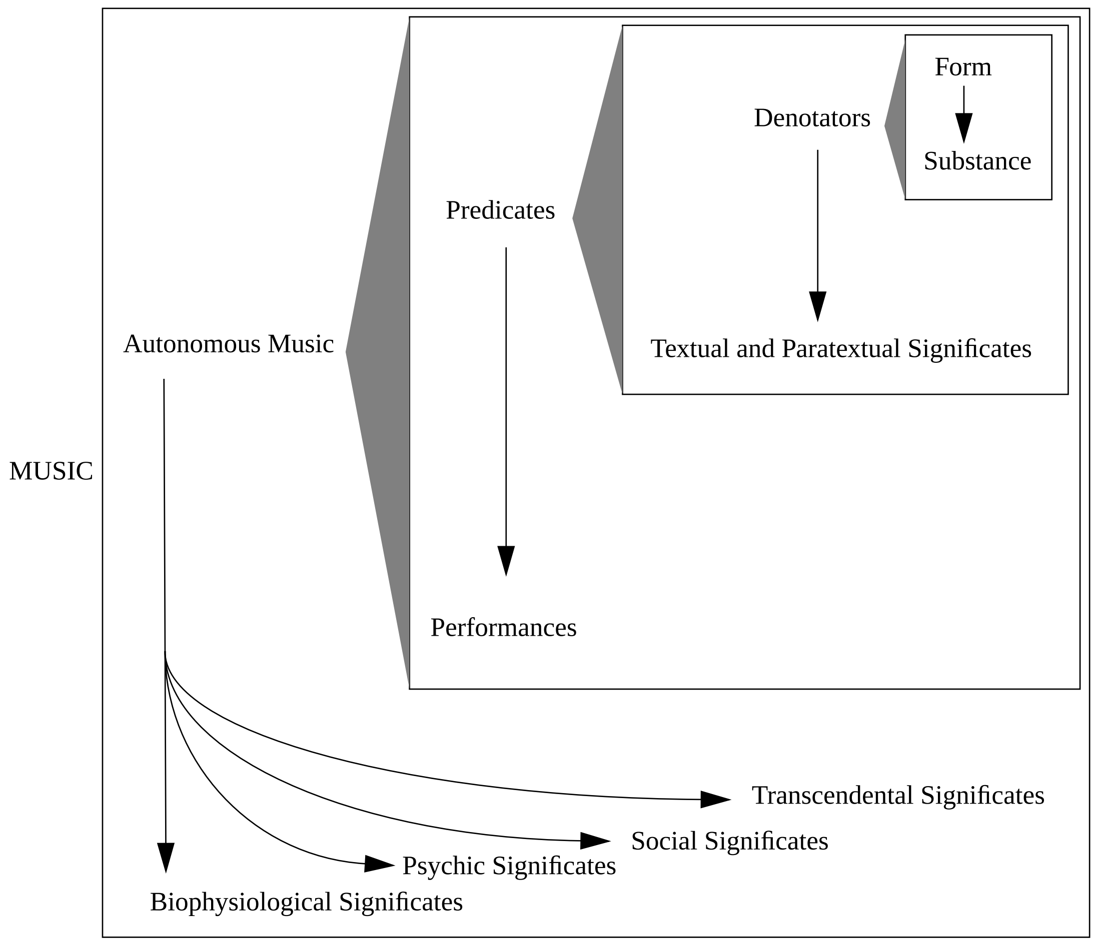



Figure 3. The scheme of articulation in music.

This scheme is shortly presented here and will be discussed in detail in the sequel. Each rectangle is a denotative sign subsystem building the expressive plane for the next supersystem of relative connotation. The arrows designate the signification processes.

Denotators are the elementary signs capturing formalized parameters and names of musical objects as they are represented in spaces of numerical, character or boolean values. These signs share a purely mathematical substance and are retrieved on the level of information technology.

Predicates are the signs built to give denotators in- and extensionally defined meaning. On this level musical notation and music theory position their system.

Predicates are the signifiers for the semiosis of music as a physically performed art. We call it *autonomous* music because it is a full-fledged production system for music, though it does not yet point at psycho-social and ideological significates.

Autonomous music is the denotator level of the full system of music with its biophysiological, psychological, social and trandscendental connotations.

### 1.2.3 Distributed Production of Meaning

The above scheme is a complex form of semiosis, and as a such, it distributes the production of meaning on many layers of the sign system. This has a serious consequence for understanding musicological concepts: As a matter of rule it it not possible to grasp the 'full' meaning of a concept on a single level. For example, the question “What is a motif?” cannot be answered *except* either under specification of the subsystem or as a distributed concept, starting with the definition of the denotators, the Predicates, the performed expression and the entire connotational ramifications.

This is a major change of concept handling in musicology since the traditional concept frameworks are built around the principle that explicit definitions of concepts can only destroy the finesses of the subject, and therefore must be avoided. The result is a permanent crisis of conceptuality fluctuating between complex intention and simplistic technicality. In the case of the above question regarding the motif concept, traditional musicology presents an absolute breakdown of structural description of motifs, burdened with an all-connotational overload of diffuse meaning [96].

The main concern of the following systematic presentation is not to dictate an axiomatic formal construct but to make plausible that the production of meaning should be distributed over several system layers if one tries to model and to understand the involved phenomenon of music.

A word of caution is necessary with respect to the localization of parts within the articulation scheme. For example, the significates of autonomous music signifiers which point to bio-physiological or psychic realities could mislead to the conclusion that these fields (such as bio-physics and psychology) ar parts of music which is wrong, of course. They only furnish the topoi of musical significates, but the specific musicality relies in the sign relations, and not in their local ingredients which reside in autonomous strata of reality.

### 1.2.4 Music and Musicology: The Metalanguage Question

As it is stated, the articultion scheme deals with music and does not specify any metalanguage level which is necessary to give the musicological reflection a semiotical status. However, this systematic extension is straightforward since metalanguage constructs are built as a vertical extension built upon the plane of the scheme, see Figure 4.

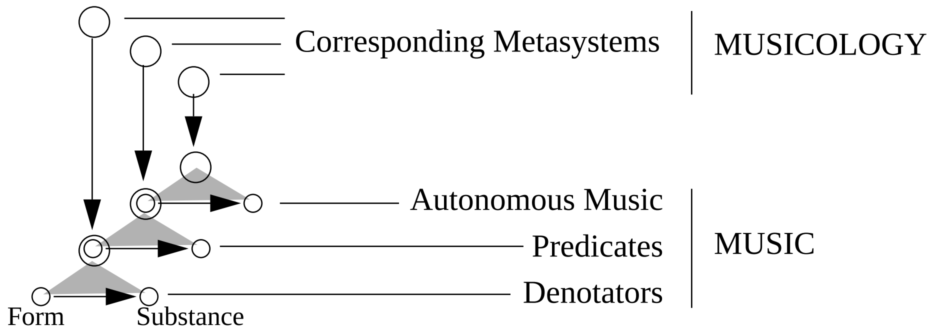



Figure 4. System and Metasystem of Music

# 2 The Mental Sign System

The mental system captures the mental reality of music as an autonomous mind construct and as a counterpart to its physical performance. It includes the subsystems of predicates and denotators shown in the overview 1.2.2.

## 2.1 Denotators

Denotators are introduced as being the basic signs for precise definitions of musical and musicological concepts. They are very explicit elementary signs and may therefore be used to describe the information suitable for music data bases of music technology [127]. For the general theory of denotators, see [80].

### 2.1.1 Form and Substance

#### *2.1.1.1 Topos and Instance — Form and Substance*

The first specification of a denotator is its *form*. The form represents the *space* where the denotator 'lives', i.e. a topos to allocate a concrete denotator as a substancial point within its ambient space. For example, the denotator of a piano note specifies the four-dimensional real vector space $\mathbf{R}^{EHLD}$of onset E, pitch H, loudness L, and duration D, see 1.1.4.3. The space topos for describing musical objects is a fundamental approach and serves the purpose to give a first formal answer to the question “Where are musical objects resp. signs?”. The variety of admitted forms is described in 2.1.2.

Within such a space, a denotator is specified as a selected point. It is an instance of this topos, a piece of substance realized within the given form. The precise definition of denotators as instances is given in 2.1.3.

##### *2.1.1.1.1 Elementary Signification by Pointers*

A universal signification tool on many levels of semiosis is the *pointer.* It is understood as a well-defined directed association of a first object $O_1$ to a second object $O_2$ which we denote by $O_1 \rightarrow O_2$. It has *no extra meaning* apart from this reference. In mathematical terms it is an ordered pair, the basic concept of the classical theory of functions. It’s the reduction to the etymological essence of “sign”: signare = to point at.

A purely formal association is quite the contrary of what is expected from semiosis. However, we intend to construct semiosis from this elementary type of association. In this sense, the present system of music semiotics is a prototype of a system of signs which are successively built from simple objects and relations to end up with complex construcs. *In an axiomatic theory of signs, the pointer relation should undeniably be a basic concept.* On this level, it is not possible to cope with the full model of semiosis proposed in section 1.2 of chapter 5 “Models of Semiosis”. Rather is this type of semiosis a mental object beyond (ante rem) any real-world considerations of organisms, interpreters, channels and behavior.

*2.1.1.2 Recursivity: Simple and Compound Denotators*

Denotator semiosis is recursively built by means of pointers and starts from simple Denotators. Recursivity is one of the most powerful construction method to build compound objects from simple, atomic elements. Recursivity is the principle to define hierarchical concepts on two basics: the 'zoo' of *simple* concepts at the *lowest* level of the hierarchy, and a universal rule to define *compound* concepts on a defined level once you know how the concepts on lower levels are built.

*2.1.1.2.1 The Concept of Simplicity*

Simple Denotators are those which form the basis of the Denotator system. We distinguish between simple Denotators for character strings (example: “crescendo”), integers (example: -24), floating-numbers, i.e. rational numbers in decimal notation of a finite length (example: 1.8906), and boolean values (YES/NO). For theoretical purposes, more general domains are required [80], but for our context (describe the basic phenomena in music and musicology) and for programming data bases the above repertoire is sufficient.

However, simplicity is not an absolute property but one which has axiomatic character within a given system. If we were—for example—involved in matematical aspects of simplicity, integers would not be simple objects, but compound objects based upon natural numbers.

*2.1.1.2.2 A Remark on Database Management System Principles*

In data base management system (DBMS) theory [117] it is necessary to have standard formats of entities which belong to data bases. Classically, such formats are special constructs from set theory, such as cartesian products, power sets and a finite, fixed number of recursive combinations of such constructs. Unfortunately, musicology does not allow to fix a finite set of such formats since there is no possibility to limit analyses or compositional constructs to finite format sets. Hence, DBMS principles need to be generalized to open-ended recursive formats. Further, DBMS constructions are not sufficient for musicological Denotator taxonomy. This is why semiotics of music needs a conceptual frame with wider range than elementary set theory. Such a frame is canonically given by mathematical category theory and its specification within topos theory [39], [64].

The following topics describe the basic constructs generalizing and geometrizing DBMS concepts. They will be treated in detail in 2.1.2.

- *Synonymy*—Change of Name
- *Products*—Reference to an n-tuple of other Denotators

- *Coproducts*—Selection of one Denotator out of a given n-tuple of Denotator types
- *Powersets*—Collection of several Denotators of one and the same type

### 2.1.2 The Structure of Forms

The underlying space of a Denotator has a pointer-like sign character and is described by the following three ingredients: the *Name*, the *Type*, and the *Coordinator* of the *Form*. To indicate the technical character of these terms, we use capital initial letters. The Name is the Form’s signifier, the Type is its signification and the Coordinator is the significate, see Figure 5.

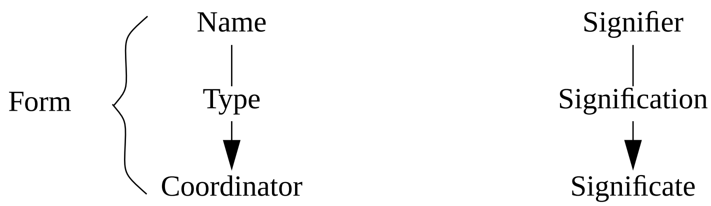



Figure 5. The sign structure of the Denotator’s Form.

A Form is identified by this triple: Form = (Name, Type, Coordinator). Here are the explicit structures that may take the places of the form’s Name, Type and Coordinator:

#### *2.1.2.1 Form Names*

The Form’s Name is a character string (the string is specified between quotation marks) to define a name.

Examples: “Note”, “Bar Line”, “Chord”, “Akkord”, “Onset”

#### *2.1.2.2 Form Types*

The Form’s type is one of the following. The explanation of these types is given in the remarks below.

##### *2.1.2.2.1 Simple*

2.1.2.2.1.1 $\alpha$: character string

2.1.2.2.1.2 i: integer

2.1.2.2.1.3 f: floating-point number

2.1.2.2.1.4 √: boolean

##### *2.1.2.2.2 Compound*

2.1.2.2.2.1 →: Synonymy

2.1.2.2.2.2 {}: Powerset

2.1.2.2.2.3 $\pi$: Product

2.1.2.2.2.4 $\pi^{o}$: Coproduct

*2.1.2.3 Form Coordinators*

The Coordinator of a Form depends on the Type:

*2.1.2.3.1 The Type is simple*

The Coordinator is a computational *default* value of the corresponding type. Default values are just values that are preset from the very beginning in order to insure that a number has been selected. Here is such a default list:

2.1.2.3.1.1 (character string) α: “” (the empty string)

2.1.2.3.1.2 (integer) i: 1

2.1.2.3.1.3 (floating-point number) f: 1.0

2.1.2.3.1.4 (Boolean) √: YES

Remark. It would seem that this value selection contradicts the very nature of a 'pure form'. However, there is a subtelty here which regards the difference between Type and Coordinator. In fact, the simple Type only specifies *any* domain that does represent the formal functionality of integers, strings, etc. Many selections of such representatives are possible. The effective selection is precisely traced by the Coordinators 2.1.2.3.1.1 through 2.1.2.3.1.4. In the general theory [80], the simple Type is a representable functor whereas the Coordinator is a representing object.

*2.1.2.3.2 The Type is compound*

The Coordinator is the reference to one other Form in these two cases:

2.1.2.3.2.1 →: Synonymy

2.1.2.3.2.2 {}: Powerset

It is a reference to a (finite) list of Forms for:

2.1.2.3.2.3 π: Product

2.1.2.3.2.4 $\pi^o$: Coproduct

These formal definitions deserve a first remark concerning compound Types. Intuitively, Synonymy and Powersets are different constructions: The former means changing signifier, the latter means taking the collection of all subsets of a given set. Similarly, the (n-fold) product means taking all n-tuples of a given sequence of sets, whereas coproducts are understood to be disjoint unions of given sequences of sets. In both cases of Synonymy and Powerset resp. Product and Coproduct, the rule of building a Coordinator is respectively the same. Thus, to give the Coordinator for a Product or a Coproduct, we just need a list of Forms. The difference cannot be more than a formal one on this level. On the level of Forms, Product and Coproduct resp. Synonymy and Power Set are 'isomorphic' constructions. Semiotically speaking, the significations “Product” resp. “Coproduct” may point from the same Name to the same list of Forms and yet be different. This is a known—though rare—case of semiosis, for example: If we write A=2*2 and A=$2^2$, this means that we have one and the same name A for the significate 4, but the signification processes from A to 4 which are indicated by the two equations are visibly different. We shall see in 2.1.3 that there is a clearcut difference between these signs when applied to define substance which is instanciated in a given Form.

A further remark concerns the terminology of “Coordinator” for the significate of a Form. It was chosen since the referenced (collection of) Form(s) defines a system of coordinate spaces which help building the Form; for the Product type, this is the usual concept of a cartesian product of coordinate spaces.

A last remark concerns the naming of Forms. Semiotically, it is clear that names in the role of signifiers are integral parts of signs. However usual mathematical techniques do not give naming this extra profile (though they should!). It is understood that the 'identity' of a concept is the one and only essential information to cope with in mathematics. But as we deal with music, the signifier usually *is* essential for the function of a sign; its identity is not covered by the mere significate.

Figure 6. shows a first exemple of a compound Form that points at four simple forms.

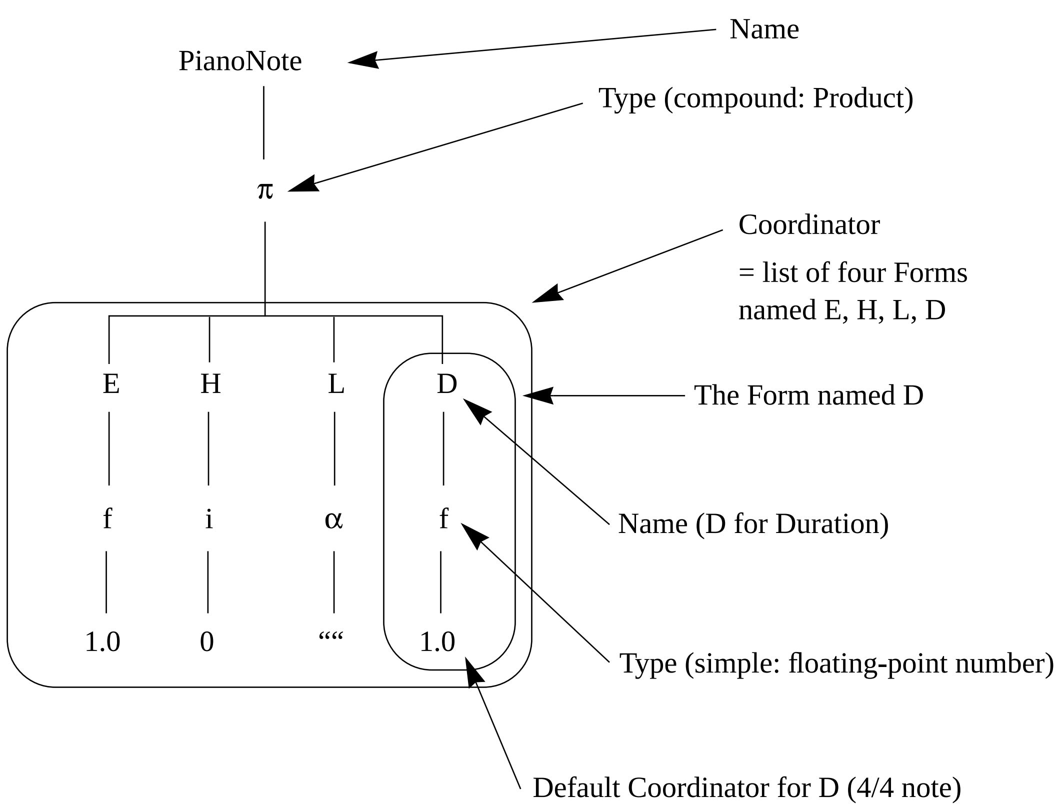


Figure 6. This example of the Form named PianoNote shows the product type which asks for a list of Forms as its Coordinator. Here, the list has four entries, the simple forms named E (=onset), H (=pitch), L (=loudness), D (=duration). These factor Forms of the Product have two floating Types, one integer Type and one character string Type. The character string for loudness reflects the fact that in classical European notation, dynamics are often indicated by characters rather than by precise numbers, see also 1.1.4.3.

It is essential to include recursive Forms in our examples since this is the basis of the open concept framework in music and musicology. The next example in Figure 7. is devoted to the generic event concept named MakroEvent, in an example for generic drum events:

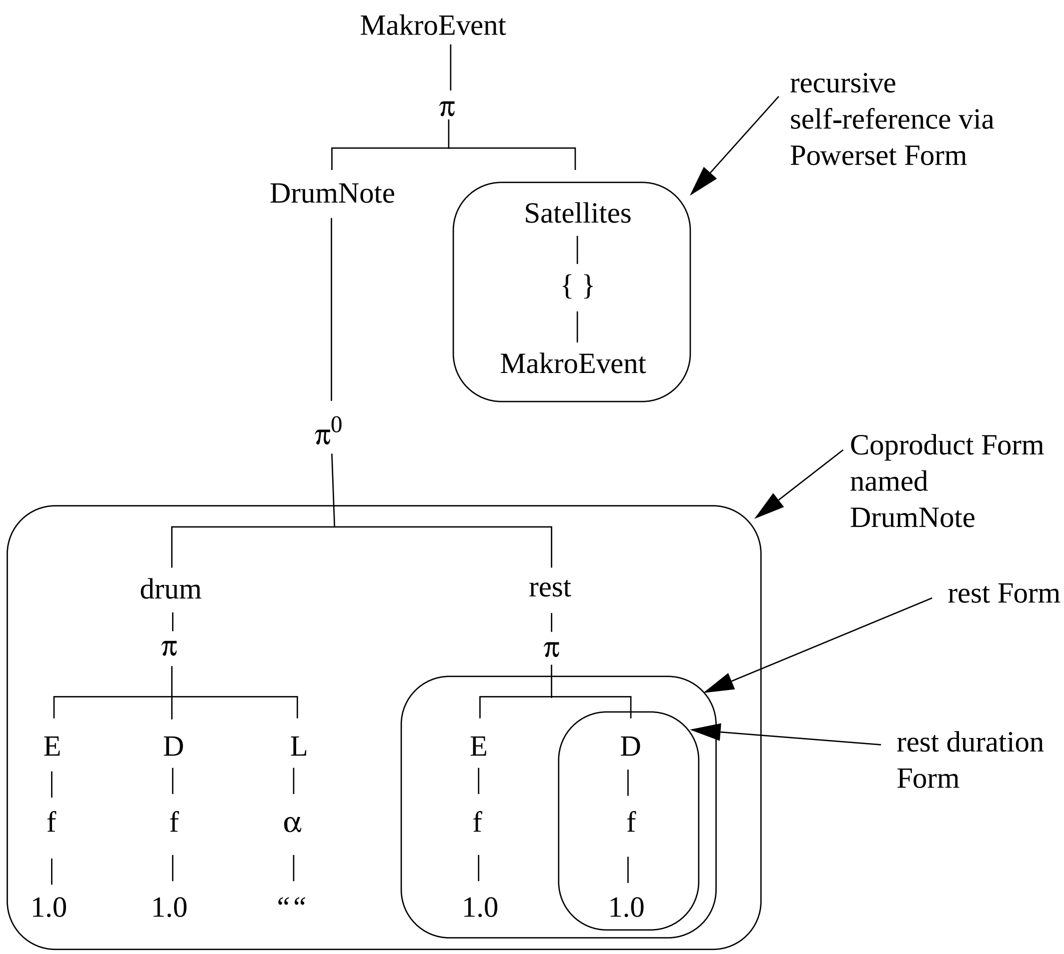



Figure 7. The Denotator named MakroEvent is a Product of Denotators DrumNote and Satellite. The DrumNote is a Coproduct of drum and rest. The point here is that the factor named Satellite of the top Product list is a Powerset Denotator with Coordinator MakroEvent. This self-reference is infinite recursion: MakroEvent is an space topos of infinite depth. We shall see in 2.1.3 that this does not force its instances to be infinite.

### 2.1.3 The Structure of Denotators

Within the given Form, a piece of 'substance' is allocated as a *Denotator*, a richer type of sign which includes its *Form*, a *Name* and the *Substance*. Observe that these are purely technical terms. Intuitively speaking, Denotators are the points within a space defined by the Form. The sign character of a Denotator is this: The Name is the Denotator's signifier, the Form is its signification and the Substance is the significate, see Figure 5. Formally, we identify a Denotator with the triple (Name, Form, Substance).

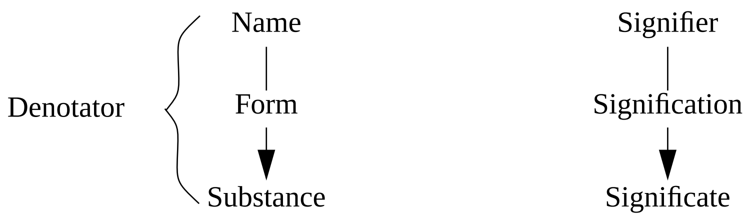



Figure 8. The definition of the sign structure of a Denotator.

This means that the Form sign structure is incorporated in the Denotator sign as a signification instance. In other words, a Denotator D 'knows' what Form F it has: we can speak of *the Denotator's Form* F = F(D). The explicit definition runs as follows:

*2.1.3.1 Denotator Names*

The Denotator's Name is a character string like with Forms (2.1.2.1). It need not coincide with the Name of its Form. Denotator Names are normally written in bold letters, Denotators are symbolized by **Name**:**Substance** → Form or by **Substance** → Form if the **Name** is clear. This indicates that **Substance** is a 'point' in the 'space' Form.

*2.1.3.2 Denotator Forms*

The Form of the Denotator sign is a Form in the sense of 2.1.2. It guarantees the type or reference to its Substance as follows:

*2.1.3.3 Denotator Substance*

This one is defined according to the Type of the Form as follows:

*2.1.3.3.1 Denotator's Form is simple*

This is a computational value according to the Form. For example, if the Form is character string, the Substance is a character string, such as "rallentando".

*2.1.3.3.2 Denotator's Form is compound*

Here, it becomes clear why the compound Form Types were given the respective names:

2.1.3.3.2.1 For Synonymies and Coproducts, the Substance is one Denotator in the following intuitive sense: S*ynonymy* means relating one (alias) name "SYN" to a given object S. In our formal setup, the Form F of Synonymy prescribes its Coordinator Form F* (2.1.2.3). The Denotator's Substance then is a Denotator S of Form F*.

Intuitively *Coproducts* are disjoint unions of several object collections. In other words, the Substance of a Coproduct Denotator is one Denotator selected from one of the given collections. The coproduct's Form has a list ($F_1$, $F_2$,...,$F_n$) of Forms as its Coordinator. Then, the selection rule says that the Denotator Substance is a denotor *of* Form either $F_1$ or $F_2$ or... $F_n$.

2.1.3.3.2.2 For Products resp. Powersets, the Substance is an ordered resp. unordered list of Denotators in the following sense: Intuitively, *Product* means cartesian product, i.e. ordered lists or "n-tuples" of elements of the n factors. In our formal setup, we have to make reference to a list ($\mathbf{D}_1$, $\mathbf{D}_2$,..., $\mathbf{D}_n$) of Denotators such that each $\mathbf{D}_i$ has Form $F_i$, the latter being the *i*th Form of the Coordinator-Forms ($F_1$, $F_2$,..., $F_n$) of the Denotator's Form.

For the *Powerset* situation, the intuitive meaning is that one takes a set of objects of a given kind. In the formal setup, we have to refer to an *unordered* list {$\mathbf{D}_1$, $\mathbf{D}_2$,..., $\mathbf{D}_n$} of (n mutally distinct) Denotators which all have one and the same Form given by the Form-Coordinator of the Denotator.

### *2.1.3.4 Examples and Illustrations of the Denotator Structure*

*We will often identify Denotators and Forms with their Names if no confusion seems likely. Ideally, such a homonymy should be avoided but this is not mandatory.*

*In praxi it is often violated, see also 2.1.3.1. Especially for simple Denotators it is customary to name them by the empty string and to identify them by Type and Coordinator.*

#### *2.1.3.4.1 Simple Denotators*

These are quite obvious. The point is that a Form, say onset form E = (E, *f*, 1.0), is not just the mathematical space of floating-point numbers (as a subspace of the rational number axis), but a space of E-named numbers. This is similar to physics where values are coupled with units, such as force, mass, energy. With the above identification convention in mind, we may consider onset Denotators **O1**:2.5 $\rightarrow$ E, **O2**:7.25 $\rightarrow$ E etc. or pitch Dentators **P**:34 $\rightarrow$ H, **Q**:34 $\rightarrow$ H for a pitch Form H = (H, *i*, 1). It is also important to admit simple substances consisting of character strings. This enables us to express non-numeric musical notation, such as a dynamical sign named *forte* with substance "*f*" and Form = (Dynamics, $\alpha$, ""). This type of simple sign also enables us to introduce open semantics, i.e. a character string, such as "con amore", may open deeper semantics in later states of semiosis, see also 2.6.

*2.1.3.4.2 Compound Denotators*

We give examples of Denotators built upon the above Forms (Figure 6. and Figure 7.)

Example 1. The PianoNote Form is a Product of four simple Forms named E, H, L, and D. A Denotator named **ThisPiaNote** of Form PianoNote refers to four Denotators

**ThisPiaNote**:(**This_E**, **This_H**, **This_L**, **This_D**) → PianoNote,

and each of them lives in its respective Form. Hence the definition of **ThisPiaNote** is completed by the specification of four respective Substances, e.g. (see Figure 9.)

- **This_E**:2.875 → E
- **This_H**:67 → H
- **This_L**:*"mf"* → L
- **This_D**:0.125 → D

In praxi, one omits evident Names and writes the short-hand expression

(2.875, 67, *"mf"*, 0.125) → EHLD.

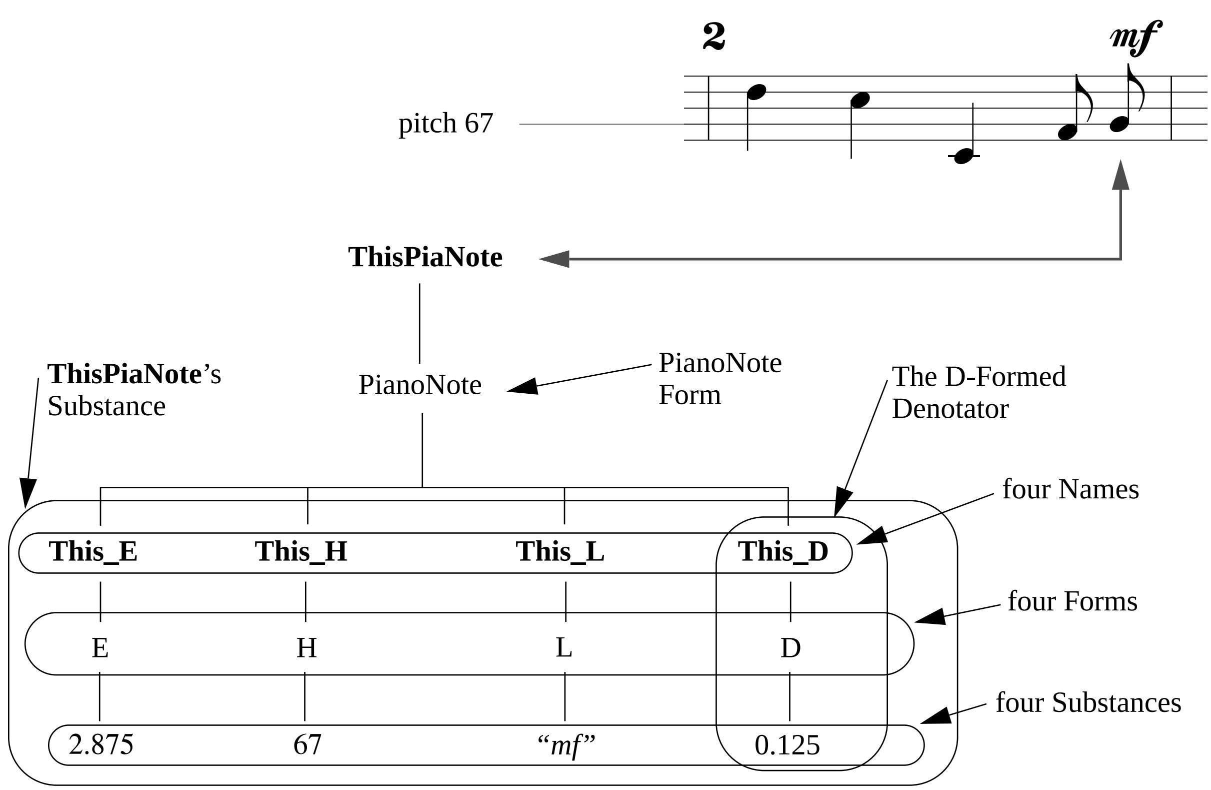



Figure 9. The full Denotator notation of an eight piano note on pitch g', on the last eight of bar 2 in 4/4 meter and played mezzoforte.

Example 2. This concerns the recursive MakroEvent Form in Figure 7. What do we have to specify for such a Denotator?

On one hand, there is an evident specification of the DrumNote formed factor of the top Product. According to the above definition of a Coproduct Denotator, this amounts to selecting either a Denotator of Form “drum” or one of Form “rest”. So it becomes clear that a DrumNote’s Substance is either that of a 'real' note or else a of a rest, to be observed by a drummer. If the Denotator of “drum” Form is chosen, its specification includes onset, duration and loudness. No loudness is needed for drum rests. Whence this construction—to be modified at will for more generic drum sound descriptions.

On the other hand, the Satellites-formed factor of a MakroEvent Denotator requires an unordered collection (a set) of Denotators of the same Form named “MakroEvent”. Again, each element of this collection refers to a DrumNote Denotator and to another Satellites Denotator. The construction is well-grounded only when the unordered collection referred to in a Satellite Denotator is empty. Then no open information is left and the recursive construction is complete.

Consequently, to get off ground, one has to select a *Satellite* Denotator $\{\mathbf{D}_1, \mathbf{D}_2, ..., \mathbf{D}_n\}$ of *DrumNote* Denotators. Next a new *DrumNote* Denotator **DN** is chosen and we get a first, non-trivial MakroEvent. The yoga of this construction is that it is now possible to build music objects anchored at selected notes (here **DN**) and carrying with them a bunch of 'secondary' notes, here the Satellite collection, $\{\mathbf{D}_1, \mathbf{D}_2, ..., \mathbf{D}_n\}$. In Figure 10. we have visualized a MakroEvent Denotator on the EL plane. This is precisely what happens with ornaments, such as trills or shakes.

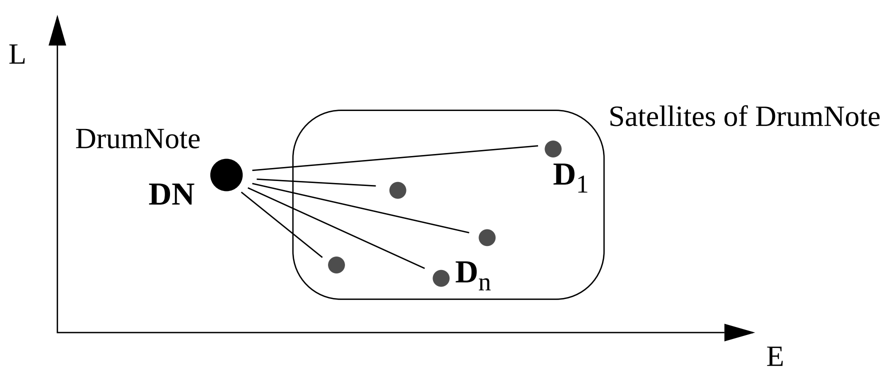



Figure 10. A MakroEvent is a construction scheme for an 'anchor note' where a collection of 'satellite notes' is attached. It is applied to grasp the situation where the geometric transformation of the anchor note determines the transformation the satellite notes [80]. The recursive structure of MakroEvent Denotators is useful for building hierarchies of note groups, such as ornaments, starting with ordinary notes and grouping successively from simple to complex systems of notes.

### 2.1.4 Total Order of Denotators

Apart from the genericity and classical Aristotelian character of the Denotator system, a lexical arrangement of Denotators is canonically guaranteed by its constrution, starting from the total orders on the simple Denotators. In what follows, we present the hierarchy of orders from simple to compound Denotators.

*2.1.4.1 Order by Names and Types.* As a Denotator carries with it the triple (FN, TP, DN) of its Form Name FN, its Type TP, and its Denotator Name DN, we may introduce a *name&type order* as the lexicographic order built from the lexicographic orders among character strings for the first two factors, togeter with the following total order

boolean < character strings < integers < floating point numbers < Products < Coproducts < Powersets

among the Types. To this data, the Substance SST is added as a fourth determinant:

(FN, TP, DN, SST).

Once the problem of defining total orders among Denotators of *fixed names and type* is settled, determinants of any coordinates can be ordered in the straightforward lexicographic way, i.e.,

(FN1, TP1, DN1, SST1) < (FN2, TP2, DN2, SST2)

if and only if the first coordinate X from the left where they differ has X1 < X2.

We are therefore left with the definition of the total order among Denotators of fixed Types.

*2.1.4.2 Order on Simple Denotators*

This kind of order is given by the type of the coordinate domains.

*2.1.4.2.1* On the *boolean Type*, the obvious order is given; i.e. NO < YES.

*2.1.4.2.2* On *character strings*, the canonical lexial order is given. Thus, for two character strings A and B, we have A < B if and only if the first character where A and B differ is prior to that of B. For example, we have “pianissimo” < “piano” because “i” preceeds “o” in the fifth item.

*2.1.4.2.3* On *integers* the usual total order among numbers is given.

*2.1.4.2.4* On *floating-point numbers* the usual total order among numbers is given.

*2.1.4.3* Order on *Product Denotators* is the lexical order, built from the total order of the factors in their defined order of enumeration. (Observe that the product of total orders would not yield a total order.) For example, for two PianoNote

Denotators A = (0.5, 63, *"p"*, 0.5) and B = (0.5, 63, *"mf"*, 3.5), we have B < A since the first differing coordinate is L and gives *"mf"* < *"p"*.

*2.1.4.4* Order on *Coproduct Denotators* is the disjoint union of the ordered sequence of the cofactors. This means that on each cofactor, the order is the given one, and for two cofactors, the elements of the prior are smaller than the elements of the later one.

*2.1.4.5* Order on *Powerset Denotators* is the following. If A and B are two (finite) sets of Denotators within an ordered Form, we set the following: If A and B are disjoint sets, A < B if max(A) < max(B). (By definition, the empty set is smaller than every other set.) If A an B are not disjoint, we set A < B if A-B < B-A.

It should be stressed that every scientific study and usage of a system of signs is confronted with lexical ordering of its members in order to build data bases and to extract reliable information from the system. This is an elementary and fundamental syntactical prerequisite for understanding the system.

In music it is essential to provide a systematic and canonical lexicographic order of the Denotators because, as a matter of rule, musical works consist rarely of several hundred and very often of tens of thousands of sound events. Any scientific study of music is therefore basically conditioned by order relations on the 'universe of sounds'.

This is not only a question of technological tools but, by the mentioned amount of information, order cannot be necglected without withdrawing from controlling the very material. For the technological implications of this perspective, see [70] and [76]. We insist on this point since to often, the study of very largedata sets in the humanities and especially in musicology has lead to a scientific debacle in favor of metaphoric pseudo-codes blurring the disorder and solving strictly no problem.

## 2.2 A Remark on Categories of Denotators

Nonewithstanding the bookkeeping character of the Denotator system, it is basically a *recursive syntactic universe of objects and relations* yielding the structural surface of what musical semiosis is about. In the sequel, we shall often refer to this universe; we denote it by **C**. It turns out that the Denotator system **C** shares properties which in mathematics is called a *category.* For the mathematically oriented reader we are going to sketch this categorical perspective in the subsequent sections 2.2.1 and 2.2.2. They may be skipped by non-mathematicians, and whenever the "category **C**" is mentioned, non-mathematicians may forget about "category" and simply understand the system **C** of Denotators.

Essentially, the interpretation by means of a category views the system **C** as being charged with *extra* structures, such as morphisms and universal constructions. The point of interpreting **C** in categorical terms is that this transforms the Denotator system from a relatively amorphous body into a well-structured organism whose objects are built from a small set of 'generic objects' and a small set of 'universal constructions' in the sense of category theory [64].

### 2.2.1 Morphisms

When forgetting its Name, a Denotator is a point **P** contained in a 'space' F called "Form". Therefore, we may view a Form as representing the set of such Denotator points. Suppose that morphisms f: F1 → F2 from Form F1 to Form F2 are *particular* set maps between these spaces when viewed as point sets. Then, a *Denotator morphism* f: **D1** → **D2** is defined on Denotators **D1** and **D2** with these properties:

- **D1** and **D2** have of Powerset Forms F(**D1**) = {F1} and F(**D2**) = {F2} (Names are irrelevant for this definition),
- f: F1 → F2 is a morphism of Forms,
- for each point P1 in the set **D1**, f(P1) is contained in **D2**.

By abuse of language, if **D1**= {**a**} and **D2** = {**b**} are singletons, then we write f:**a** → **b** for f:{**a**} → {**b**}.

Denotator morphisms are thus induced by their Form morphisms. Now, Form morphisms will be those which arise from natural transformations in the sense of category theory. This is the essence of the definition of morphisms for the category of local compositions in mathematical music theory [70]. This means viewing Forms as functors. For the precise definitions we refer to [80].

### 2.2.2 Logic and Geometry of Universal Constructions

From the preceding Denotator structures it is possible to deduce new Denotators by universal constructions of category theory, such as fiber products and amalgamated sums [64], [127]. In particular, geometric counterparts of logical constructions such as disjunction (via intersection), conjunction (via union) and relative negation (via difference) are feasible.

Semiotically this means that apart the motivation of semiosis by recursion for compound Denotators, as described in 2.1.1.2, we are given a rich mathematical suprastructure of syntactical nature, which admits geometric interpretations. Hence the Denotator level offers a variety of construction tools to enrich motivated versus arbitrary semiosis.

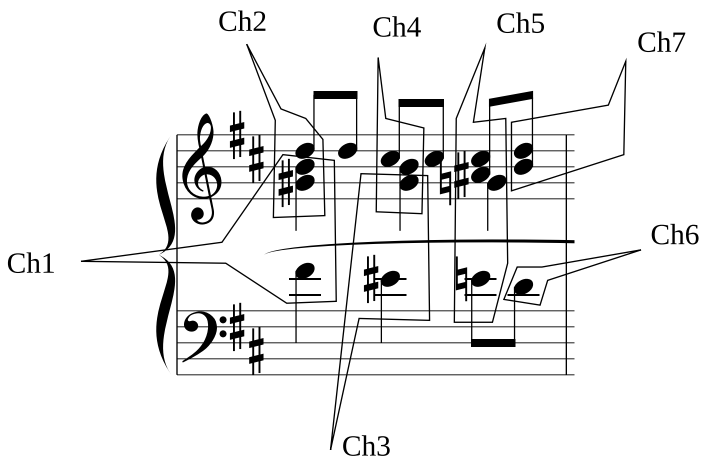
## 2.3 Denotative Semiology

On the Denotator level, one has a rich syntactical structure which we are going to review now. Because of the poor, essentially character- or number-oriented semantic content of Denotators, the formal manipulation tools are the main system operations. This means that denotative meaning is above all constructed from complex syntactical tools. On this level, music resembles mathematics, see also 2.4.1.2 on this subject.

### 2.3.1 Syntax of Denotators

#### *2.3.1.1 The Order of Denotators and Contiguity*

Contiguity is a main feature of syntagmatic organization. The universal order on the system of Denotators defined in 2.1.4 regulates some of the basic contiguity questions once for all. This is a major achievement because in music, the syntagmatic organization is a) an open system, there are no letter-like 'atoms', and b) the syntactical units are not distributed on a one-dimensional time-driven syntax. Within a set of chord Denotators, for example, a non-evident order must be introduced. As soon as the chord set is not the standard selection of successive chords in a temporal chord progression, the evident temporal continguity of "successive" chords breakes down. Figure 11. shows such a critical set of chords as it may arise in harmonic analysis.




Ch1 < Ch2 < Ch3 < Ch4 < Ch5 < Ch6 < Ch7

Figure 11. The system of these seven chord Denotators is not linearly ordered by time, so, for simultaneous chords, contiguity has to be defined on a higher level. For example, Ch1 and Ch2 are simultaneous; in this case—according to Powerset order defined in 2.1.4.5—we have Ch1 < Ch2 since the highest pitch of Ch1 outside Ch2 is smaller than the highest pitch of Ch2 outside Ch1.

The universal construction applied to all Denotator types guarantees that this order, when applied to the list of chords, has nothing arbitrary. Order for Denotators is a property that can be implemented in music data base systems by a small rule system and enables a universal search and navigator engine.

#### *2.3.1.2 Hierarchy of Syntactical Layers*

Besides the contiguity of syntagmatic units generated by the total order in 2.1.4, their recursive construction principle 2.1.1.2 yields a hierarchy, starting from simple Denotators and ramifying into more and more complex Denotators. This contiguity principle is a structural one, not generated through order relations of the value domains. In linguistics, it corresponds to the hierarchical contiguity of a phoneme within a morpheme, for example. This hierarchical extension of musical syntax is the formal backbone of a “vertical” poetology (“vertikale Aequivalenzklassen”) in the sense of Posner [91], see also 5.2.3.3.

*2.3.1.3 Combinatorial Nerves of Compositions as Syntactical Forms*

The traditional description of hierarchical levels of music syntax resides on the global-local dichotomy of musical grouping. The crucial tool of classification of this structure type is the concept of *local* and *global composition* [70]. Basically, a local composition is a finite set of musical objects such as it is generated by the Powerset Form 2.1.2.3.2.2. By double application of the Powerset Form, a more complex Form is generated, see Figure 12.

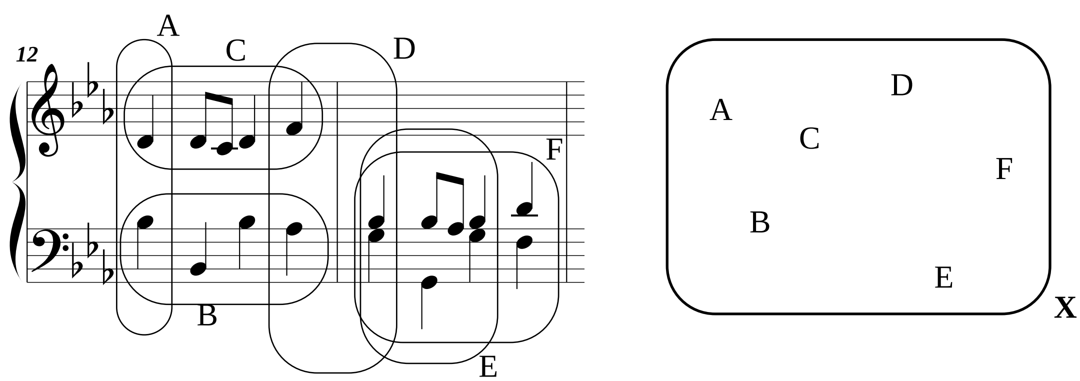



Figure 12. The local compositions A, B, C, D, E, F give rise to the global compositon X.

This Form denotes sets of sets of Denotators of a given type. For example, in Figure 12., the PianoNote Denotators of bars 12 and 13 are grouped into Powerset Denotators A, B, C, D, E, F. These “charts” form an “atlas” that covers the two bars and is viewed as a new object: the covering **X** = {A, B, C, D, E, F} which now has the Form “Powerset of Powerset of PianoNote”. The charts A to F are called *local compositions* because they intuitively group local parts of the given material; the atlas **X** is called a *global composition* because it collects and unites local aspects of the given material.

To such a global composition **X**, a *combinatorial nerve* N(**X**) is associated by standard methods from combinatorial topology [70]. This is a graphical representation of the connections among the local charts: In our example (Figure 12.), each chart is represented by a point, two points are connected by a line if they contain common notes, and three points are connected by a triangle if they share notes, see Figure 13.

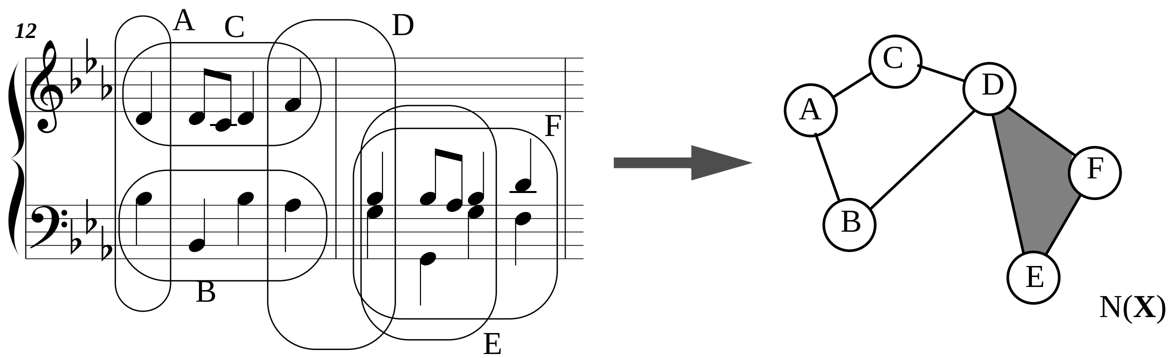



Figure 13. The nerve of a global compositon.

This contiguity structure is crucial for classification of global compositions and has been considered by Schönberg [105] in the case of the “harmonic strip” of a chord progression [70].

### 2.3.2 Denotatative Paradigmata

In linguistics, paradigms in the sense of Saussure [102] rely on the concept of association or equivalence. (Observe that in semiotics equivalence is not, in general, an equivalence relation in the mathematical sense.) In musicology, this concept is realized in several ways. Classification basically distinguishes between (topological) similarity, and (symmetric) correspondance. Similarity connotates deformation of continuous parameters of gestalts, usually within a metrical ambient space. Correspondance is tied to symmetry operations moving points to other points while preserving internal relations of the corresponding objects.

#### *2.3.2.1 Topological Similarity*

Similarity is a topological equivalence principle. Two Denotators of the same Form are said to be similar if they are topologically neighboring. This means that the 'space' described by the Form is given a topology. For example, consider the Form named “EH-Motif” (seeFigure 14.) where E and H are floating-point-coordinated.

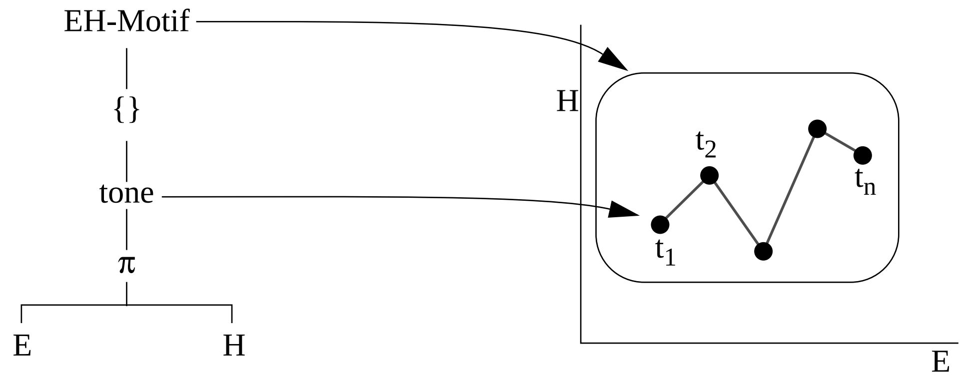



Figure 14. A motif in the EH-plane.

Motives of this Form are defined to be its Denotators such that no two tones have equal onset. Hence, the motive's tones $t_1, t_2, ..., t_n$ are Denotators ordered by increasing onsets. To define a topology, we proceed as follows: Given two motives $M = (t_1, t_2, ..., t_n)$, $N = (s_1, s_2, ..., s_n)$ of each n tones in the temporal order, set

$Dist(M,N) = Min_d(|t_1-s_1+d| +...+ |t_n-s_n+d|)$, the minimum being taken over all d, and where $|A|$ denotes the Euclidean length $|A| = \sqrt{A_E^2 + A_H^2}$ of $A = (A_E, A_H)$.

Given distance function Dist, we can define for any positive real number e the toplogical e-neigborhood $U_e(M)$ of a motif M as being the set of motives N with n points such that $Dist(M,N) < e$, see Figure 15.

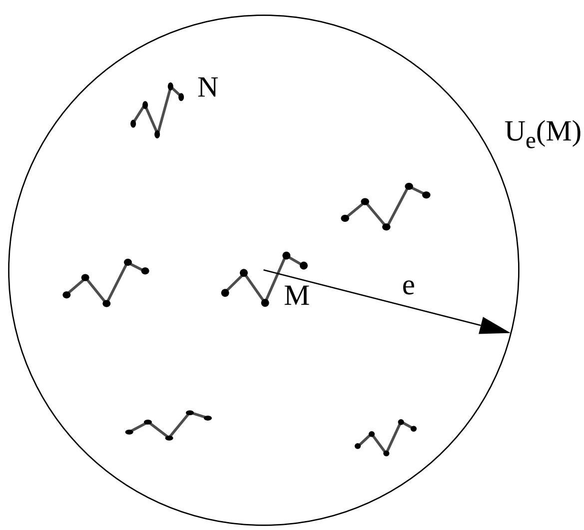



Figure 15. The topological e-neigborhood of motif M.

When e becomes smaller, the neighborhood shrinks continuously, and we are looking at a steadily narrower "window" of motives around M. Similarity is then a quantitative property related to the distance limit e which defines the neighborhood.

Besides the selection of the neighborhood radius e, each choice of an underlying distance function defines a different similarity concept. This freedom reflects the variability of the theoretical approach. It is essential that—in general—this type of equivalence is not transitive, not even reflexive in some important cases. A crucial example is Meyer-Eppler's theory of valences [81]. According to valence theory, the pitch of a sound B is said to be *within the valence* of the pitch of a fixed sound A if the sounds cannot be distinguished in pitch by "a majority of listeners". Evidently, this relation is not transitive since A and B resp. A and B' may have the same pitch valence without B and B' having the same pitch valence. Since this similarity concept cannot produce mutually disjoint equivalence classes, it is not possible to define pitch via such a psychometrical criterion.

*2.3.2.2 Symmetry Transformations*

These concern equivalence under a well-defined operation and encompasses the following two situations. (Such operations are special instances of morphisms, as described in 2.2.1, between Denotators.) The *first* situation concerns actions of invertible symmetries. This means that we are given a collection—usually a mathematical group—of symmetries transforming Denotators in an reversible way. The classical example is the *counterpoint group* generated by pitch inversions, pitch and time translations, and retrogrades. This type of symmetry acts on the Denotators—such as the above tones—having onset E and pitch H, and leaves other coordinates unaltered, see Figure 16. Each of these symmetries can be followed by the corresponding inverse symmetry, and the resulting figure is the original one.

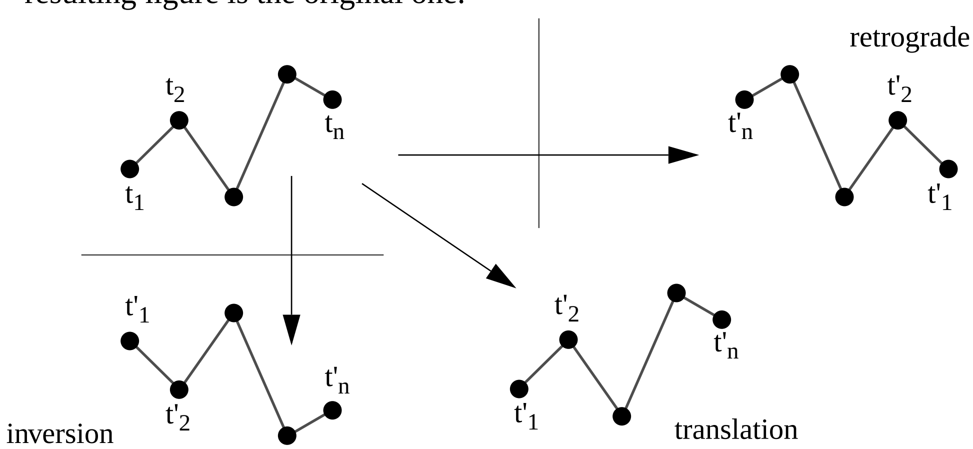



Figure 16. Three symmetry transformations of a set of EH events $t_1$, $t_2$, ..., $t_n$ under an inversion, a retrograde, and a translation.

The *second* situation deals with non-invertible symmetries. Such transformations cannot be undone, the transformed objetcs are 'degenerate' with respect to the original objects. Typical examples in the above EH-setting are projections onto lines of the EH space, see Figure 17.

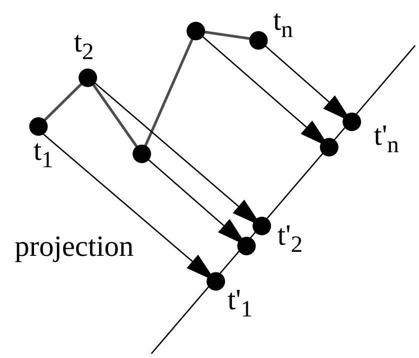



Figure 17. This projection symmetry destroys the information about the angles between the successive sections of the polygon and hence cannot be inverted.

Non-invertible symmetries are a kind of mixture between invertible symmetries and topological similarity. They deal with 'deformation' and are a basic tool for comparing Denotators under a *specific* operation rather than under an unstructured neighboring paradigm of pure topology. For a systematic treatment of this aspect, see [70], [80], and [87].

### 2.3.3 Denotative Classification by Local and Global Compositions

#### *2.3.3.1 The Semiosis of Classification*

Quite generally, semiosis is based on paradigmatic classes of signs rather than on individual, unrelated signs. It is therefore crucial to ask for classification of local and global Denotators.

##### *2.3.3.1.1 Local and Global Classification*

Classification of local and global compositions under topological similarity and symmetry transformations is concerned with the description of topologies defined by similarities and with the building of equivalence classes under symmetries.

The first task has not been studied in depth, except in contexts dealing with theory and software for motif analysis, see [46], [77]; similarity considerations are also known from music theorists studying pitch class sets, see [14] and [84] for further references.

The second task has been studied more intensely. Classification under groups of symmetries has been investigated in [34], [43], [54], [94], [67], [70], [84], [87], and [93].

In some cases, global classification has been established, see [67], [70], [71]. Musicologically speaking, global classification deals with sets of notes which are given a fixed grouping. Classification then requires that groupings are conserved under symmetries. For example, the diatonic scale of pitch classes modulo octave admits a unique inner symmetry: the inversion at d. Under this symmetry, each triadic degree is transformed into another triadic degree. The grouping defined by triadic degrees is then conserved under the inner symmetry of the diatonic scale.

Classification under non-invertible symmetry actions has been studied in [67], [70], and [87]. The general classification of actions under non-invertible symmetries is far from settled. One of the rare examples of complete deformation-theoretic classification is the Hasse-diagram of specializations (non-invertible symmetry actions) on the 26 three-element motif classes in 12-periodic pitch and onset [70]. As a Denotator Form, such a motif M could have the Powerset Form over a Product $E_{12}\pi H_{12}$ of the simple onset Form named $E_{12}$ and the simple pitch Form named $H_{12}$, both with coordinates in the domain $\mathbf{Z}_{12}$ of integers modulo 12 instead of the integers $\mathbf{Z}$. A general symmetry on $\mathbf{Z}_{12}$ could be represented as being a Powerset Denotator named $Graph_{12}$ over $E_{12}\pi E_{12}$:

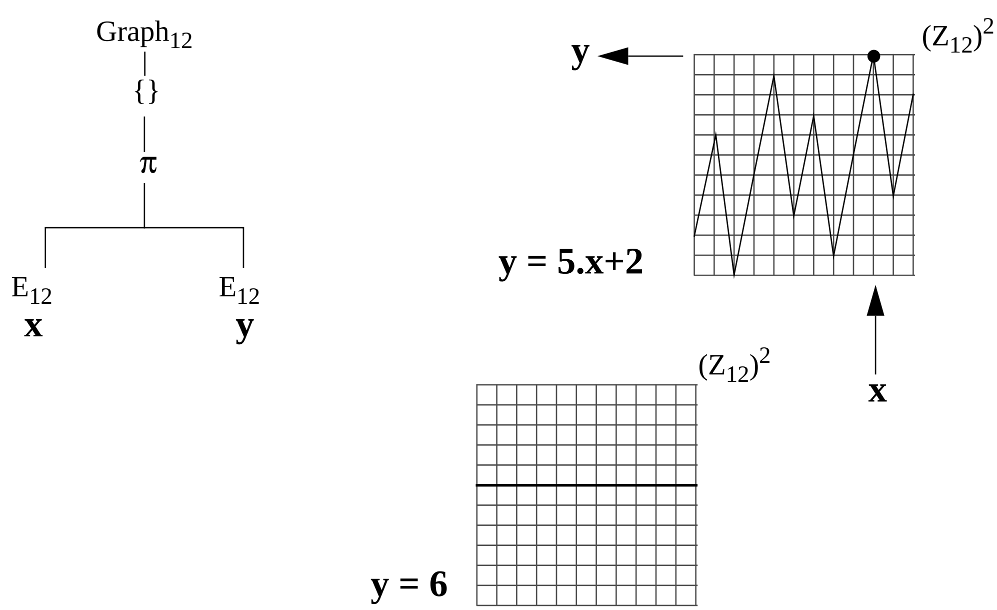



Figure 18. As Denotators, symmetries can be represented by graphs of Form Powerset over the Coordinator $E_{12}\pi E_{12}$, i.e. the torus $(\mathbf{Z}_{12})^2$. Above, we see the (invertible) symmetry y = 5.x+2 of counterpoint autocomplementarity [69]; below, we show the constant symmetry y = const. = 6. Symmetries on $(\mathbf{Z}_{12})^2$ are called “fractal tones” and serve as a basis for a 'non-objective' model of function theory: Tones are not plain objects but symmetries, i.e. movements between objects, see [87].

This new field of deformation paradigms yields connections between musical Denotators that had not been recognized as being esthetically relevant in the past, see 2.3.3.1.2.

*2.3.3.1.2 Classification and Esthetics*

Production of meaning heavily relies on reference to equivalence classes, this is the yoga of Jakobson's poetical function [51]. Classification itself is a crucial instance for supplementary semiosis in poetical contexts, such as they occur per default in music. For example, it could be shown that the syntactical location of equivalence classes of three-element motives in $(\mathbf{Z}_{12})^2$ and their deformation relations in Schubert's setting op. 72 “Lied zu singen auf dem Wasser” of Leopold Stolberg's synonymous poem is highly symmetric within the poem's dactylic frame [70], see Figure 19.

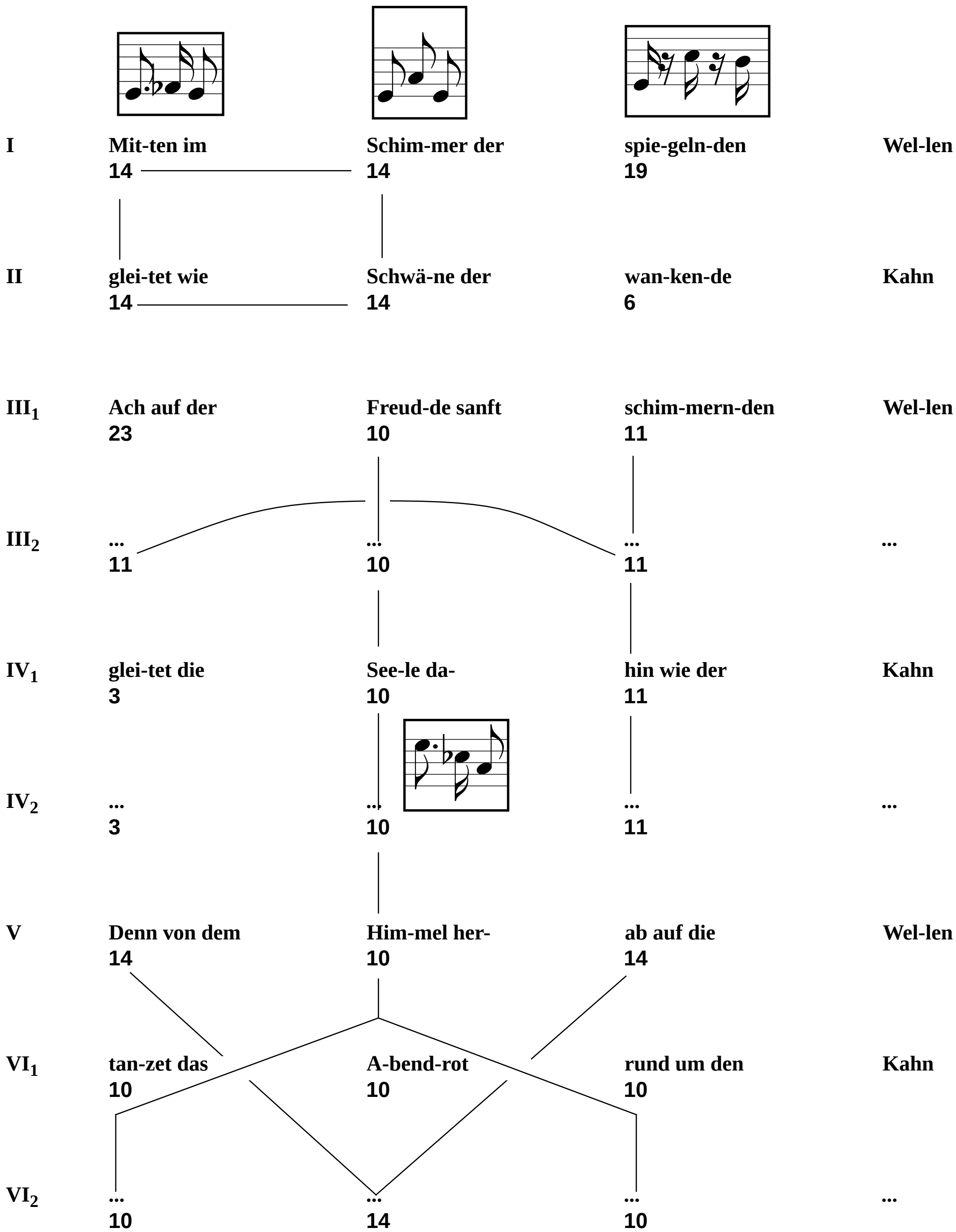



Figure 19. The dactylic frame of Leopold Stolberg's "Lied zu singen auf dem Wasser", together with the class numbers of the three-element motifs. Four occurences of them are shown in bass clef.

Further, the technique of classification yields a connection to the esthetical function of performance. The connection is set up by the technique of “resolution” of a given composition [70]. The resultion is a kind of “ideal positioning” of tones within a space of sound parameters such that their relative position is optimally recognized. Geometrically, this procedure means putting point configurations into “general position”. Intuitively, this amounts to viewing the configuration from a perspective which gives the configuration a most advantageous view: For example, none of the tones is hidden behind another, etc. In the theory of the string quartet [70], the resolution of the composition for string quartet indicates how a good performance should be shaped in order to make the structure of the composition transparent. In other words: Classification makes use of ideal perspectives, and these in turn indicate which performance can help evidencing the composition’s structure on the esthetic level.

The communicative success of a musical message is directly coupled to the *evidence of the formation* of such classes. For example, in dodecaphonic composition, the fact that we are given a collection of transformations of the generating twelve-tone row must be confronted with the problem of making this fact evident to the listener. This is not an obligation for the composer, but the understanding of such a construct is seriously dependent upon the accessibility to the generating row via their transformations. Otherwise, this background is blurred and polysemic if not insignificant.

*2.3.3.2 Characteristic Differences to Linguistic Sign Systems*

The pragmatic aspect of evidencing classes is vital to the musical system since it is not automatic, as with language, but it has to be learned and juged within the dia- and synchronic path of music. Classification of music Denotators is much more complicated than in the case of linguistic signs since there is no vital and lifelong acquaintance with such classes, and since their dimensionality is considerably higher than for linguistic signs. Hence it is not possible to communicate classes except while their building principles are simultaneously communicated. Here we have an excellent phenomenon of dominance of Saussure’s “parole” over “langue” [102]. In the above example of dodecaphonic composition technique, the 48 representatives of the counterpoint class of the generating row are not automatically recognized, not even by the trained ear. They are gestalts of high complexity and they do live in a spatio-temporal space which is difficult to be viewed in a geometric way. Therefore it is not sufficient to write down a syntax out of 48 representatives of the generating row by plain statement. It is necessary to give the listener the possibility to recognize that a transformation is being effectuated for connecting two instances of a row class. If the composition method does not cope with this communicative imperative, music is not sufficiently communicative to succeed, a fact that has intrigued Schoenberg’s followers.

### 2.3.4 Arbitrary and Motivated Denotative Semiosis

On the Denotator level, arbitrary signs are the small corpus of simple Denotators. To understand their meaning, the extra-systemic knowledge of the Coordinator domains of character strings, integers, floating numbers, and boolean symbols is required. This competence is not supported by the Denotator system: it is arbitrary to the system. The vast majority of Denotators is motivated by the constructions of compound Denotators as they were described in 2.1.1 to 2.1.3, and their extensions to logico-geometric universals as explained in 2.2.2. Observe that this relates to the fact that the dichotomy arbitrary/motivated is never an absolute one: it is relative to the given system of signs that this mark has to be assigned. The relation of a signifier to its significate is arbitrary if the system does not provide means to identify the significate from the signifier. In this case, the sign is a 'pure pointer', an elementary data unit without interior structure.

However, it is evident that the technical usage of the motivation concept as being opposed to arbitrary semiosis does not imply evidence of semiosis for the user of such signs. The existence of a well-structured path to meaning does not imply that it be estabilshed or canonized among its users.

This is the precise differentiation between language motivation and speech motivation, to translate Saussure’s dichotomy. The latter lacks of canonized evidence in motivation speech and can only be understood by its usage whereas language is canonized in its evidence. Speech motivation is like living in a city without map, language motivation means knowing a city from a map.

### 2.3.5 Ethnomusicological Aspects of Denotator Systems

#### *2.3.5.1 Suppan’s Four Analytical Methods in Ethnomusicology*

According to Suppan’s overview of analytical methods in enthnomusicology [112], four points of view: gestalt, structure, model, and type, can be distinguished. *Gestalt* refers to “interplay of forces between the different members of the whole”. *Structure* means determination of formal components such as meter, tempo, weight, time signature, rhythmical and melodic declamation and tonality. It is collected into a “formula” relating to melody, harmony, rhythm and form. In addition, there is a list of syntagmatic or paradigmatic relations to be observed for structural identifications. These are: addition, modification, correspondence, contrast, association, variation, equivalence, sequence, row and chain. Suppan’s concept of *model* splits into the “symbolic” model referring to gestalt and structure and the “iconic” model relating to faithful representation. The concept of *structure type* includes “form type”, “line type”, and “rhythm type”, *gestalt type* refers to “melody types”.

In view of what precedes this section (2.3.1 through 2.3.3), the Denotator system and its classification perspectives are a formal frame for realizing Suppan’s generic concepts. For a reliable, editable and communicative data base storage of enthnomusicological data and facts, the Denotator system presents a non-restrictive, precise and open semiotic frame.

*2.3.5.2 Denotators as Non-Restrictive Descriptors*

We want to make this clear by examples: Denotators are very useful for formally repertorizing ethnomucisological data and facts. The possibility to apply character strings as coordinates opens the way to incomplete semantics. For example, it is not necessary to misrepresent or over-interpret the pitch data of a note in a ethnological context in favour of the European lexemata of pitch when denotating an Indian melody. However, when building a model of pitches for that context, it is still possible to map the character strings to numbers, such as European pitch classes, MIDI numbers or *whatever* may be relevant to the given scientific project. This is precisely what the RUBATO analysis and performance platform (see [72], [99]) makes possible in the case of European score Denotators (see below 2.5.2.1) such as dynamics names *mf*, *pp* etc., or the fermata Denotator 𝄐. Whereas the Denotator is recorded as character string coordinate by “*mf*”, “*pp*” or “fermata”, the user may interpret these coordinates by numerical evaluation for performance purposes. But until that realization, the Denotators keep their full potential of “European ethnological context of notation”.

This procedure may be generalized to the end of substituting character strings by entire Denotators in order to 'fill up symbolic strings' with more explicit Denotators. This substitution process is understood as yielding a 'decoding' method for 'deepening meaning' of signs, see Figure 20.

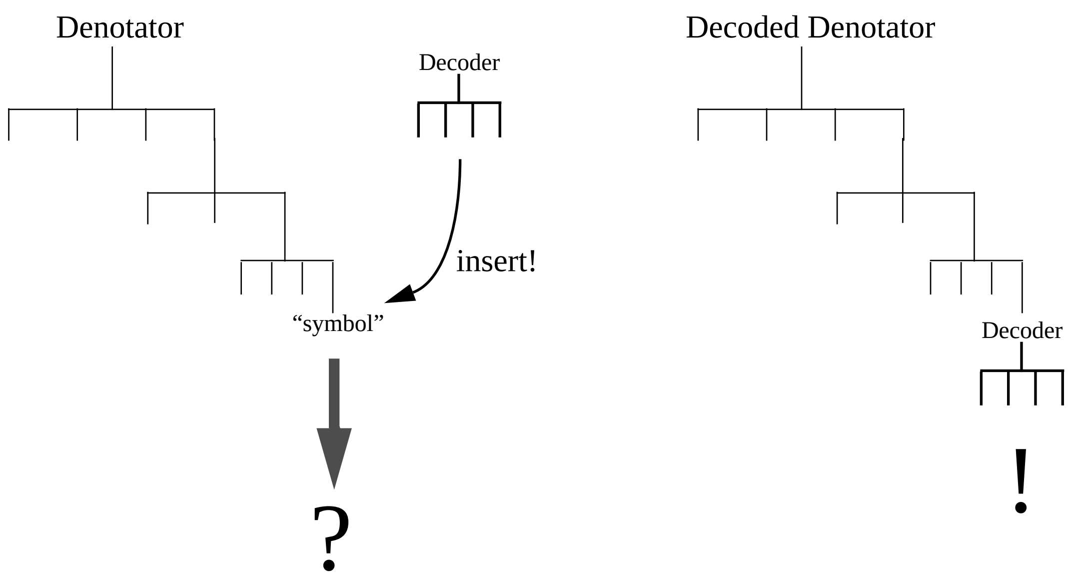



Figure 20. Decoding a semantically incomplete Denotator by insertion of a Decoder Denotator in a symbolic string coordinate.

This is no luxury for the enthnomusicological research, quite the contrary: Without such an open Denotator system, the retrieval of ethnomusicological data would fail from the beginning since the original information is distorted in an irreversible way if the record is meant to be a reliable first order source.

### 2.3.6 The Semantic Limits of Denotators

The Denotator system has its very strict limits and requires a supersystem of connotation to grasp deeper layers of meaning. Already with the above example of enthnomusicological signification it became evident that the Denotator system is only a signifier surface pointing at interpretative, performative, and emotional resp. social meaning.

Moreover, Denotators are not sensible to what really exists in music, as a member of the repertoire of a given culture, for example. In fact, this is an essential fact about music: In the real world, Denotators are far from realized in their complete potentiality. Beethoven's Fifth Symphony is not just one of a large repertoire of given Denotators! Its existence has far-reaching consequences on the theory and practice of music and its meaning. This is the reason why Denotators must be *deepened* to yield this existential aspect underlying music.

## 2.4 Predicates

### 2.4.1 Predicates as Connotational Signs Built upon Denotators

#### *2.4.1.1 Actuality and Potentiality*

In mathematics, once a domain of objects has been consistently defined, it is no question that they are all available resp. 'exist' without further differentiation. Once prime numbers are defined, their instances are just there, no question of distinguishing explicitely those we have already dealt with from the others. (However, for computer mathematics, the prime numbers which have been dealt with are definitely more concrete than the others.)

The fundamental difference between mathematical set or category theory and Denotator theory is that the 'existence' of Denotators with respect to music or musicology is *not* equivalent to their purely mathematical existence. Rather must we consider a specific type of allocation or instanciation, be it on a computer's memory or in an intellectual framework, such as the composer's mind or a given composition.

The point is that, within a fixed discourse, we do not permit automatic access to Denotators. This is a rigorous discipline about what is given and what is only possibly given, a fundamental feature in musical thought or musicological analysis.

For example, in the diachronic evolution of the music system or within a specific material allocation within an information system (a data base), this may be relevant. In particular, if one deals with musicological analysis, it is essential to make precise the universe of objects one deals with, be it for classification or for ad hoc reference.

This is no a priori limitation of the available 'material', but a 'declaration duty' of what we are allowed to refer to.

##### *2.4.1.2 Mathematical and Musicological Existence*

Denotators share a kind of mathematical existence. Whether we view them in a set or category theoretical perspective, they share a layer of abstract existence. In the context of music semiotics, it becomes relevant to couple semiotic specification in the sense of Hjelmslev’s glossematic [45] with existenciality: *Denotation and connotation are ontologically sensitive concepts. They do not only reflect ontology but are possibly responsible for its very production.* This contrasts musicology from physics: The latter do deal with a fairly objective subject to be described by mathematics, whereas the subject of musicology is far more human nature and as a such does not only exist but is essentially created. Therefore, this ontological enrichment has to be dealt with explicitely and in a differentiated way.

##### *2.4.1.3 The Predicate Concept*

In order to differentiate the Denotator ontology from the musicological one, the Denotator system is viewed as the denotative layer of a supersystem whose signs are called (musical) *predicates*. Here, the Denotators play the role of signifiers, whereas the significates are instances of 'specifically' musicological meaning. This is the model to be opened in the sequel. It is based upon the insight of section 1.2 that musicological meaning is a multilayered fact to be succesively constructed via Hjelmslev chains of denotator/connotator systems.

#### 2.4.2 Introversive and Extroversive Semiosis

To get off ground with the discourse on musicological meaning, we review Agavu’s work on music semiology [5] which follows the lines of Jakobson’s research in modern poetology [50]. Agavu follows Jakobson in distinguishing *introversive* vs. *extroversive* semiosis.

Introversive semiosis is production of meaning on the ground of intratextual signs. Agavu calls this the *universe of structure*. Examples: Schenker’s “Ursatz” (beginning/middle/ending), Ratner’s model of harmonical functions and, of course, all elementary signs for metric, rhythmical, motivic, harmonical etc. structures. Introversive semiosis could be circumscribed by *textual meaning* because the text is the relevant reference for introversive semiosis.

Extroversive semiosis makes use of signs which transcend the system of musical signs in the narrow sense of the word. Agavu refers to the *universe of topics*. Topics are signs having a significate *beyond* the text. The author gives 27 examples within the form of his analysis (reaching from 1770 to 1830, i.e. embracing the first viennese school):

- alla breve, alla zoppa, amoroso, aria, bourrée, brilliant style, cadenza, Empfindsamkeit, fanfar, French overture, gavotte, hunt style, learnde style, Mannheim rocket, march, minuet, musette, ombra, opera buffa, pastoral, recitative, sarabande, Seufzermotiv, singing style, Sturm und Drang, Turkish music.

These signs have a surface which has a regular textual meaning. In fact, particular groups of sound events do have a particular structure. But the deeper meaning, in some sense a connotative significate, reaches beyond the text, and it resides in a historiographical and/or music(ologic)al competence. It can only be realized by the competence of the listener/musician and his/her idiomatic expertise.

We see that Agavu's access to musical meaning is characterized by a dichotomy between precise textual and denotative semiosis and some kind of black box semiosis referring to an exterior competence. This is the nature of music(ologic)al context: It is an open system and should be treated as a such. With regard to this open ended semiosis, we have introduced the term of *paratextual meaning*.

This motivates the distinction between textual and paratextual meaning: meaning is not a formally closed feature and has to be dealt with in a open way.

### 2.4.3 Dealing with Open Semiosis

In the building of the predicate concept, semiosis that starts from the Denotator level has to be opened with respect to

- diachronic development: the set of predicates may change with time (cultural epochs)
- synchronic development: the set of predicates depend on the spacial (cultural) context
- incomplete semiosis: meaning may be incomplete, provisional or expressedly indetermined.

Let us give an illustration: The diachronic extension of the repertoire of compositions determines the experimental material upon which music analysis has to be executed, tested and developed. This is no time invariant. For instance, the Tristan chord is far more than just one spot within an abstract list of chords. The synchronic analysis of ethnomusicological data is heavily dependent upon the cultural region where it is applied. As already explained in 2.3.5, the extroversive meaning of data (such as "fermata") may be incomplete (for performance) such that one has to deal with black box semiosis without refraining from formal handling. We do not yet know "everything" about a sign, but we have to handle it within its context. In reality, incomplete semiosis is the rule, not the exception!

To control this variaty of processes of semiosis it is necessary to set up an adequate system of signification mechanisms.

### 2.4.4 Textual and Paratextual Signification

#### *2.4.4.1 Truth Values and Meaning*

In order to distinguish potential from actual instances of Denotators in the spirit of Agawu's universe of *structure*, it is necessary to be able to tell which instances "are the case", and which are not. This enrichment of ontology is determined by extensionalitiy. Predicates are related to sets of Denotator instances which *do* exist. For example, if we describe piano notes by special types of Denotators, the predicate "piano notes of concerto XY" would cover all these Denotators for the notes of the score XY attributed to the piano.

So far, existence by extension is seemingly purely formal; however, we are not yet talking about the "full" meaning of tones. This is but the first step transcending mathematical Denotators. But the difference really is this: notes that "are the case" are the only ones that we have access to. The others are "mathematical fiction"—this is the ontological distinction.

Remark: By means of techniques of mathematical topos theory [64], extensionality need not be the binary bit of deterministic logic. If we were given a more sophisticated subobject classifier within a corresponding topos, the very concept of "being the case" would broaden to fuzzy generalizations of extensionality, in the sense that one also considers "notes that probably are part of a composition".

#### *2.4.4.2 Classifying Open Semiosis*

Meaning through extensionality is complemented by meaning through intensionality; by the above extensionality information only one aspect of predictative meaning is covered. More precisely, musical Denotators may also have an intensional meaning, independent of extensionality. This is what Agawu alludes to when introducing topics. It turns out that intensional meaning represents a much richer type of semiosis. Extensional meaning is not always the relevant aspect of meaning. For example, the extensional determination of crescendo Denotators does not tell what will happen in physical terms when a crescendo is played. Or a piano note may specify the piano as an instrumet without specifying any physical properties a piano sound should have. To achieve this missing information, a second kind of meaning is required.

The following sections give several perspectives of this kind of open semiosis (without claim of completeness).

##### *2.4.4.2.1 Semiosis as a Process*

To begin with, semiosis is not a state but a process which increases or decreases richness of meaning as a function of system time. What could be an intensional meaning at a given moment can be transformed into an explicit extensional meaning after additional information was added [21].

##### *2.4.4.2.2 Synchronic Pointers: Competence*

Meaning in the intensional direction can be the reference to another instance which 'knows' more about the music. This is a pointer to a competence exterior to the structural data. For example: The expert teacher in piano music knows how a specific articulation sign has to be realized on a grand piano.

*2.4.4.2.3 Diachronic Pointers: Tradition and Progress*

Another pointer type of intensional character is directed towards historical topoi or towards paradigmata of progress. Here, meaning is anchored in historical style knowledge, for example.

### 2.4.5 The Formal System of Predicative Semiology

Viewed as a formal setup, the *predicative semiology* ***Sem*** is based on the category **C** of Denotators in the following way. (Recall (2.2) that "category" is synonymous with "Denotator system" to non-mathematicians.) Then, by definition, ***Sem*** consists of the following, see also Figure 21.

- A collection ***Ex*** of *signifier* expressions (to be specified in 2.5).
- Two not necessarily covering, but overlaping subcollections ***Tex*** and ***Paratex*** of ***Ex***. The first, ***Tex***, defines the *textual* expressions, the second, ***Paratex***, defines the *paratextual* expressions. Such expressions will be denoted in *script* fonts.
- Two *signification* functions sig:***Tex*** $\rightarrow$ ***Texig*** resp**.** parasig:***Paratex*** $\rightarrow$ ***Paratexig*** with codomains ***Texig*** resp. ***Paratexig*** containing the textual resp. paratextual *significates* (to be specified below).

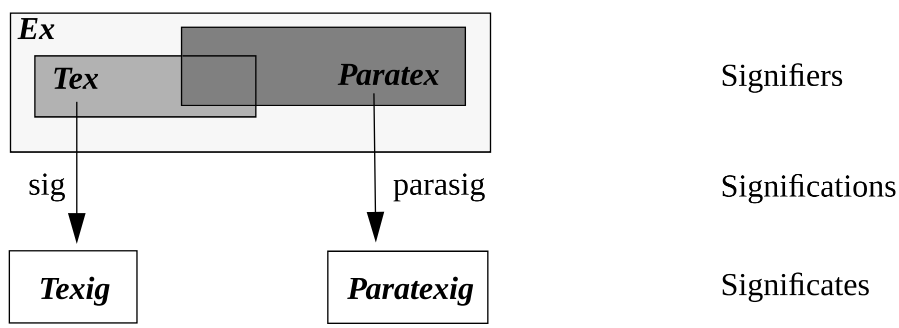



Figure 21. The structure of a predicative semiology

By definition, a *textual* (resp. *paratextual*) *Predicate* is a triplet (*E*, sig, S=sig(*E*)) (resp. (*PE*, parasig, PS=parasig(*PE*))) consisting of signifier *E* in ***Tex*** (resp. *PE* in ***Paratex***), signification sig (resp. signification parasig) and significate S in ***Texig*** (resp. PS in ***Paratexig***). This is nothing but the formalized listing of Saussure's three ingredients of a sign. The entire procedure of deducing the significate S resp. PS from the expression *E* resp. *PE* is subsumed within the signification sig resp. parasig. The only essential difference so far is that we are given not one but two possible signification arrows associated with expressions in the intersection of ***Tex*** and ***Paratex***. The set ***Texig*** of textual significates is explicitely defined as union of all set maps

$S: \mathbf{C}^n \rightarrow \Omega,$

n = 1,2,3,..., where $\Omega$ = {NO,YES} is the boolean classifier. In other words, a significate is a map S. And this equivalently means that we are given its *support* $S^{-1}$(YES) in $\mathbf{C}^n$, a set which—by abuse of language—we again call the significate of *E*. This set has to be interpreted as the collection of those Denotators which "are the case" with respect to the signifier *E*. So, if *E* is an expression pointing at all chords in a specific composition, then S = sig(*E*) should be the function whose significate are all chords which "come into existence" within this composition. The significate collects all "fictitious" Denotator objects from the mental construction **C** that "do exist" resp. "are the case" in this context. We formally write **D**/*E* to indicate that sig(*E*)(**D**) = YES. In order to make a Predicate's variables in $\mathbf{C}^n$ evident, the Predicate *E* may also be written in one of the more suggestive forms $(x_1, x_2,..., x_n)/E$ or $E(x_1, x_2,..., x_n)$. Then the evaluation yields the truth value $(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)/E = E(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)$ for every n-tuple $(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)$.

Remark for mathematicians: It should be stressed that **C** is the category whose elements are the morphisms and not merely the objects; the latter are identified with the identities. This means that S can also encompass morphisms, not only objects. In this perspective, the Predicates **D**/*E* define predicative objects in **C**, and the thus enriched category will be denoted **C**/*Pred* and called a predicative category. For the theory of predicative categories, see [80].

At this stage, the set ***Paratexig*** is not further specified, it may contain 'anything' which is susceptible of being the paratextual significate. See 2.6 for further specification.

The set ***Ex*** of expressions will be discussed in 2.5. It is in particular the set of textual expressions ***Tex*** that has to be described from its generation principles which are the core of predicative signification.

### 2.4.6 Denotators as Signifiers

To make explicit the sign structure relating the denotative level of Denotators with the connotation level of Predicates, it is now straightforward that the *textual significate* of a Denotator **D** (resp. an n-tuple of Denotators $(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)$) can be defined by the *textual* evaluation map **D**/tex*: E* ~> **D**/*E* (resp. $(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)$/tex*: E* ~> $(\mathbf{D}_1, \mathbf{D}_2,..., \mathbf{D}_n)/E$). Intuitively, the *textual significate of a Denotator is its global role regarding the textual Predicates*. One could also say that the textual significate of a Denotator is its '(textual) predicative paradigm'. The corresponding signification mechanism is based upon the predicative semiology ***Sem*** in the way defined above. It is suggested that *paratextual significate* **D**/paratex of a Dentotator **D** be defined by the collection of all significates parasig(*E*) of expressions *E* in the intersection ***Tex*** ∩ ***Paratex*** where we have **D**/*E*. This means that one collects all paratextual significates of expressions for which the Denotator **D** "is the case".

## 2.5 Classification of Textual Predicates

Predicates are built from arbitrary Predicates by means of logical and geometric procedures of motivation. The characteristic difference to constructions of Denotators is that now, the *existential markedness* must be observed throughout the entire construction process. It is not only important to be able to construct a structure but to recognize that it "is the case" in the same way as its ingredients are.

### 2.5.1 Arbitrary Predicates

We can distinguish three types of arbitrary Predicates: prima vista, mathematical and shifter Predicates. These are the “atomic Predicates” of this language as far as their emergence cannot further be justified *within* the language but has to be accepted as an input from external resp. a priori considerations. Among these atomic types, prima vista 2.5.2.1 and mathematical 2.5.2.2 Predicates are lexical: They can be described by precise criteria and they are independent of the user of the system. Shifter Predicates (2.5.3.2) are not justifiable except that a user introduces them “by free will”, just for interest or for another reason without further explanation.

Of course, neither of these arbitrariness criteria is absolute arbitrariness. Any concept of arbitrariness must be a relative one. There are motivations: prima vista is given by competence in translating score signs into Denotators relating to the *given* score, mathematical Predicates are mathematically motivated, and shifter Predicates may have any other motivation. But relatively to the Predicate sign system ***Sem***, they are arbitrary.

### 2.5.2 Lexical Arbitrary Predicates

#### *2.5.2.1 Prima vista Predicates*

Prima vista Predicates are those related to score reading. Recall that the concept of score is not restricted to the classical European music culture. But we shall only give a rather complete list of prima vista Predicates from classical European music. From this list, selected Predicates will be discussed in more detail in order to illustrate the general procedure and to present templates for other Predicates.

##### *2.5.2.1.1 List of Prima Vista Predicates from Classical European Music*

Staves, Braces and Systems, Ledger Lines and Octave Signs, Clefs, Stems, Flags and Beams, Rests and Pauses, Ties, Key Signatures, Time Signatures, Accidents, Barlines and Repeat Signs, Slurs, Dynamic Marks, Articulation, Ornamentation Signs, Tempo Indications, Arpeggio, Composer, Name of the Composition, Expression, Instruments, Lyrics, Comments, Jazz-Harmony, Gestures, Number Sheets, see also [95]. Others will be added below. See also [19], Vol. 8 and 9, for non-European Predicates.

*2.5.2.1.2 Some Explicit Prima Vista Predicates (Templates)*

As mentioned above, Predicate expressions are written in script fonts, such as "*AbsoluteTempo*" in the following example.

2.5.2.1.2.1 Tempo Indications

An *absolute* tempo indication can be either a numerical Mälzel sign asshown in Figure 22.

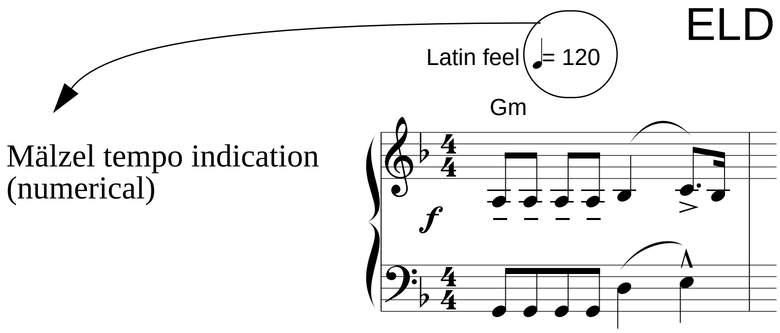



Figure 22. The Mälzel tempo indication.

or a verbal indication such as it is shown in Figure 23.

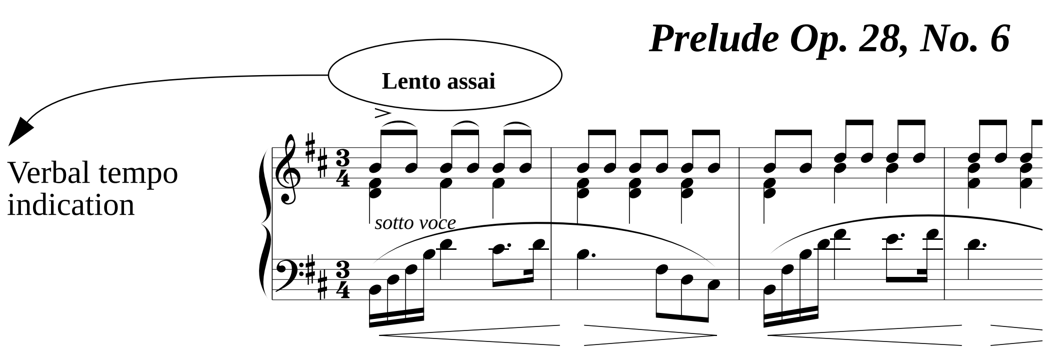



Figure 23. A verbal tempo indication.

Both can be integrated by a Denotator named ATC (Figure 24.) with the Form of a (empty-named) Coproduct of two simple variants: the Mälzel/Quarter Form with coordinates in floating numbers, and the VerbalTempo Form with coordinates in character strings, inserted in a Product with a floating point onset Form E, and with a Form Cp for the composition's name.

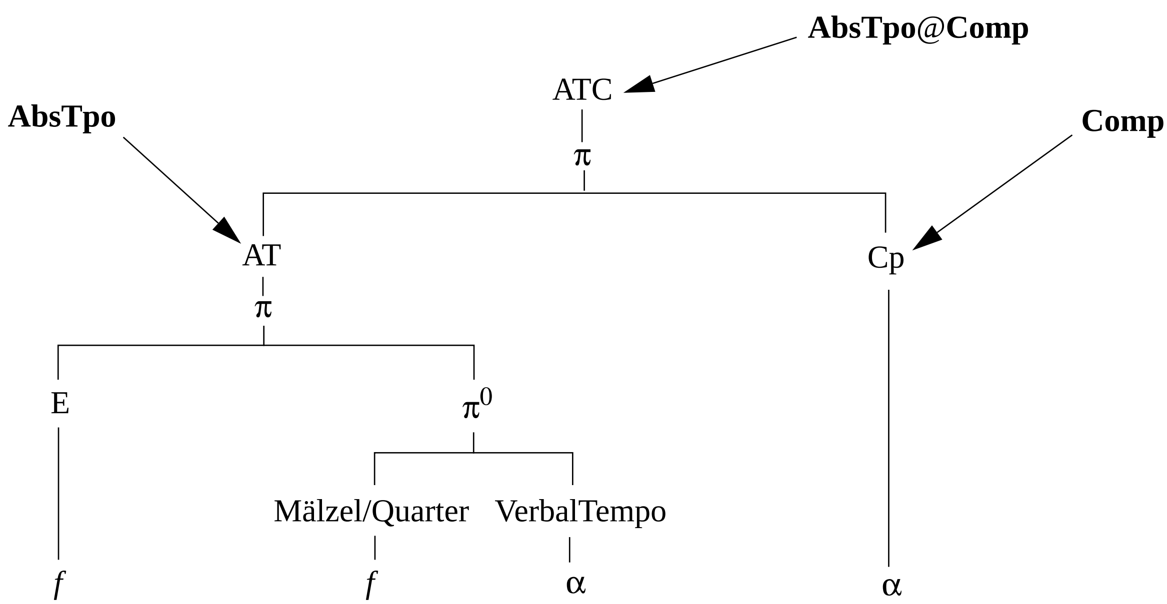



Figure 24. The Denotator ATC for absolute tempo.

Let the expression "*AbsoluteTempo*" by definition have the following significate.

S(*AbsoluteTempo*): $\mathbf{C} \rightarrow \Omega$

It takes the value YES for every Denotator **X** of Form ATC if and only if it is *true* that there is a composition named **Comp** (a Denotator of Form Cp) which shares the absolute tempo **AbsTpo** of Form AT, we denote this by **X** = **AbsTpo@Comp** ("**AbsTpo** *at* **Comp**").

To be clear, there is nothing unique in the definition of such a Predicate as far as its information content is concerned. One can imagine many other ways to define absolute tempi by use of other Denotator forms. But the essential is that each depends on the musicological competence to instanciate the significate. Note also that, as already mentioned, the significate is a function of historical time and cultural space: Before Mälzel's invention of the metronome, there was no possibility to look for the corresponding numerical tempo indications. But this is not part of the Predicate motivation in the strict sense.

Also, note that the verbal specification of VerbalTempo Form is not complete in its semantics. We come back to this example in 2.6.

Let us next look at the example in Figure 25. of a relative tempo indication for slowing down the given tempo during a defined duration.

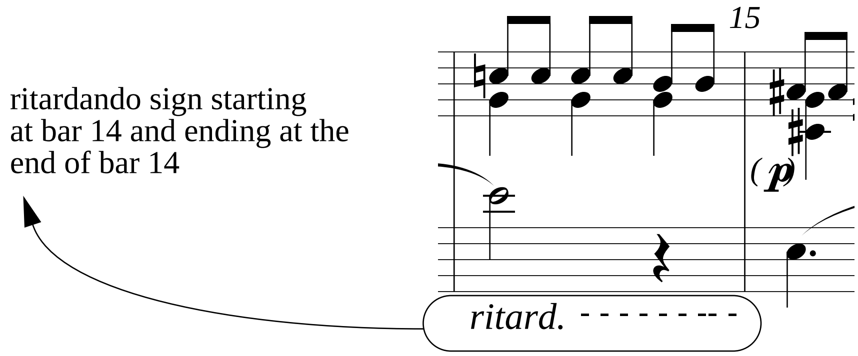



Figure 25. The "ritardando" sign.

This sign does not refer to numeric data, it has an onset of Form E, a duration of Form D and a Name of Form VerbalRelTpo, and, as above, a composition of Form Cp where it appears. So we are dealing with a Form named RTC shown in Figure 26.

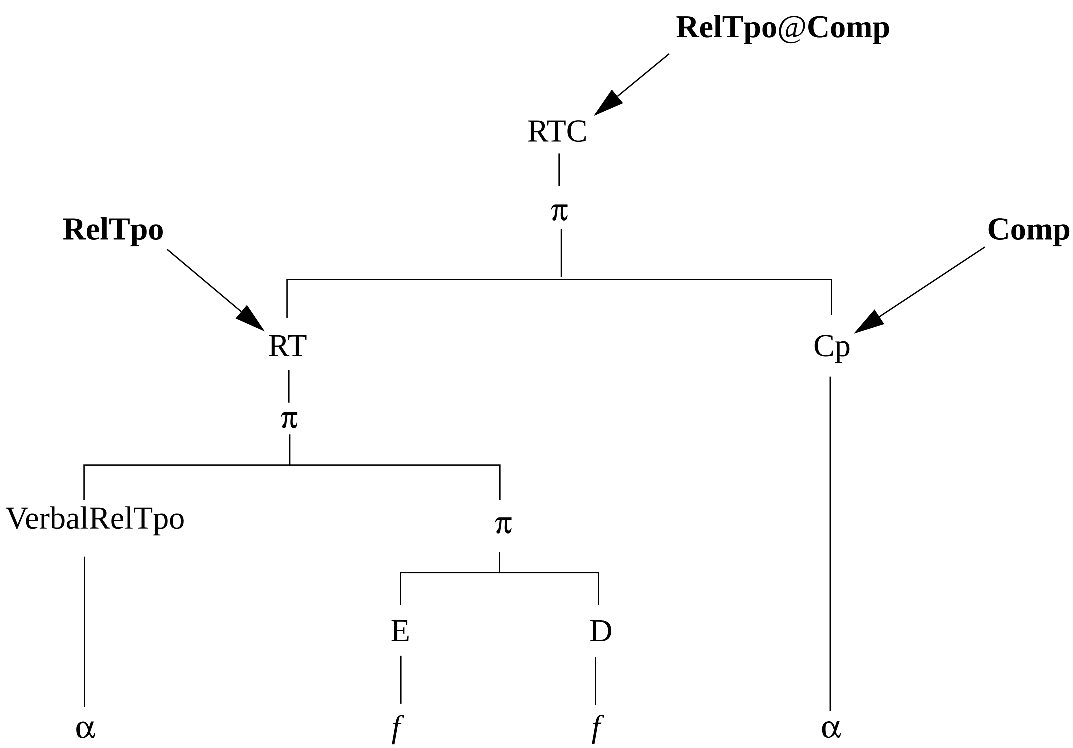



Figure 26. The RTC Denotator for relative tempo.

Here, "ritard." would be the coordinate of the Denotator at Name "VerbalRelTpo", the start of the Denotator being the E coordinate, the end being the number onset + duration from E and D. The rest is analogous to the previous example: We set an expression *RelativeTempo* and define the significate as explained above. Again, the verbal description of relative tempi does not grasp all of what such a sign points at, we come back to this open semiosis in 2.6.

It is a useful exercise to define a Predicate and the corresonding Denotator for slurs. Here, instead of singular events, we have to collect sets of notes connected through a slur, and this requires the Powerset Form.

2.5.2.1.2.2 Dynamic Marks

This type of prima vista Predicates is not essentially different from the above type. We include it because it will have a delicate paratextual aspect to be discussed in 2.6.

As textual Predicates, absolute dynamic marks such as *mf*, *pp* etc. are very much the same as absolute tempo indications. Let us set the Denotator such that it catches the set of all notes in a composition which have to be played with a specific absolute dynamic sign. For this, we suppose that we are given a Denotator Form NOTE which is general enough to include all note types which share dynamics in a determined context. Then, we have to define a Form including the set of notes of Form NoteSet within a composition and subjected to a specific dynamic sign denoted in the Form VerbalAbsDyn. This is represented by the Form ADC (Absolute Dynamics in a Composition) shown in Figure 27.

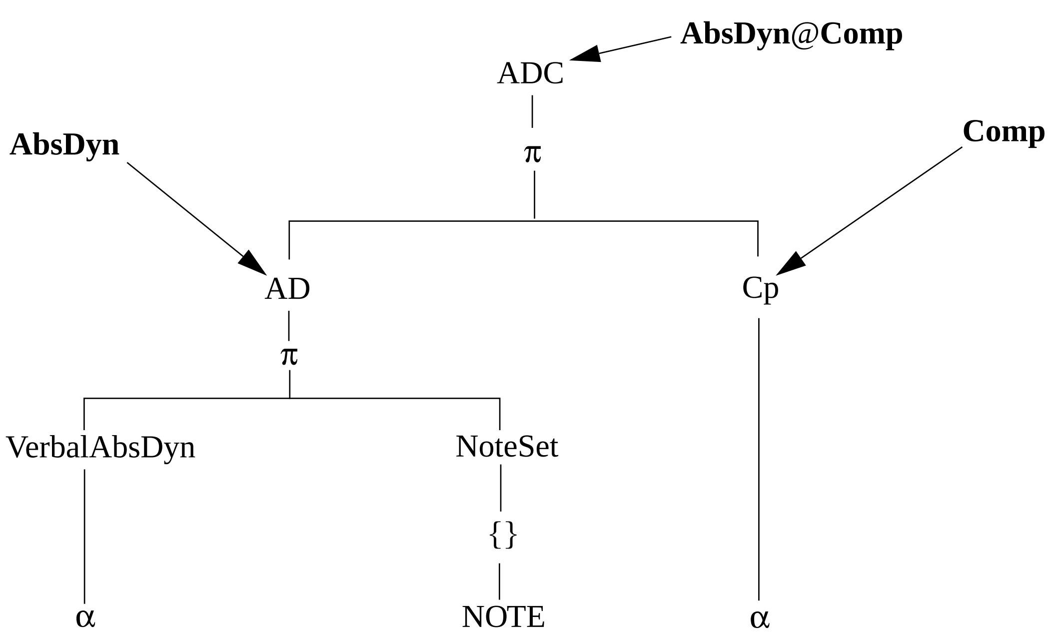



Figure 27. The ADC Denotator for absolute dynamics.

The concrete Denotator for the absolute dynamics **AbsDyn** which exists in the given composition **Comp** is again denotated by **AbsDyn@Comp**.

Finally, the Predicate expression *AbsoluteDynamics* will evaluate to all (complete) sets of notes in a composition sharing the property of being played “prima vista” with the dynamics coordinate of VerbalAbsDyn.

2.5.2.1.2.3 Key Signature

This Predicate type is particularly simple: It shares an onset E, a composition Cp where it takes place, and a codification of the key alterations defining the signature. In the usual European context, this latter is defined by the integer named “KeyLevel” of sharps ♯ or flats ♭, and may be encoded as postive integers (1,2,3,...) for sharps, negative numbers (-1, -2, ...) for flats, and 0 for no alterations. Hence we obtain the situation shown in Figure 28.

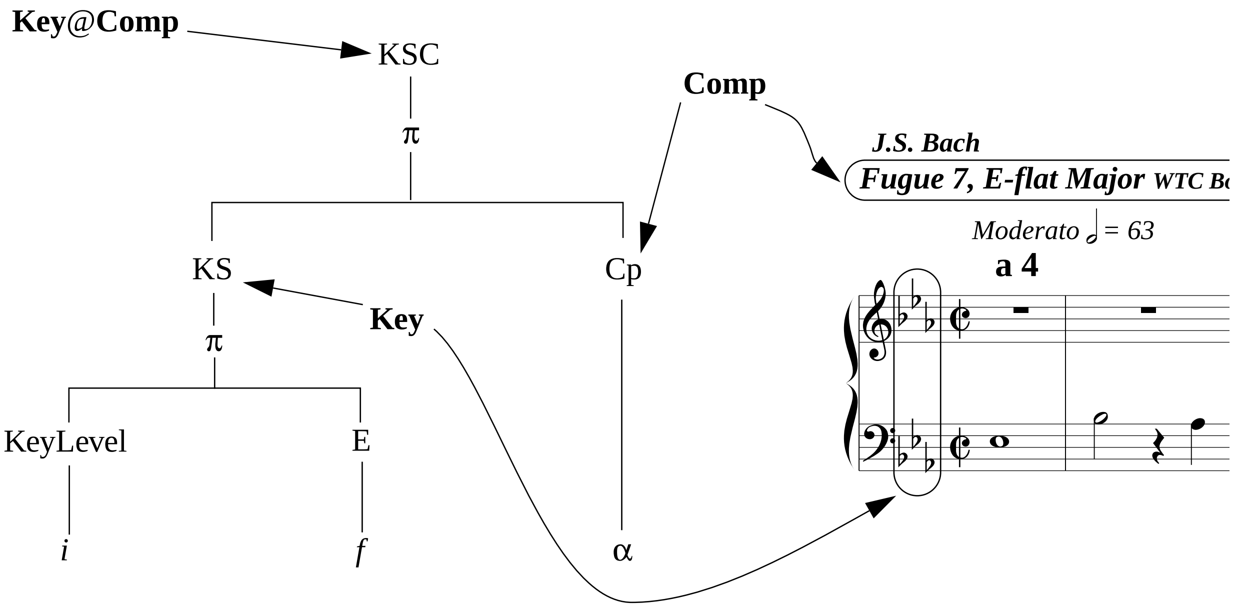



Figure 28. The KSC Denotator for key signature.

A Denotator of the associated prediacte of expression *KeySignature* will then be denoted by **Key@Comp**/*KeySignature* resp. simply **Key@Comp** if the textual expression is clear from the context.

The point here is that in case we deal with piano music (no freedom of tuning), this Predicate lacks of any further semantics *beyond* the given text if we *refrain from* the paratextual predications by key signatures such as Beethoven’s “h-moll - schwarze Tonart” which may influence performance: So far, it is purely textual; we come back to this example in 2.6.

### 2.5.2.2 *Mathematical Predicates*

Mathematical Predicates have extensions of Denotators defined by mathematical criteria. One looks at mathematically defined properties of Denotators, such as onset quantities or boolean specifications, and then selects those Denotators which fulfill these properties. We give three elementary examples which may be extended and completed in many ways. In particular, they do not claim to define all the aspects of the concepts they name (such as “chord”).

Example 1: Chords. We want to fix Denotators which comprehend chords as sets of simultaneous notes. To this end, sets of notes, for piano say, are defined by the Form NoteGroup = (NoteGroup, { }, PianoNote), using the Coordinator PianoNote from 2.1.2.3. Then, by definition, the Expression *PianoChord* will take truth value YES precisely on the Denotators **Ch** → NoteGroup such that all its Substance points **Note_1** → PianoNote, ..., **Note_n** → PianoNote have one and the same E-formed onset coordinate E_1 = E_2 = ... E_n. Recall that such a Denotator is symbolized by **Ch**/*PianoChord*.

Example 2: Melodic Motives. We again start from the Form NoteGroup from the above example, but now, ask that the onset coordinates E_i are pairwise distinct and define the significate of the expression *Motif* to select those Denotators **Mt** → NoteGroup which verify this condition: **Mt**/*Motif*.

Example 3: N-element groups of notes. We fix a natural number N and want to select those sets of piano notes which have at most N elements. Denote this Predicate by the expression *≤N*, thus defining the corresponding Denotators **D** by **D**/*≤N*. This last example shows that expressions may contain variables, such as N in this case.

These three examples suggest that there may be a legitimate musical or musicological *interest* to introduce certain mathematical properties for Denotators. But these properties are above all pure mathematics and cannot be deduced from other properties by *formal* arguments; this is why they are arbitrary to the Predicate system.

#### 2.5.2.2.1 *Mathematical and Musical Foundation*

We made a point in distinguishing pure mathematical existence from musical relevance resp. existence of mathematical properties in the lexical foundation for arbitrary Predicates. This may—at first sight—seem unnecessarily restrictive. Why should a mathematical criterion not be unrestrictedly accessible within music and its theory? The reason is that, besides some historical identifications (Pythagorean school), mathematical objects are not automatically relevant to music. For example, a Fibonacci sequence does not automatically have musical meaning. Only when it is introduced as a composer’s or analyzer’s criterion, it gains the status of a predicative instance. Hence, its application has to be declared as an admitted conceptual tool; meaning as a *musical* Predicate is not for free to mathematical criteria, they have to be given a semantical status beyond mathematics. One of the reasons for this declaration duty is that cognitive aspects of music may need a very clear explication of which concepts are thought to be relevant within a given context. For example, the discussion of consonance and dissonance perception should be sensitive towards mathematical procedures involved in recognition of sonance classes. As soon as cognitive performance has to be traced in the cortical or subcortical tissue, the question of modules for mathematical tasks is primordial.

### 2.5.3 Arbitrary Deixis

Until now, arbitrary Predicates were drawn from lexical data, be it of notational prima vista nature related to scores, or of mathematical nature. There is another major source of bringing Predicates into being: deictic criteria. This means that extension is not found by lexical retrieval but through pragmatic criteria: for every user of a sign, the extension may be different.

#### *2.5.3.1 Existence Versus Lexicology*

In music, Predicates do not only exist 'automatically' or relating to a lexicon of possible choices. Very often, it is pure decision of a user to bring extension of a Denotator into life. Whereas in language, lexical signs dominate and do represent a manifestly predetermined ontology, in music and to some degree also in musicology, shifters are a natural means of semiosis: being and becoming a musical object may be a result of individual decisions. The essential to a formal system is not the deictic arbitrariness, once a Predicate has been initialized, it may be used just like others. However, the mode of coming into existence to the system must be traced.

#### *2.5.3.2 Shifters Types*

According to communicative coordinates, shifters are differentiated relative to poietic and esthesic perspectives. The neutral niveau is omitted here since it excludes, by definition, the deictic dimension.

##### *2.5.3.2.1 Creational Shifters*

These shifters typically come up by the composer’s decision to define a determined set of Denotator instances which will become the objects of his/her composition. Here, the underlying composition—or components of it—is the creation of a Predicate in function of an autonomous decision of the composer. For example, the choice of a composition’s motivic germ **MyMotif** → NoteGroup by a composer is not just one of many possible Predicates lodaded with the property of being a motif, i.e. verifying the Predicate **MyMotif**/*Motif*, it is *this particular motif* that was chosen objectively by the composer and thus has a special position among the Denotators of Form NoteGroup *and* among the Predicates encompassed within the Predicate expressed by *motif*. The expression corresponding to this very indiviuum could be denoted by *ThisMotivicGerm*, an expression that evaluates to YES if and only if we deal with this composer's concrete and unique choice of the germ: **MyMotif**/*ThisMotivicGerm* is a Predicate with exactly one affirmative answer and with no possibility to be traced within a genuinely lexical neighborhood.

##### *2.5.3.2.2 Shifters of Interest*

The esthesic counterpart of creational shifters is the set of extensions considered by analytical interest. Often, there is no lexial reason to consider a particular composition or a special chord, there is just "scientific" curiosity, or interest. In this context, a composition which we may identify by a simple character string Denotator **S** for the composition's name, is symbolized by *!*, and we write **S***!* for the fact that there is a 'singular interest' in **S**.

### 2.5.4 Motivation Methods

There is a sharp difference between Denotator motivation and Predicate motivation: It is much more difficult to construct new Predicates from given ones than to build Denotators since everything has to be checked for its extension. In more intuitive words: Existence has to be checked *together* with mere construction. This obstacle becomes evident also on a technical level in the mathematical study of the predicative category **C**/*Pred* (see the remark in 2.4.5). We shall see in a moment that this is a delicate enrichment of sign structure.

Motivation has to build new Predicates from given ones, and this building process is grounded on the lexical and deictic arbitrary Predicates introduced in 2.5.2 and 2.5.3. Each time we proceed to construct a new Predicate, this means that one is given a certain arsenal of Denotators **D** which "are the case" by already constructed Predicates *P*: **D**/*P*. Now, "being the case" is not mere intuition, one has to imagine that these Predicates have pointers of their Denotators within a storage media such as human or machine memory. So "being the case" really means to exist on a more explicit level than far-out platonic ideas. This has a deep "intuitionistic" consequence:

***Construction Principle.*** *Construction of new Predicates must be based on the restriction to already existing instances.*

We distinguish logical from geometric motivation procedures.

#### *2.5.4.1 Logical Motivation*

##### *2.5.4.1.1 Conjunction, Disjunction and Negation*

If we are given two (expressions of) textual Predicates *P* and *Q*, and if their significates are defined on the same power $\mathbf{C}^n$, then the conjunction *P* & *Q* resp. the disjunction *P* v *Q* are the intersections resp. the unions of the supports of their characteristic functions. Observe that these constructions reside on already defined extensions: No creation of new n-tuples of Denotators of the support is required.

Example 1. We start from the mathematically arbitrary Predicates *Motif* and ≤*N* on dentotators **Mt** → NoteGroup, as described in 2.5.2.2. From this Predicates, we can build the conjunction Predicate *Motif* & $\leq N$. It extends on all Denotators **M**→ NoteGroup which denote motives of at most N elements, see Figure 29. Note that here, the Denotators' names are not relevant for the Predicates.

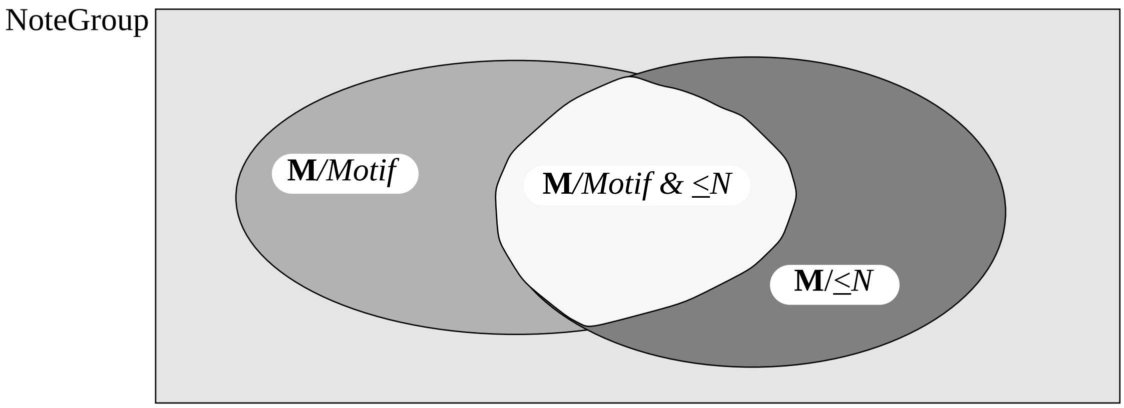



Figure 29. The conjunction of Predicates is defined by the intersection of the support in the Denotator form space.

Negation is the key example to understand the difference between Denotators and Predicates. If we take a Predicate *B* and look for the negation of its extension, this looks odd: The above construction principle implies that unrestricted negation of existence is *not* existence. If we look for all chords which are *not* in a given score, for example, we have to be provided with a superset for these chords. It is not sufficient to look at the Denotators: At this stage, they are merely concepts, not existing things. Therefore, negation cannot be defined unrestrictedly. It is only possible to construct a difference Predicate $A\neg B$ with respect to a given Predicate *A*, i.e. a relative negation $\neg_A B$: From the support of *A*, the elements not contained in the support of *B* are selected.

Example. If the evident mathematical Predicate $>N$ is not defined, the construction principle does not allow to define it by the unrestricted negation $\neg\leq N$; there has to be a difference construction in order to realize it. Hence, in order to select NoteGroup-formed motif Denotators with at least N+1 elements, we may look at the difference Predicate $\neg_{Motif} \leq N$. This becomes particularly important while dealing with computer memory where Predicates have to be stored. The overall area to retrieve Predicates is a fundamental, and essentially *finite* domain for operating purposes; without this allocation data, no system can effectively work.

At this point, it becomes evident that musicological Predicates are viewed as strong ties to existence and much less to mathematical ideas. This does not prevent from using mathematical constructs, but their availability is not for free.

*2.5.4.1.2 Existence and Universal Quantifiers*

In the same vein, existence and universal quantifiers are clear *except* that the ground where existence or allness takes place is a relative one. For example, $\forall x P(x, y)$ should read $\forall_A x P(x, y)$, i.e. we are allowed to select the x from the extension of an already given Predicate *A*.

Example. Suppose we want to express the fact that a motif **M** → NoteGroup is contained in all motives **N** → NoteGroup with at least n elements within a given composition CP. Select the set **NotesCP** → NoteGroup of notes of this composition by the prima vista Predicate *Notes@CP*. Further write *Sub*(**N**, **M**) for the mathematical arbitrary Predicate evaluating to YES on pairs of Denotators **N**, **M** → NoteGroup such that $\mathbf{N} \subseteq \mathbf{M}$. Then, the property *P*(X, Y) of being a motiv X in a motif Y of at least n elements reads

$P_n$(X, Y) = Y/≥*n* & *Sub*(X, Y) & X/*Motif* & Y/*Motif*

Next, we set the Predicate sub(*Notes@CP*) for Denotators **Z** → NoteGroup verifying *Sub*(**Z**, **NotesCP**), more precisely:

(**D**,**N**)/sub(*Notes@CP*) := *Sub*(**D**, **N**) & **N**/*Notes@CP*. Here, we may omit **N** since it is uniquely determined (**N** = **NotesCP**), whence the above notation.

This being, the required Predicate $Q_{n,Notes@CP}$ is this:

$$\forall_{sub(Notes@CP)} Y \;\; P_n(X, Y) \;=\; Q_{n,\, Notes@CP}(X)$$

*2.5.4.2 Geometric Motivtion*

Geometric motivation is a methodology of constructing Predicates from given ones by universal geometric constructions known to mathematicians as limits and colimits. We shall restrict overselves to an elementary example here and refer to [72], [80] for the general theory. However, it should be stressed that this motivation type is much more powerful than the logical type and subconciously resp. informally has always been used in musical and musicological reasoning.

Example. If one is interested in singletons **S** = {x} of notes which are the intersection of a chord **CH** and a motif **M** within a given composition **NotesCP**, this constitues a complex relationship involving eight Predicates (notations as above):

**CH**/*PianoChord*

**M**/*Motif*

**NotesCP**/*Notes@CP*

*Sub*(**CH**, **NotesCP**)

*Sub*(**M**, **NotesCP**)

*Sub*(**S**, **CH**)

*Sub*(**S**, **M**)

Substance(**S**) = Substance(**CH**) ∩ Substance(**M**)

One does not only want to express that "**S** is the intersection of **CH** and of **M**", but also that there are precise relations of inclusion and that the three given Predicates are chrods, motives and compositions. This complex Predicate around **S** is denoted by the diagram shown in Figure 30.

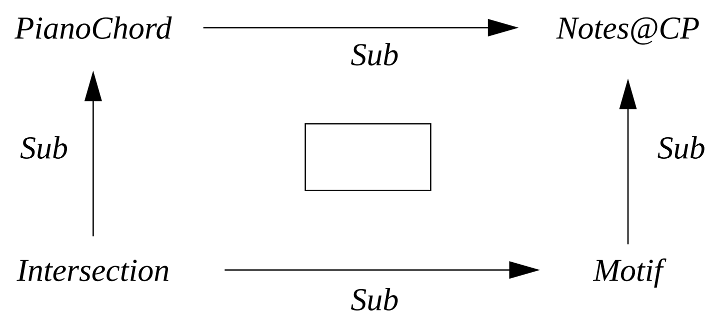



Figure 30. The diagram for an intersection Predicate

where the middle square symbolizes that in mathematics, the diagram is a pull-back limit diagram [39]. This mathematical statement can be summarized to the point that the intersection Predicate *Intersection* realized in **S**/*Intersection* is a complex construction involving all the ingredients listed above. This is a prototypical situation in musicology: **S** is not merely the isolated set {x}, but stems from a piano chord and a motif in a given composition etc.

Observe that here, the intersection **S** is not the intersection of extensions as with the logical conjunction. The intersection is taking place between the chords and motives. This is a geometric construction within the Form PianoNotes inducing the NoteGroup Form, see Figure 31.

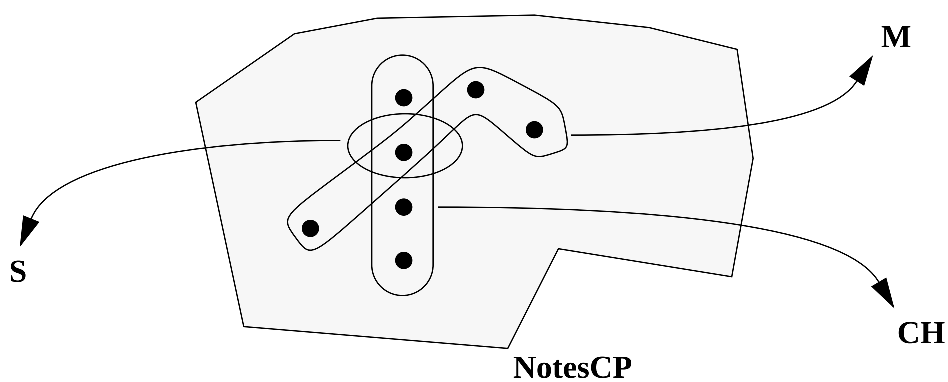



Figure 31. The geometric construction of the intersection Predicate **S** in relation with motif Predicate **M** and chord Predicate **CH** within composition Predicate **NotesCP**.

## 2.6 Classification of Paratextual Predicates

Beyond the text, classification is less systematic or formalized. The signification function parasig targets at open semantic domains. We know from 2.4.5 that a paratextual Predicate is a triple (expression, parasig function, significate). This can be of a very general specification: technological, stylistic or historical. Hence, the following outline is more sketchy and prospective than the preceding chapter. It is however still possible to give a generic classification of paratextuality. In this sense, paratextuality is not simply the negation of textualiy. Meaning here is quite a different thing, this was already discussed in 2.4.4.1 and 2.4.4.2. But this intensional variant of "meaning" is not just a methodological embarrassment, encompassing everthing that is not extensionally understood; this is discussed in the following.

### 2.6.1 Paratextual Predicates: Extroversive Semiosis to What?

Openness should be understood as a pointer to exterior instances of semiosis. For example, if historical and stylistic competence is required to understand Agawu's topics such as "alla zappa" or "Mannheimer Rakete" [5], this does not categorically abolish extensionality, is simply shifts it to a black box of semiosis alluded to by Leibniz' concept of "possible worlds", see also Carnap's corresponding stratification of intensionality into extensional perspectives within possible worlds [13], [58]. In this sense, paratextual semiosis is only an incomplete information to meaning. What the extroversive pointer points at is rather 'semiosis in progress' than a 'discomfiture of textuality'.

### 2.6.2 Double Semiosis

Many expressions are tied to double, textual and paratextual semiosis. For example, *rall.* or a trill are charged by a well-defined textual semantics: A rallentando sign has onset and duration. It covers a set of notes, i.e. it is defined by an extension covering all sets of notes (Powerset Denotator over note Denotators). However, beyond this textual meaning, performance has to realize a tempo curve which is a function not only of the text but of the interpreter, and the individual performance. With a trill, the situation is slightly different. In contrast to the rallentando sign which does only *reproduce* the given notes, the trill *produces new notes* beyond the written ones. We can thus distinguish between reproductive and productive paratextual Predicates.

#### *2.6.2.1 Reproductive Predicates*

Reproductive Predicates are defined by conserving the given note material. But this does not mean that they are non-creative. In the contrary, they are the core of human expressivity.

##### *2.6.2.1.1 Performance Predicates*

There are agogical, dynamical, or articulation signs such as the fermata sign 𝄐, *crescendo* or a slur are performance Predicates with a reproductive character. Their meaning transcends the text and points at the physical realization of a piece of music.

*2.6.2.1.2 Expressive Predicates*

Certain poietical signs such as *con brio*, *languissant* etc. should express emotions. A priori, they do only transmit what the composer wants the artist to express, but the precise meaning is not codified. This one has to be realized through a personal and/or educational ground. Such an expressive Predicate does not directly dignify performance, it rather constitutes a metasign whose significate is a bunch of performance signs as described in 2.6.2.1.1, viz the set of possible performance Predicates which may express the denoted emotion. This is an example for black box semiosis of paratextual Predicates, as mentioned in 2.6.1.

*2.6.2.1.3 Lyrics*

Lyrics, such as they are present in song texts, are linguistic signs with clear-cut onsets and varying but well-defined durations. Their denotative semantic structure is completely determined by the autonomous linguistic meaning. However, musical structures will greatly influence the poetical superstructures, and vice versa. In particular, lyrics are metasigns with respect to performance as discussed in 2.6.2.1.2.

*2.6.2.1.4 Choreographic and Dramaturgic Indications*

For performances and theatrical pieces such as Noh theatre or operas, music is paralleled by many indications for action and other men-oriented behaviour with clear-cut onsets and varying but well-defined durations.

*2.6.2.1.5 Musicological and Historical Competence*

This type of Predicates includes Agawu's list of topics, style indications in liner notes, marginal notes, comments etc. on the scores, sociocultural coordinates through references to the sociocultural context, such as religious or national or political puroses, further biographic data such as the composer's name, dedications etc., finally historiograhic references by the date or place of the composition's making, etc.

This type of Predicate is a good example of paratextuality as a pointer to external meaning *without* definite loss of extensionality. In fact, historical facts may become precise within specific lexical and extensional semiosis.

*2.6.2.2 Productive Predicates*

These are designed to produce new notes apart the written ones. This is a classical example of the extension of the score concept to processual functions beyond suspected 'passive notation'.

*2.6.2.2.1 Lexical Productive Predicates*

Some of the production processes are codified and may be executed only after consultation of a lexicon resp. an expert with lexical function.

###### 2.6.2.2.1.1 Ornaments

For classical European music, there are detailed decoding lists for ornaments (trills, praller etc.) as a function of composer and historical coordinates [11]. With non-European cultures, such lists often make part of the oral tradition.

###### 2.6.2.2.1.2 Improvisational Patterns

Some Predicates—such as jazz notation of melodies and harmonic chord progressions—are explicitely defined for production of large ensembles of new notes. In the jazz context, a certain lexical reference is given by specialized music schools determining how a chord progression should be played. Even if the chord realization is not uniquely determined, the set of allowed chords is rather well determined.

##### *2.6.2.2.2 Shifting Productive Predicates*

Besides the lexical codification of productive Predicates, there is a large variety of mainly user-defined Predicates; this is a fairly open research area.

###### 2.6.2.2.2.1 Creational Predicates

In music directions where the Saussurean “langue” is dominated by “parole”, such as oral traditions in afro-american black music, many Predicates open a vast field of deictic production which is properly termed as creative act. As an example, we may consider the jazz term “swing” which shifts according to the musician and to the stylistic perspective. The meaning of the Predicate *swing* is a kind of personal property of the musician which uses this Predicate. Its usage is not a passive reproductive, but a source of continuous creativity. This may seem difficult to understand for scientists, but to the musicians it is quite substancial.

###### 2.6.2.2.2.2 Unintentional Predicates

Some Predicates in random process oriented music directions, such as the “musique aléatoire” written by Bierre Boulez [10] and Iannis Xenakis [126], or the random-driven compositions of John Cage [57], intentionally set up random effects, leaving to the musicians’ mood to produce more or less determined effects to break the deterministic performance. These Predicates are shifters by their very nature, but do not claim any creative activities. For this reason, the performance of this type of compositions is also supported by machine-generated random decisions.

# 3 THE PERFORMANCE SYSTEM

This is the second big subsystem of music semiotics, see the overview in Figure 3. The performance system mainly sticks to the physical reality layer, but it also related to psychic reality.

Remark. In the Standard Music Description Language SMDL, a specialization of the SGML document standard [108], the performance system is called “gestural system”, whereas the Predicate system is termed “logical system”. Unfortunately, this terminology fails to hit the point since performance is not less logic that predicative reality. Further, the gestural aspect of performance is only one of its aspects. Therefore, we do not adopt this terminology in spite of its standard claim.

## 3.1 Mental and Physical Semiosis

### 3.1.1 Ontology of the Predicate and Performance Layers

The ontological status of the Predicate layer is substantially a mental one. That for textual Predicates this is neither of physical nor of psychic nature, is clear. This is not quite evident for paratextual Predicates. For those pointing at historical meaning, for example, the ontology is manifestly mental. For others, such as performance oriented types (agogics, dynamics, articulation, see 2.6.2.1.1), it is a meaning *pointing* at the reality of the performance. But it remains of mental character since it does neither include the detailed representation of the execution parameters nor does it—a fortiori—put the execution into reality, it is a *mental prerequisite* for the physical realization.

It is up to the next connotational level whose denotational level is the mental system of Predicates to deal with the physical music description. To this end a system of signification is required. It deals with the processes that happen when we “make” music and must be in state of transforming the mental corpus into the physical data of a performance. In European musicology, it was only recently recognized [4] that this aspect is essential to the ontology of a musical composition. In other cultures, for instance in Asian or in African traditions, the mental level *per se* is secondary compared to the transformational work and its result.

### 3.1.2 The Question of the Identity of a Musical Composition

This ontological differentiation leads to the question of the identification of a work of music: What is the identity of Beethoven’s Fifth?

#### *3.1.2.1 Abstract Identity*

A first identification of a musical work **S** takes place by the instanciation of all necessary information to be able to play the music. Naively speaking, one may identify this with the score. More precisely, this will be the set of all arbitrary Predicates *associated* with the score. This means that we collect the Predicates deduced from reading the score without further analyzing it and thus includes all textual prima vista Predicates with their paratextual signification, but it *excludes* all mathematical and shifter Predicates. It is not yet the neutral level in the sense of Molino [82], Ruwet [100] and Nattiez [86], but only a propedeutical identification of the material where to get off ground. We call this the *abstract* or *material identity* of the work.

#### *3.1.2.2 Neutral Identity*

From the material data successive analyses enrich our 'knowledge about the score'. Semiotically speaking, this means generating all Predicates *related* to the material Predicates by means of the motivation tools and arbitrary Predicates described in 2.5.4.1, 2.5.4.2 and 2.5.1. De facto, this amounts to systematically establish *all possible analyses of the given work*, as far as they are grounded on objective Predicate calculus. This means declaring all prerequisites, all tools of deduction, all supplementary Predicates (such as mathematical arbitrary Predicates) and all results.

This analytical data describes the total of what analytical interpretation of the work may reveal. It is a collection of all perspectives of looking at the material, and of all *comparative* studies relating such perspectives. This excludes selective analysis for any reason whatsoever. Following Ruwet [100], such a total of rational understanding is called the *neutral* identification of the work. The most important work in neutral musical analysis research is to construct minimal bases of analyses determining all possible analyses, i.e. the neutral identity of a work.

#### *3.1.2.3 Esthesic Identity*

From the total neutral identity, esthesic perspectives intervene by *selection* of determined analyses. The justification of any such selection is given by the esthesic point of view which defines valuations of analyses for historical, psychological, social and individual reasons.

A distinguished esthesic position is that of the composer’s poiesis. Seemingly, this is an impossible construction since, by definition, the poiesis is never esthesic. However, in hermeneutics [7], esthesis is known to be a type of *retrograde poiesis*. In other words, the retrograde of the orignal poiesis is merely a distinguished type of esthesis. In this sense, the variety of esthesic selections of analyses is the collection of variations of retrograde poieses. The valuation leading to the original retrograde poiesis, the sometimes sought “ideal analysis”, is the one which is defined by the biographical position of the composer in the space-time of his/her culture.

The collection of all esthesic analyses of a work defines its *esthesic* identity. It is not merely the system of all selections within the neutral identity but includes the valuations backing the different selections. Now, each performance of a work is based on a particular esthesic perspective, and aims at making it evident to the auditory. In other words, *performance deals with expressive communication of the esthesic identity.* And as a such it is embedded in an infinity of perspecitves of the given work. It is only the full-fledged esthesic identity that establishes the complete ontology of a work, and hence *performance is an essential part of the work*, an insight that was stressed by Adorno [4] and Valéry [116]. This evidence may suggest a general performanc theory of fine arts: what does it mean, for example, to perform a sculpture, a painting?

## 3.2 Performance Score Theory

This essentially is the theory of signification processes transforming Predicates into physically meaningful objects. The core of this theory is the description and analysis of the performance score, an *additional score layer* on the mental level that is layed over the classically known 'mental' score. This additional score will be termed *performance score* and may be compared to a lense system deforming the mental score into a performed physical output score, see Figure 32.

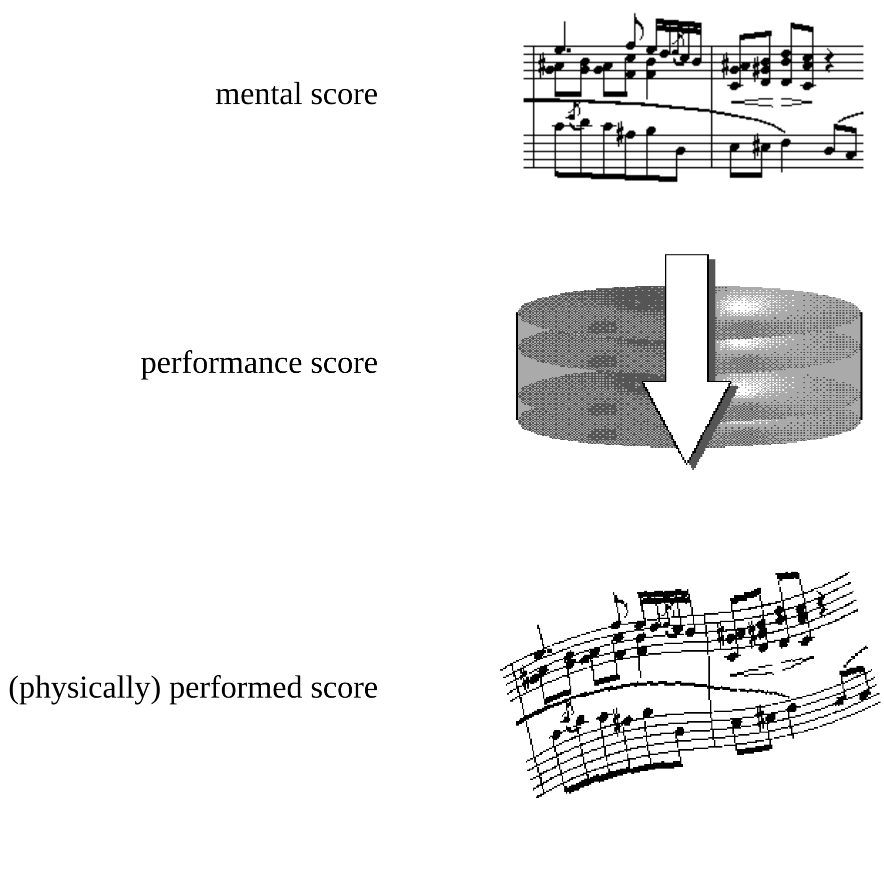



Figure 32. Intuitively, the 'lense system' of the performance score is responsible for the 'deformation' of the mental score yielding the performed (physical) ouput score.

### 3.2.1 Overview of Score Layers

Since a generic score concept would require a more general setup than semiotics, we postpone the very concept of a *score* to 3.2.6 and first define the *a priori combined* concepts “mental score” and “performance score”.

#### *3.2.1.1 The Mental Score*

The *mental score* is the one we have known and discussed previously: the abstract or material identity of a work. Recall from 2.3.5.2 that the non-restrictive character of the Denotator system helps including very general ethnomusical situations such that the concept of a mental score is not restricted to or centered around European Denotator samples.

#### *3.2.1.2 The Performance Score*

Performance deals with transformation from mental signs qua signifiers into their significates on the physical level. According to the present performance theory, this signification process is split into two submodules which will be made explicit in 3.2.2 and 3.2.3: 1. the transformation mechanisms of *performance vector fields* and *stemma genealogy* according to [72], [80], for defining the deformations of mental sound parameters into physical parameters; 2. the rationales, termed *performance grammars* (KTH school [35], [111]), for producing the *performance vector fields* and *stemma genealogie*s by use of *performance operators* (see [72], [80]) which reside on mental analyses of melodic, harmonic, rhythmical or contrapuntal structures, based on the system of Predicates, and expressed by *weight* functions.

##### *3.2.1.2.1 Technological Semiosis*

The representation of signs with physical signifacte is by its very nature channeled through technological mediators. For performance by means of electronic devices, the significate is defined on the level of machine-specific codes, such as MIDI or Scorefile code [1]. For pre-electronic instrumental performance, the code is written in a more gestural language since in the technology of classical instruments, actions are realized by human gesture actions on the instrument’s sound production devices, such as strings, keys, pedals, percussion surfaces etc. Whatever the technology, the final physical significate is only pointed at through the instrumental technology, see Figure 33.

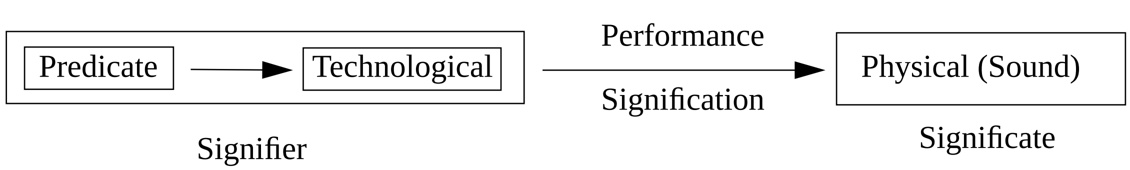



Figure 33. The physical significate of the performance sign is split into a connotational physical sound significate pointed at via a denotational subsystem of technological significate.

Although this intermediate connotation layer (physical meaning being postponed to a connotational terminal) seems to be of rather technical character, it is a crucial subject to signification processes. In fact, if we compare MIDI code to physical modeling (software-driven modeling of dynamical systems of acoustic instruments [109]), or to pre-electronic instrument technology, the variety of avaliable performance operators increases dramatically when switching away from MIDI to physical modeling or to pre-electronic instrument technology. Whereas with MIDI, the synthesis of a sound is fairly encapsulated within channel and program change numbers, classical instrument technology and physical modeling open access to poietic aspects of performance. This is why physical modeling tends to recover the expressivity of human musicians and hence will play a crucial role in future performance research.

##### *3.2.1.2.2 Physical Semiosis*

The terminal semantics of performance is physical 'realization' of the Predicate signifiers. In principle one should distinguish between a data representation of physical character and its existential realization. This is the distinction between possessing an audio document and playing it here and now. Again, it becomes evident that semiosis has a deep impact on ontological aspects.

It seems that this is quite a narrow view of musical meaning since physical realization does, indeed, cancel all the transcendental “Überbau”. But it is true that the core of performance is this physical meaning. However, the listener will start constructing further semiosis from this *and* from further knowledge stemming from the *entire* signification process originating from the mental score. Observe that connotation does rely on the *entire* denotational stratum, and not only on its significate.

### 3.2.2 Structure of Performance Scores

A *performance score* (PS) is a *global* object layed over the mental score. It encompasses the transformation prescriptions to generate the physical realizations of the Predicate symbols. The global structure is defined via a covering of the mental score by *local performance scores* (LPS). These take care of different parts of the mental score, such as periods, bars, certain complex small portions within bars etc.. The concrete covering by an “atlas of LPS” is not uniquely determined but varies as a function of the applied performance grammar.

The point of such a covering is that on overlapping regions of two LPS, the prescriptions should lead to a well-defined (unique) result. This is what in the mathematical theory of manifolds is called “glueing together local structures” [59], see also 2.3.1.3 for such a covering situation in mathematical music theory.

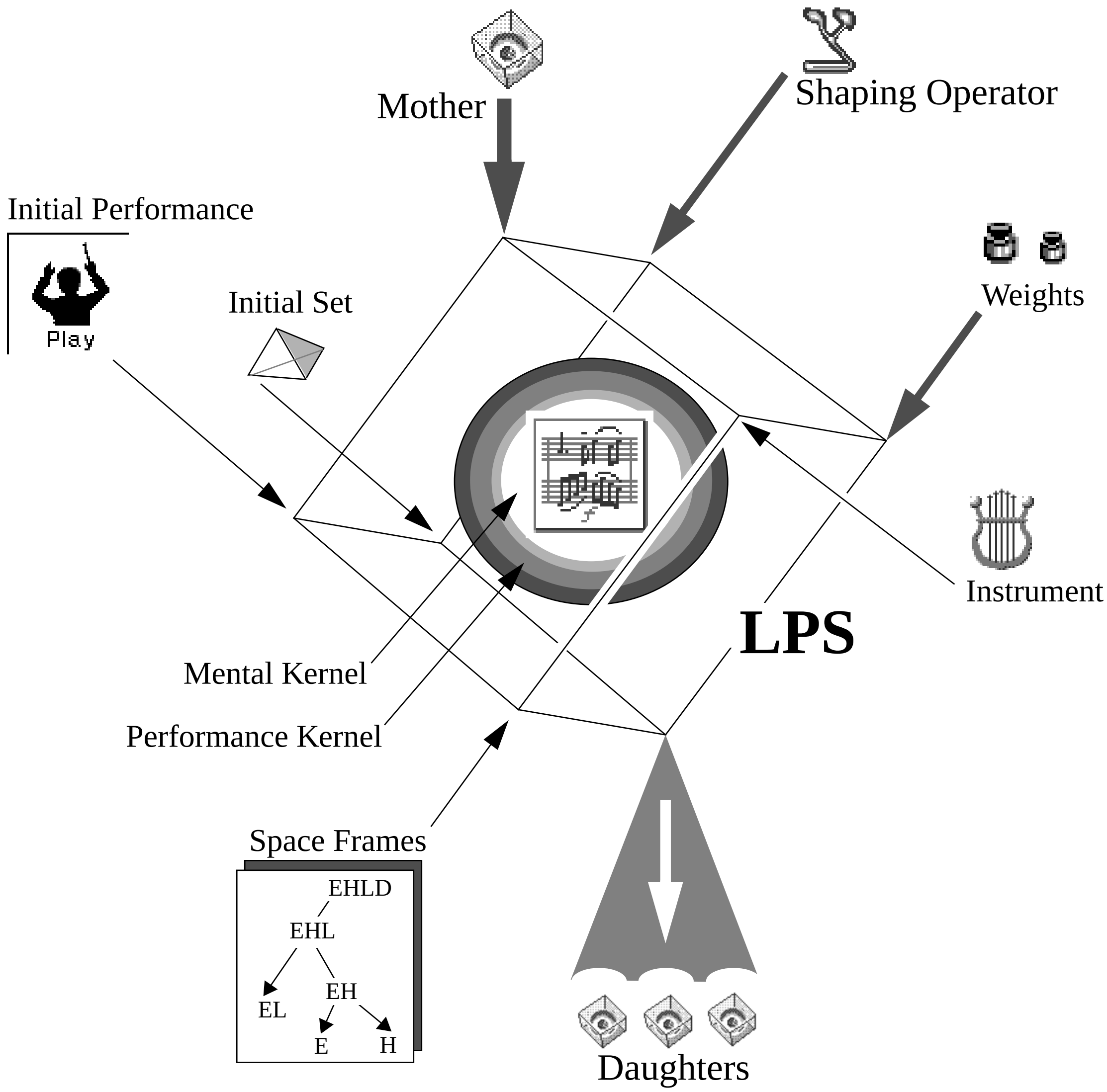



Figure 34. The components of a Local Performance Score.

*3.2.2.1 Local Performance Scores*

We shall see in 3.2.3.3 that an LPS is not an isolated object, but shares inheritance from a 'mother' LPS and inherits its own structure to the collection of its 'daughter' LPS. This genealogical reference embeds the LPS into a development process of successive refinement of performances to be discussed in 3.2.3.3.

To begin with, we want to introduce the LPS structure as a such. An LPS consists of a

- (mental) kernel
- performance kernel
- instrumentation data
- initial set
- initial performance
- space frame
- shaping operator
- weights
- mother LPS
- list of daughter LPS

Let us specify these components which are visualized as vertexes of a cube and of its center (kernel and performance kernel), see Figure 34.

*3.2.2.1.1 Mental and Performance Kernels*

Each LPS takes care of a particular subset of the given mental score: the (*mental*) *kernel* of the LPS. The transformed, physically meningful events of the kernel build a second collection, termed *performance kernel* of the LPS. So, if a tone of the kernel is defined in mental parameters, such as semi-tones or quarter note durations, the transformed event is given in physical coordinates, such as logarithm of frequency (physical pitch) or seconds. This means that performance is not a global process spread over the totality of the musical composition. Each part that is covered by the LPS via its kernel realizes a particular performance mode whose result is condensed in the performance kernel.

*3.2.2.1.2 Instrumentation*

This specification is clear. But ist should be stressed that it is a complex sign encoding all details of a physically meaningful instrument. This also refers to the above distinction between technological 3.2.1.2.1 and physical 3.2.1.2.2 semiosis. In particular, the instrumentation is responsible for the spectrum of performance specifications related to the specific instrument. For example, if the sound parameters include glissando data, the instrument has to respond to this information in order to transform it into physical expression.

*3.2.2.1.3 Initial Set*

Initial sets define the anchorage points to get a performance off ground. For tempo, this is the onset point within the mental score, where the conductor initiates the piece. Without knowing this point, no musical performance can begin to exist in physical time. For tuning, which is the pitch analogy to tempo, the initial set typically is the chamber tone from which the physical reference of all pitch values is deduced. In this sense all physical sound parameters are referenced to initial sets.

In general, initial sets can be extremely involved simplicial complexes [80]. This becomes evident from the fact that the PS is a covering of LPS, each of which has a proper initial set, telling it where to start its performance. As mentioned above, glueing together several LPS has to cope with consistency conditions of the performance. Hence if we know the performance data from a prior LPS, a later LPS that 'starts' where the prior LPS 'ended' has to define its initial set from the performance of the prior LPS, and this data can have a complex shape.

*3.2.2.1.4 Initial Performance*

This data makes explicit the physical events of the performance on the tones within the initial set. It is the turning point from mental to physical reality. It is the typical action of a conductor or bandleader when starting a performance by a downward movement of the baton or an equivalent gesture. Its character is the instanciation of a shifter: “Here and now, we start our performance.” See 3.2.4 for a more detailed discussion.

*3.2.2.1.5 Space Frame*

On one hand, an operational performance concept needs a frame which determines the limits of parameter values where the entire performance calculations take place (for search tasks, for example).

On the other, the concept of “performance space” is more complex than the simple statement of the *total parameter space* where the kernel is embedded. This is due to the fact that there are several a priori space decisions that control the performance structure by means of relations between different groupings of the parameters of the total space. These relations regulate the mutual involvment of parameter groupings when performance is calculated. For example, duration D is by default linked to onset E: duration cannot be isolated from onset since in any reasonable setting, *there is no shaping of durations without taking into account tempo information*. Vice versa, tempo is usually well-defined without recursion to duration, see 2.5.2.1.2.1. This may be rephrased by a hierarchy graph ED $\rightarrow$ E stating that for tempo and articulation shaping—which takes place in the $\mathbf{R}^{ED}$ space—the onset factor $\mathbf{R}^{E}$ is *autonomous*, but the duration space $\mathbf{R}^{D}$ is *not* [73], [80].

Every performance has its specific *hierarchy graph of linkages among its parameter subspaces*. Figure 35. shows the default hierarchy for piano music in the four-dimensional space $\mathbf{R}^{EHLD}$. For refined performances of piano music, the default hierarchy usually reduces to a proper sub-graph.

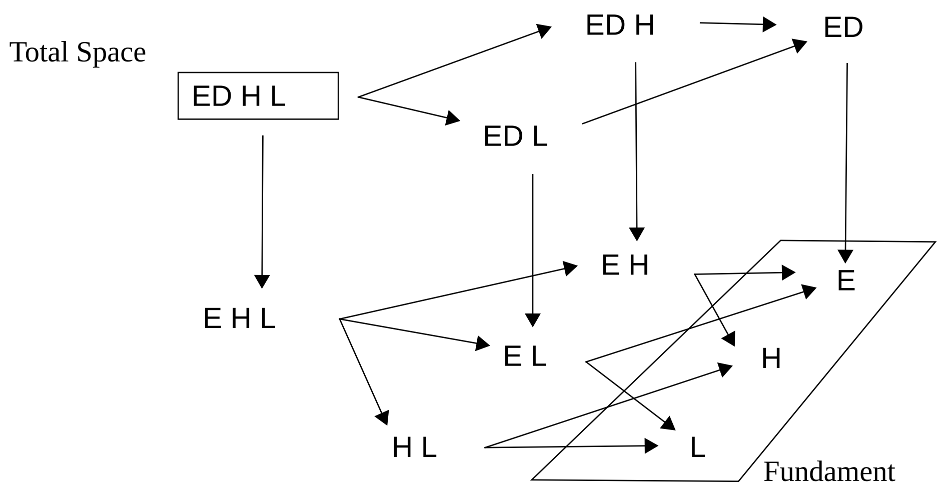



Figure 35. The default space hierarchy for piano performances. The total parameter space EDHL (short hand for $\mathbf{R}^{EDHL}$, the order of the parameters is permuted with respect to the hierarchy) ramifies into a hierarchy which terminates in its 'fundament', the basic spaces of the hierarchy. For example, the performance on the level EDL decomposes into the autonomous performance directives for the basic intensit space L, and those for the tempo-articulation ED $\rightarrow$ E, which in turn is based on tempo for E, but does *not* split D from E since any reasonable performance directive in D refers (among others) to tempo.

The hierarchy graph of the LPS gives a general frame for the actions of shaping operators.

*3.2.2.1.6 Shaping Operator*

Every local hierarchy is built in function of a selected instance of the available performance grammars. This instance is called the shaping operator of the LPS. Generically, an operator inherits the already existing performance data from the LPS' mother (see 3.2.2.1.8). From these and with respect to the loaded weight of the LPS (see 3.2.2.1.7), new performance data are produced. To date, there is no systematic account of reasonable shaping operators, however, the overall effect of shaping operators is a *deformation of the performance field* of the LPS' mother. The performance field is a particular vector field on the total parameter space. Hence, every LPS bears it's performance field as a reshaped versions of its mother's field. (The 'root' field is a constant field.)

Summarizing, a performance field can be understood as being a generalization of the commonly known tempo curve which is the performance field on the onset space. A tempo and articulation field on the ED space is shown in Figure 36.

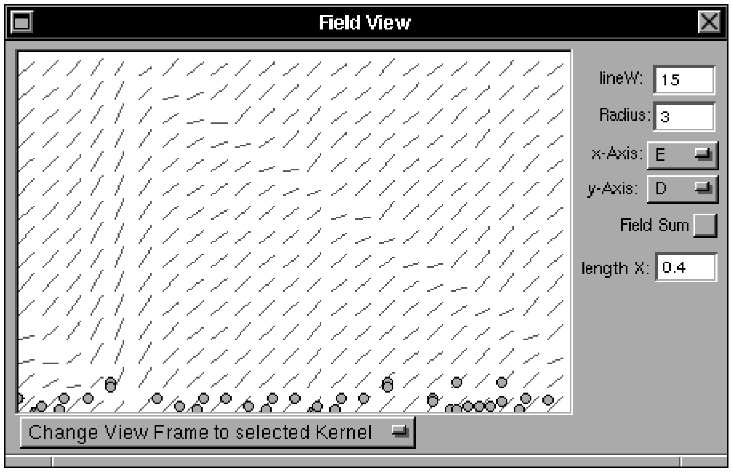



Figure 36. A tempo and articulation performance field on the ED plane as it is shown in the RUBATO performance platform [78]. The E-projection of the field is the tempo curve. The small spheres show the tone projections onto the ED plane.

The remarkable qualitative fact about semiosis of performance as explicited via performance fields is that they introduce infinitesimal precision and differentiation of musical expression into signification theory.

*3.2.2.1.7 Weights*

Whereas the structure theory of performances is well understood by means of performance fields, the link to semantics of expression is less clear. Basically, there are three mechanisms which are responsible for transforming Predicates into performance: *rational* analysis of the *mental* score (attributed to *mental* reality), *emotional* motivation (attributed to *psychic* reality), and *gestural* motivation (attributed to *physical* reality).

Performing a mental score from its rational analysis is a fundamentally different semiotic situation from performance by use of genuinely emotional or gestural rationales. The former situation produces the significate by reference to the signifier on the Predicate level, albeit the analytical motivation process (instances of the score's neutral identity) may be involved. In contrast, the latter situations insert the musical signs into an extramusical semiosis where the musical system's signs of type Predicate $\rightarrow$ performance are only the denotative subsystem pointing at emotional or gestural significates.

This situation resembles the prosodic performance of a linguistic text as an expression of emotion. For example, the meaning of sentence "I hate you!" is perfectly understandable, but the prosodic shaping (stressing the middle word, among other measures) is in addition charged with the transmission of the speaker's *feeling* of hate. Since this type of expressive connotation in music is dealt with in 4.2.4, we shall postpone its discussion to that section.

We are therefore left with the signification mechanism which is responsible for the *production of the* LPS' *performance field from the analyses* of the mental score, i.e. from instances of the score's neutral identity. More concretely: How can the mother's tempo curve be reshaped according to the rational insight from the mental score? Since the structure of a performance field is *quantitatively* specified, at some moment of the signification process, quantitative data have to be produced. In other words, *rational analysis of the mental score must condense to a numerical substratum in order to be accessible to shaping of performance.* In performance theory this latter is called a *(analytical) weight*.

Being charged with a set of weights, the shaping operators (within the selected performance grammar) are in state of reshaping the performance field. For example, the mother's tempo curve T(E) may be deformed by a melodic weight in the following straightforward way: Suppose that the melodic weight is a positive numerical function M(E) of the composition's onset E that quantifies a kind of "melodic intensity" at onset E. Then an operator may just deform T(E) to the new tempo curve $T_M(E) := T(E)/M(E)$. This operator slows down tempo each time when the melodic intensity increases.

### *3.2.2.1.8 Mother LPS and the List of Daughter LPS*

The specification of a mother LPS makes precise the fundamental fact that *performance is the result of a multi-level process*: One starts from a "mechanical" prima vista performance as a 'primary mother' and follows a path of successive inheritance of the maternal performance data as an input for the LPS performance. Within this genealogy, an LPS may have several daughters. For example, if the given score has been performed as a whole on the mother's level, one may proceed by a split of the score into several subsets of notes, according to groupings into voices or/and periods. The entire system of primary mother LPS and its daughters, granddaughters, etc. is called the *stemma of a performance*, see the example in Figure 37.

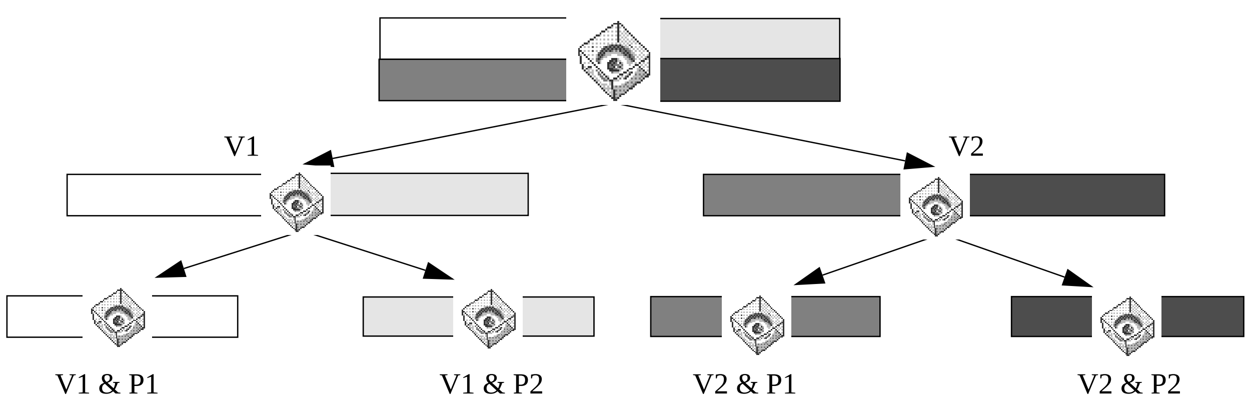



Figure 37. A stemma for a score with two voices V1, V2 and two periods P1, P2. The daughters are constructed according to these groupings.

The leaves of this genealogical tree are the final performances of the given mental score. They normally include more or less small portions of the original material, such as single bars, ornaments, or motives. In the example of Figure 37. the leaves are V1 & P1, V1 & P2, V2 & P1, and V2 & P2. Apart from the technical scope of glueing the atlas of the stemma's leaves to a global PS, the formation of this atlas reflects our undestanding of the piece. Such an LPS atlas is part of the performance grammar.

The multi-level process of stemmatic semiosis is described by the series

$$S(0) \rightarrow S(1) \rightarrow ... \rightarrow S(d) \rightarrow S(d+1) \rightarrow ... \rightarrow S(n)$$

of successively growing substemmata S(d) of depth d, counted from the top LPS. This series is nothing else than a Hjelmslev denotation/connotation chain where S(0) is the initial denotation level, corresponding to the mental score. The intermediate performance S(d) is the denotational layer for performance S(d+1), and S(n) is the final performance, see Figure 38.

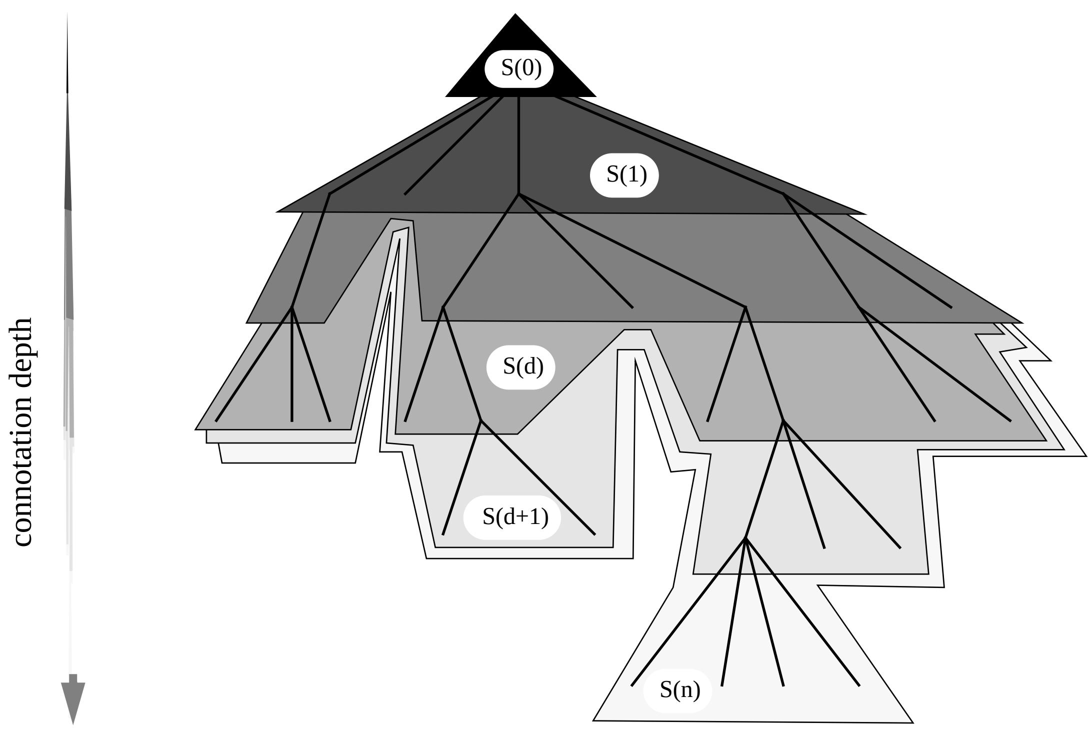



Figure 38. The series of successively growing substemmata as a connotational deepening process.

### 3.2.3 Lexical Determinants of Performance Semiosis

Although performance seems largely tied to shifters, there are several aspects of pronouncedly lexical character. This seemingly contradictory fact resolves when looking more closely at the type of involved lexical signs.

*3.2.3.1 Analyses of the Mental Score*

As mentioned above, performance grammars make use of results from the mental analyses of a score, i.e. from its neutral identification. This corpus of neutral analyses is a lexical instance to be consulted before performing. As the total of neutral analyses is never available, the analytical library is always determined by the shifting primitives of individual selection.

*3.2.3.2 Performance Grammars*

As sketched in the course of 3.2.2.1.7, these are the methods to apply given analyses in order to shape or reshape performance fields according to specific shaping principles. Morphems of such grammars are the shaping operators which build new sets of daughters from a given stemmatic 'family'. Presently, the performance grammar lexicon of analytical weights contains harmonic, metric, melodic, and grouping analyzers, and a dozen shaping operators, see [78], [111], [114]. A systematic description of more elaborate structures of such grammars is outstanding. This is due to the difficult problem of how performance operators have to be designed and combined in order to convey the message of the neutral layer *with optimal communicative effect of evidence*.

*3.2.3.3 The Stemma as a Historiographic Production Scheme*

The stemma reflects the fact that performance is a *diachronic* process. The mother-daughter paradigm is a remarkable semiotical fact. It documents the growing of the significate in time and fixes it on the level of the stemma. In this sense, it is parallel to the etymological metamorphosis of meaning: The result is the current meaning, but it cannot be understood except through its history. As a such, a stemma produces historical meaning. The series in Figure 38. ressembles a series of annual rings. Building the lexicon of stemmata means repertorizing the different ways in which a score has been performed resp. rehearsed. Music critique is a traditional and inexact reading of this goal: to trace the existing stemmata and to make them avaliable to the future creators and analyzers of performance.

*3.2.3.4 Grouping and Splitting Inheritance*

The tree structure of a stemma is not quite the ultimate structure of the stemma. There is a reversed movement to the splitting of an LPS into its daughters. This is due to the following problem: In practice, building daughters may occur while splitting a period into eight bars and then elaborating on their individual agogics, say. After this splitting work it may happen that again, shaping will take place on a common ground, i.e. the individual agogics can be followed by a common grouping application of an agogical operator, see Figure 39.

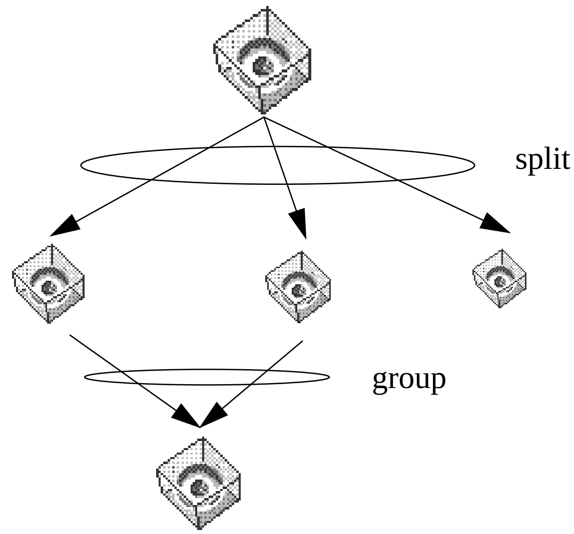



Figure 39. Splitting and (re)grouping are complementary ramification processes of a realistic stemma.

### 3.2.4 Deixis of Performance and its Coordinates

One pillar of performance is of deictic character. We have the following instances of this aspect:

#### *3.2.4.1 The Role of Initial Sets*

It was explained in 3.2.2.1.3 and 3.2.2.1.4 that the initial set and performance are the set of mental events, together with their physical performance which is a priori defined by the performer. Every interpretant of the performance sign (e.g. the conductor) will define his/her own value according to the moment he/she feels ready for starting. This is a *magic* moment which transforms the mental Predicates into life. After this moment, the remaining physical coordinates are only 'flags attached to the initial point' by means of the performance flow of the performance field. This is a very deep anchorage of musical signs in living reality: Music can definitely and substantially not be reduced to lexicality, it has to happen. Conductors such as Sergiu Celibidache have based their entire performance philosophy on this point [104].

#### *3.2.4.2 Technological and Physical Shifters*

Instrumental specifications may be more or less lexical. For example, the specification “keyboard” is a roughly lexical instrumentation. But there are very different types of keyboards: upright pianos, grands, electronic keyboards, etc. The exact realization as a deictic sign is left to the 'user'. In extreme cases the instrument is physically built each time a music event happens (e.g. the one-stringed Anzaad instrument of Tuareg music [63]).

Another, often neglected physical shifter of extreme importance is the space where the music is played. Be it a concert hall, a rainy corner or your living room, it is mostly left to the performing realization to define these coordinates.

*3.2.4.3 Reproduction and Shifters*

This point alludes to the problem of reproduction of a work of art. For painting art there is almost no freedom for reproduction. It is extremely non-shifting, reproduction is understood as a massive violation of the work's identity. For music, this is completely different, mostly for the reason that physical realization is essentially anchored in time (3.2.4.1), and by use of time as a material parameter. Without the initial set specifications, performance is an anchorless boat on the ocean of space-time; reproduction does not mean copying but anchoring the original in reality.

*3.2.4.4 Technolgy and Lexicality*

Lexicalitiy is not only a question of concepts, it is also related to perspectives of technology. The performance system makes this evident within. Before the advent of modern information technology it was not thinkable to grasp such complex objects as performance stemmata with their operators and performance fields. Only information technology has permitted the construction of lexica for performance signs. In other words, lexicality is intimately tied to the possibility to realize lexical contents. It would have been nonsene to envisage lexica of tempo curves without being abel to put them into reality. Therefore performance was for a long time a domain of pure shifter signs, controlled by the magic of the shaman-artist who transforms symbols into reality.

### 3.2.5 Synchronicity and Diachronicity of Performance

We have shown that performance is the stemmatic result of a historical rehearshal development which includes the 'prehistory' of analytical preliminaries on the Predicate level. Performance is therefore also a historical process in the large. The question behind this fact is: a history of what? In the first rank, it is the history of communicating one's understanding of and access to the neutral identity of a work within a determined context of culture and tradition (emotional and more “transcendental” connotations will be discussed in section 4.1).

*3.2.5.1 The Shift from Shifters to Lexemata*

As was noticed by de la Motte-Haber [21] there is a historical shift from performance parameters to parameters of the mental score. It is claimed that through history, parameters of the performance signification process from the mental to the physical layer of reality tend to be increasingly integrated in the composition domain. This means that signs which originate as shifters (such as the gestural neumes) loose their deictic variability and successively 'freeze' to lexemata (the notes of present western music culture).

*3.2.5.2 Existential and Mental Understanding*

There is a well-known tension between thinking and playing music [118]. This is based in the metaphysical root of music in histroy, such as the ancient Pythagorean school [119], and in the existential foundation of artistic expressivity. Whereas the former relates to spiritual abstraction, the latter relates to gestural realization. Therefore—*in the traditional European perspective*—thinking music suggests reduction of the total phenomenon to Predicate signifiers, whereas making music tends to downsize it to the significates of pure physical gestures. That both of them are incomplete was on one hand pointed out by Eduard Hanslick's famous characterization of the content of music as sounding moved forms ("tönend bewegte Formen") [42]. On the other, this dichotomy is radically contradicted witin other musical traditions (black African music or jazz, for example).

### 3.2.6 Remarks on Inverse Performance and Polysemy of Music

If performance is viewed as a communication of the mental signifier through the physical significate, the inverse problem of decoding the physical (resp. technological) output arises. This is called the *inverse performance* problem. In its most technical and classical form it means reconstructing a score from audio data. On a higher cognitive level it includes reconstructing the neutral analysis and its transformation instances on the stemmatic genealogy, including the performance grammar specifications.

This subject deals with polysemy of music in the following sense. The reconstruction has to retrace the mental signifier and the performative signification process within a large variety of a priori possibilities. The scientific description of this variety leads to difficult mathematical problems on one hand [74]. On the other, is throws light on the theory of music criticism which essentially deals with this reconstruction issue.

### 3.2.7 Remarks on the Generic Score Concept

In section 1.1.1.1.2 we contended that making music is always based upon spiritual schemes which we call scores: oral or written text frames of extra-physical specification. Apart from classical western traditions where this fact is evient, the score concept is also adequate for describing traditions which are more towards ethnomusicological antipodes. First example: In the music of Noh theater [55], there are different score instances, e.g. for vocal *utai* music denoted in melodic units (*fushi*) to the right of texts, or for the *hayashi* notation systems for flutes and drums. Second example: The improvisational culture of jazz which in its *making* only marginally relates to traditional western scores, is based on the concept of the *interior score* ("partition intérieure" [107]). This means that, even for free jazz improvisers, there is an interior reference system of lexical character, together with a selection code which guides performance. The fundamental fact behind the basic role of the score concept for music is that human organization in a complex time-space of acoustical and gestural nature cannot be executed without an interpersonal spiritual orientation common to the responsible participants.

# 4 Physiological, Psychic And Spiritual Connotation

## 4.1 The Individual and Social Meaning of Music

Once the autonomous sign corpus on the basis of Predicates and performances is concieved, the extremal level of connotation can be tackled: physiological, psychic and spiritual meaning of music under individual and social perspectives.

At this point it becomes indispensable to keep the entire topographic cube of music (1.1.1) in mind. The reason is that, for this connotational level, all topological loci become intertwined along the process of signification. This is a secure indication that semiotic considerations must be coupled with the complexity of musical ontology in order to take care of the delicate phenomenon of musical meaning.

In this chapter we shall only describe the different significates without discussing the methodological implications; this is postponed to section 5.1.

## 4.2 Individual Meaning

### 4.2.1 The Crucial Role of Deixis

In the following sections it will become evident that music points at individual meaning of fundamentally deictic character. In other words, each human realizes the effect of music on his/her psyche or body in an extremely differentiated way.

This is not a defect but a natural characteristic, and it is a major research target to determine the variety of shifter contents associated with one and the same autonomous sign. We shall see in section 4.3 that ideological indoctrination is also built upon the negation of this basic fact.

### 4.2.2 Causality and Signification

It should be stressed that in this context, “effect” is not to be taken in its connotation of causality, but related to the production of a significate: music *means* these effects. Music is in state of meaning the entire life spectrum. (“Musik ist das ganze Leben.” [123]) A song can *mean* happyness, it can *mean* “Dance!”. Musical meaning can be produced by means of causality. But it would be to narrow a view if the causal background would be taken as an obstacle to musical meaning. The fact of signification is not bound to any specific mechanism—be it of physical, mental, or psychic nature. This remark is a basic issue for the following reflections. Without this open approach, music would be damned to a fairly meaningless existence, and the musical sign system would loose its most important instanciation. After all, the troubadour wants to communicate love through his song, and not 'abstract' motives. Love then is the meaning of his commmunication, and this meaning acts directly on the soul of his beloved lady—if the performance is understood. And in jazz, the song “It aint mean a thing if it aint got that swing” declares that the jazz life feeling is transported via the swinging performance. It would be a theoretical misfunction to miss this very 'heart' of music semiotics. In Africa tradition, music means fight for freedom, life, nothing less [85]!

### 4.2.3 Biophysical Correlates of Music

#### *4.2.3.1 Sensomotoric Semiosis*

On the sensorial level, music can signify sweat, “skin orgasm” or heartbeat. This is much more than a causal instance and can be compared to Pavlovian conditioning (see 5.2.1.2 in this handbook). It constitues an irreducible and intense contribution to meaning; for a number of listeners, additional meaning can hardly be exhibited. In the same vein of semiosis, on the motoric level, music can point at dance. In this situation, dance music then is merely the signifier and is not considered as an autonomous sign. For instance, dance floor music or techno are composed and percieved as stimulantia for motoric exstasis and may completely vanish qua autonomous structure. That is why in pop music concerts, the auditory normally stands upright instead of sitting: Music makes them dancing. Without this transformation of sound, there would be no meaning. Understanding is realized by *performing* the dance.

As a matter of fact, every individual reacts in a proper way with his/her body when dancing, or with regard to the physiological response. This constitutes the shifter character of sensomotoric semiosis: This type of meaning is a pragmatic function of the individual interpratant. Situated within Jakobson’s dichotomy of code/communication [51]—analogous to Saussure’s dichotomy of langue/parole—sensomotoric semiosis is a radical overhead of communication resp. parole in what Barthes called the “fight of code against communication” [6]. This disequilibrium to the disadvantage of code explains the strict intimacy of sensomotoric semiosis: In this context, music communicates a very strong 'content' shifting towards the individual which vehemently rejects interpersonal codification.

#### *4.2.3.2 Neurophysiological Semiosis*

It was proved [90] that surface EEG significantly changes by musical stimuli. Significant responses of Depth EEG to consonant and dissonant interval stimuli were found within the emotional brain (hippocampal formation) [69]. This latter effect can be related to the gate function of the hippocampus for access to inconscious contens of emotional memory [124]. Here again (see 4.2.3.1), the individual listener generates shifting significates of one and the same musical performance output, according to his/her subconscious formation. Very probably, this level of physiological semiosis is one of the strongest shifters since the extermely individual emotional memory is a dominating semantic force in music.

### 4.2.4 Individual Psychological Correlates

#### *4.2.4.1 Expressive Signification*

When a piece of autonmous music is viewed as an expression of the composer’s psychic constituents, such as emotions, this *poietically* oriented semiosis transgresses different communicative coordinates of the cube of musical topography, see left half of Figure 40. The autonomous performance work (on the level of the performance system, see chapter 3) is situated on the neutral level as an expression of the composer's intention. The composer is the key (the interpretant) to his/her work's expressive signification which points at the psychic determinants of the *work's making* which yield the presented performance.

#### *4.2.4.2 Impressive Signification*

Viewed in its alternative function to impress the listener, the autonomous performance work (on the level of the performance system, see chapter 3) directs its semiosis from the neutral position towards esthesic meaning produced by the listener interpretant, see right half of Figure 40.

This important expressive/impressive polysemy splits signification according to communicative perspectives. In music critique this is an important factor insofar as the performed work always means two a priori different, and often radically diverging significates, depending of the expressive or impressive semiotic perspective, see also 3.1.2.3 for the related question of a work's esthesic identity.

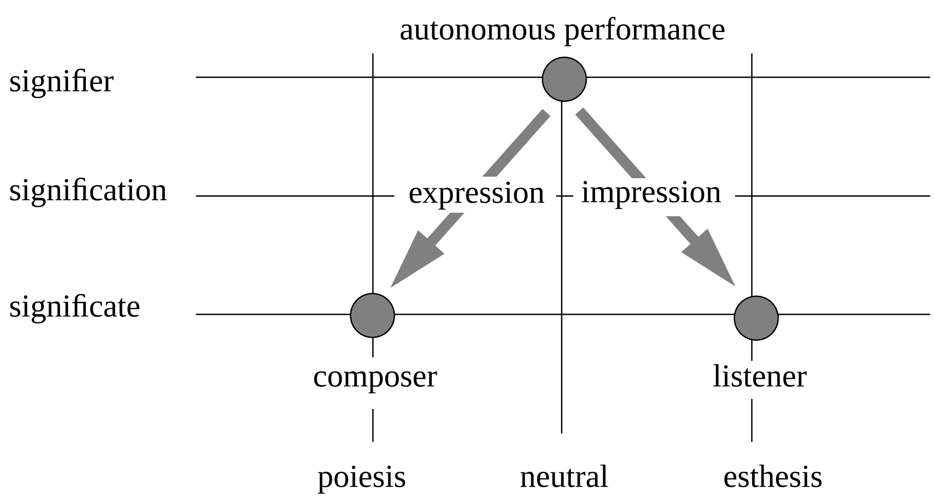



Figure 40. Expressive and impressive semiosis of autonomous performance are coupled with coordinate changes on the axis of communication.

#### *4.2.4.3 Music and Emotion*

In music psychology, musical structure is sometimes conjectured to be isomorphic to emotional structure [38], [60]. This is problematic for several reasons:

1. One and the same musical sign complex, given, for example, in the form of an autonomous performance, can provoke signify different emotions in impressive as well as expressive directions, and individually shifted. Thus, an isomor-

phism in form of a one-to-one correspondence has no evidence, it must be constructed.

2. The hypothesis is not verifiable/falsifiable as long as the structure of emotions is not made much more explicit. Presently, the structure theory of music is incomparably more precise and elaborate than the structure theory of emotions. The concept of isomorphism cannot be applied as long as the morphology of the comparanda is not in the same state of explicitness.

3. Even the very elementary analogy of emotional agitation/dynamism cannot be paralleled by musical agitation/dynamism since musical agitation does not necessarily relate to the emotional analog.

4. Such an isomorphism would imply downsizing musical structures to emotional ones *without* regard to ample areas of rational structures on the compositional as well as on the analytical level.

### 4.2.5 The Performing Artist within the Musical Communication Process

#### *4.2.5.1 Gestural Performance Signs*

By definition, gestural performance signs are tied to physical realization and bear a basic shifting significate. However, their lexical component is equally present, in complete analogy with linguistic shifters.

##### *4.2.5.1.1 Lexical Sign Components*

These include the standardized lexicon of music director gestures, and gestures which are behavioral universals such as placing the index at one’s lips which are shaped as a small circle, meaning the desire of quietness.

In certain determined music cultures, special gestures are known, such as unequivoque sexual allusions of pop stars or turning away from public, the famous onstage gesture of disdain by jazz trumpeter Miles Davis.

Usually, the performance gesture is part of a performance grammar, either to prescribe a performance operator or to execute it. The former type is exemplified by movements of the director’s baton which communicates a tempo curve, together with dynamics and articulation operators. The latter is exemplified by a violinists body movements realizing tempo etc. without further mediator.

##### *4.2.5.1.2 Shifter Components*

Whereas it is necessary to understand the lexical meaning of a baton’s movements, its full meaning is only realized when the baton is really moved. This is the magic of the director’s take-off: Everybody onstage and in the audience then understands the message: Now and here, the music comes into life. The shifter component of performance gestures relates to the factors already discussed with initial sets in 3.2.4.1.

*4.2.5.2 Performance and Physical Dynamics*

In the line of the isomorphism hypothesis 4.2.4.3, performance scientists have tried to instanciate litteral physical dynamics to describe performance shapes [114]. This seems justified by the fact that motoric activity is a known music significate (4.2.3.1.). However, dynamics of dance cannot be reduced to physical dynamics: the variety of dance movements is not described in the general framework of Newton's laws, not more than a sonata is determined by general acoustics. Physics is a necessary, but not a sufficient condition for art. If dance gestures are supposed to correspond in some way to musical performance, this correspondence can on ly work on a level of spiritual shaping and not of basic laws of mechanics.

*4.2.5.3 Splitting the Communicative Tripartition*

In an abstract settup, a work is communicated from poiesis to esthesis via the neutral niveau. In concreto, this does not work without the intertwining estheses of performing artists. The neutral identity on the predicative level is percieved in an esthesic act by the artist and then taken as a significant surface to be transformed in a second poietic act into the performance which constitues a second neutral level of the work, and which englobes the first one quasi in a performative nutshell. Only now is the audience confronted to the esthesic act of valuating the performed work by use of particular tools of criticism, and via personal sensomotoric responses. Recall that this differentiation does not put into question Molino's tripartition but shows its power in the same way as Hjelmslev's denotation/connotation paradigm has its power in the clarification of interior splitting of sign systems, see 1.1.2.

## 4.3 Social Meaning

Though it is tempting to view social meaning of music as a further connotation deduced from individual meaning, this cannot be the scope of descriptive semiotics of music. There are reasons to accept a *mutual* causality between individual and social semiosis. This is why one should prefer the representation of social semiosis of music as being a formally parallel branch to individual semiosis.

### 4.3.1 Mass-Psychological Semiosis

According to the general insights of mass psychology (e.g. [61]) it can be expected that social semiosis of emotionally significant music should have a profiled mass pyschological profile.

*4.3.1.1 Music as a Social Event*

Mass psychology has shown that collectives are more than the juxtaposition of individuals. Therefore, as a social event pointed at collectives, music has a direct collective expression and impression (parallel to signification for individual semiosis, 4.2.4). The poietic significate expressed by the performer is known to *adapt* to the audience in the form of the “feeling the audience”. In the impressive perspective, the meaning articulates in feelings of “togetherness”, “good vibrations”, “extasy”. Psycholinguistically speaking, the pronouns “we” resp. “they” of the *collective* unit replace the pronouns “I” resp. “he/she/it” of the *subjective* unit.

##### *4.3.1.1.1 The Concerto Context*

The concerto context is a specification of the communicative interaction level of musical performance with its audience. It is basically supposed that the performed music expresses a content essentially built on the Predicate level, see section 2.4. Within this specification, textual and paratextual Predicates are both present. The communication is of *monological* nature.

###### 4.3.1.1.1.1 Music in the Private Ambient

This audience’s consensus requires that there is an intimate communication of the autonomous performance, and the meaning is built upon this private, quasi-conspirative dialog.

###### 4.3.1.1.1.2 Chamber Music

With chamber music, the humanistic culture is invoked [33], where we particiate in a cultivated high-level non-verbal dialog of poetical character. The social meaning thus conveyed aims at estblishing a spiritual elite which is capable to “understand” the poetic message.

###### 4.3.1.1.1.3 Concert Hall Music

This points at the celebration of the “group”, be it the upper class or the fan group of a pop subculture, such as Michael Jackson’s teenager community. In this context, the “we” is much stronger than in the previous situations. Accordingly, the meaning of the performance is directed at a construction of collective consciousness.

###### 4.3.1.1.1.4 Global AV-Media-Supported Concerto

In contrast to the preceding concerto type, the global audio-visual concerto, such as TV transmissions of mega song potpourris of Pavarotti and friends, is a fictuous collective distributed in millions of microscopic, isolated and passive living room communities. This consensus is built by the selection of the musical performance via audience rating—a 'confirmation' of the imaginary “we”. The social implication of this type of concerto monolog is a considerable regress to collective lullaby archetypes, as they are described by mass psychology [61].

##### *4.3.1.1.2 The Performance Art Context*

The musical performance art breaks down the monological restriction of concerti. The artists become part of the “we”, but within this collective, they remain *primi inter pares*. In contrast to concerti, the shifter character of the performance becomes dominant, it is not merely the question to realize the predefined “event”, but also the variable, interactively created outcome of each occurence of a performance.

##### *4.3.1.1.3 Music in Multimedia Art Forms*

In theater, films, operas, operettes, and musicals, the central significate is the dramatic content of the piece [89]; in this context, the meaning of music is essentially that of a trigger for the poetical signification on the level of collective sub- or semi-conscious.

##### *4.3.1.1.4 The Interactive Global Composition and Performance*

This is an electronic Internet production method based on collective composition and performance on electronic music media. It not only breakes down the monolog of concerto forms but also the superiority of the artists in performance art. Here, everybody is participant of the compostion and performance, based upon a shared Denotator lexicon. The production of meaning is distributed among a distributed worldwide community.

##### *4.3.1.1.5 The Ritual Context*

Music in rituals conveys the magic of the shifter of “here and now”, a generic characteristic of the ritual. It instanciates artificial worlds of ritual contents, such as religion, football, executions, acts of state. This power of music is directly evident and present in view of the magic of performance instanciation as discussed in 3.2.4.1.

##### *4.3.1.1.6 Ambient Music*

Muzak, night club music, dinner music, rest room music and ariplane music are ambient contexts. They give music a connotation of a trigger background with special flavours: Muzak for supermarkets creates a nutrition lullaby, muzak for office and industrial workers defines a subconscious embedding in an imaginary house of harmonious prosperity and productivity. Night club music mimics the 'melody of life', a desire of being part of a well-defined ambitus of the 'biographic composition'. Dinner music is a suggestion of harmony, togetherness and apeasement of the vegetative nervous system via physiological effects as discussed in 4.2.3.1. Rest room music is a simple auditive lie, covering the acoustical tabou zone and creating the illusion of cultural presence in a sphere of unambiguous animality.

#### *4.3.1.2 Mass-Psychological Conditioning of Musical Structure*

Musical structure which is produced and used for social connotation is conditioned by this target. This feedback condition forces the structures to be simple, with direct communication contents to the mass psyche, as noted in 4.3.1.1. In particular, from the classical characterizations of mass psyche, there is a large amount of redunancy (corresponding to lowered memory of mass psyche [61]), a harmonic character with strong action on the emotional brain (especially the hippocampal formation [69]), or simple melody for easy memorization.

### 4.3.2 Political, Ideological and Religious Semiosis

This level of connotation is the extremal globalization of social connotation [92]. However, it does not necessarily act on the psychic level of individual or mass specification, though it is often based on such mediators.

#### *4.3.2.1 Propaganda*

Propaganda music, such as Schenkendorf's "Hitler Hymne" [92], serves the evocation of artifacts of political forces and canalizes streams of (sub)consciousness to the targets of propaganda. The music's nonverbal character leaves imagination an empty space to be filled with ideological projections.

#### *4.3.2.2 Weltanschauung*

This is the modeling of a total view of the world; music then points at a particular life orientation. For example, rap is an expression of black ghetto life, eurhythmics of anthroposophy, cool jazz of existentialistic life style, and esotheric music of neo-Pythagorean harmony and meditation.

#### *4.3.2.3 Religion*

This music is a system of signs expressing resligious values. For example Bach's music, as being an expression of God's eternity. Quite generally, sacred music is an invocation of transcendental harmony and allness. In the Christian tradition, for example, large pipe organs are placed in huge cavities of churches, thus producing a sound reverberation connotating divine eternity.

# 5 Semiotic Aspects Of Methodology Of Music Research

Semiotic description and analysis of musicological methodology serves as a powerful orientation within the ever changing technology of research tools.

## 5.1 Fundamental Questions on Music Methodology

### 5.1.1 The Musical Topography as a Guideline to Method Differentiation

Methods of musicological research are a function of the topoi which research focusses at. Apart from general knowledge about epistemology and tools of scientific research, such as statistics, or measurement theory, this functionality is the essential aspect of methodology: Without topographical specification, methods do not make sense. For example, the search for a valid concept of pitch is obsolete without communicative specification.

#### *5.1.1.1 Methodologies without Guideline*

Topographically speaking, there are two methodology types without guideline:

A. those which occupy one specific topos and tend to reduce phenomena in every topographic position to this selected topos. Examples are psychological, physical, or esthesical *reductionism*. An example of psychological reductionism has been discussed in 4.2.4.3.

B. those which change topographical positions without either systmatic reasons or even without consciousness. Such an *ubiquitary discourse* abuses topography to mimic a coherent reasonment by topographical switch. For example, frequent occurrences of score analysis constantly switch between esthesic, neutral and poietic positions in the construction of a discourse that would be manifestly inconsistent on a selected level.

#### *5.1.1.2 The Problem of Objective Knowledge in Musicology*

Semiotically speaking, the problem of objective knowledge in musicology crystallizes around the shifter problem. We have seen that on all levels of the musicological discourse, shifters play a central role. This starts on the mental level of global compositions as being user-specific coverings of given prima vista data, see 2.3.1.3, and it extends to the level of social polysemy, as discussed in section 4.3. The complexity of music phenomena, in particular on the shifter level, is no reason whatsoever to introduce feuilletonistic vagueness, it merely gives a psychological explanation of the temptation to switch to the feuilleton as a surrogate of scientific investigation.

The question then is whether a scientific theory of shifters is possible or whether shifters per se contradict scientific discourse. There are two aspects of shifters which make them hard to handle in a scientific way: They seem to allude to *non-objective factors*, and they basically convey *polysemy in music*.

The first difficulty is not substantial: An objective discourse about non-objective phenomena is quite standard in the humanities (and even in quantum physics): For example, emotions constitute a major and classical research topic in psychology, and theories of shifter structures of personal pronomina [9] or the theory of speech acts are well-established fields of linguistic research.

The second difficulty deserves a special attention:

#### *5.1.1.3 Polysemy versus Precision?*

Music(ologic)al polysemy has been a major objection to its scientific discourse. It is contended that polysemy is in contradiction to presicion. But there is no logical argument against a precise description of polysemy. A well-known example of an exact theory of polysemy is the mathematical theory of algebraic equations. In general, a solution X of an equation f(x) = 0 is a sign having multiple significates. The description of the variety of solutions, i.e. the collection of all valid semioses of the signifier “solution X of f(x) = 0”, is a successful branch of mathematics, viz algebraic geometry. The reason of this success is that the signification mechanism specified in the equation f(x) = 0 is explicit and precise. Hence *it is not the problem of eliminating polysemy, but to analyze it in a powerful language*. In computational musicology, the theory of global compositions is an example of adequate scientific formalization of polysemy for the analysis of musical texts. Since multiplicities of performances do express—among others—multiplicities of analyses [56], the theory of global compositions is part of the germ of performance theory. Quite radically, the neutral identification of a musical work (3.1.2.2) is precisely the organized ensemble of polysemies on the analytical level.

### 5.1.2 What is a Musicological Experiment?

The experimental paradigm is classically tied to natural sciences. In musicology, experiments have only been considered in psychometrical and acoustical research. Unfortunately, music theory and esthetic theory have hardly ever been viewed as genuine objects of experimental research. On one side, this is due to the well-known state of pre-scientific discourse in musicology, in particular its lack of precision, see 5.1.1.3. On the other, the experimental paradigm was restricted to a given *exterior* nature or, at least, an objectifiable set of measurable data do be modeled and tested by use of empirical methods.

#### *5.1.2.1 Nature and Construction*

In musicology, the concept of nature is a problematic one. Music is virtually absent in nature—it is a human construction. Therefore, making experiments within this constructive ambient seems not to be an obvious research method: What should be verified or falsified under the absence of an objectively given nature?

This last question includes a false premise: It suggests that no given nature is to be inquired. This error resides on the seemingly marked position of nature vis-a-vis man: We ask the question, nature answers. There is however a *non-marked variant* of the experimental paradigm. *It describes experiments as being tests for mutual adequacy of two layers:* We are testing the congruence of a scientific model with an corresponding material. In this rephrasing, human productivity offers ample material of "given nature", for instance models, e.g. music theories, to be tested for adequacy to a selected corpus of compositions. This view abolishes supremacy and ontological priority of exterior nature.

In the visualization on the cube of musical topography (1.1.1), musicological experiments may occur as a confrontation of esthesic and poietic categories, and, more generally, of any two topoi within the cube.

#### *5.1.2.2 Experiments in the Humanities*

As suggested above, experiments as a paradigm of testing adequacy are suited to be carried out quite generally in the humanities. In this framework, experimenting means testing mutual understanding between different layers of spiritual activity. *Experiments in the humanities are operationalizations of the process of understanding spiritual activities.* For example, designing and implementing complex object-oriented software has been viewed as a subject of empirical computer science in the sense of experiments with one's own thinking processes [2].

#### *5.1.2.3 Computer Aided Models*

Experiments in the humanities have a better chance to be scientifically valid if their parameters and input-output data are under detailled control. Therefore, computer-based experiments are not a fashionable alternative, they are the very basis of experiments in the humanities. *Computers are the counterpart of the experimental instruments known from natural sciences.* Experiments in performance research, such as tempo curves, or analytical experiments with quantitative models of harmony, have become feasible only within the frame of information technology.

## 5.2 The Methodological Spectrum

### 5.2.1 Physically Oriented Methods

#### *5.2.1.1 The Semiotic Concept of a Music Instrument*

We have seen in 3.2.1.2.1 that as a semiotic instance, a musical instrument is a tool for the signification process from the technological performance data to the physical level of reality. The instrument's performance is a function of the technological specification of sound parameters. The performance signification does not produce direct physical output but only the technologically meaningful output.

As shown in 3.2.1.2.1, this means that an instrument defines an denotative subsystem in the sense of Hjelmslev [45]: The performance process involves a connotative system from the denotative instrument to the physical output.

Methodogically, ths implies that the study of music instruments has to deal with this connotational situation, in particular, a theory of music instruments must be sectioned according to the specific articulation between denotative technology and connotative physicality. Accordingly, *performance theory* cannot be indifferent against this data, it *is always coupled with the variety of instrumental technology.*

*5.2.1.2 Sound Analysis and Synthesis*

A sound event as a physical significate does refer to two different signification processes: to the poietic and to the esthesic specification. Poiesis is a function of the applied instruments and means that a determined (artificial or natural) sound production technology is realized.

Besides the classical direct gestural excitation of a dynamical system, such as a drum or a violin, mathematically driven function types, such as Fourier or frequeny-modulation (FM) methods, are known for electronic sound synthesis. For the esthesic activity of sound analysis, virtually the same methods can be applied, though their analytical power is not always adequate for the given sound colors. Despite of the fundamental polysemy of music it is often believed that sound synthesis and analysis should coincide, and ideally, the synthesis process should be in one-to-one relation with its generating parameters. Even if the mathematical problem of representing any sound event by a unique universal parameter system could be solved, the poietic and esthesic sound parameters would be autonomous and could differ for many reasons. The overall situation is shown in Figure 41.

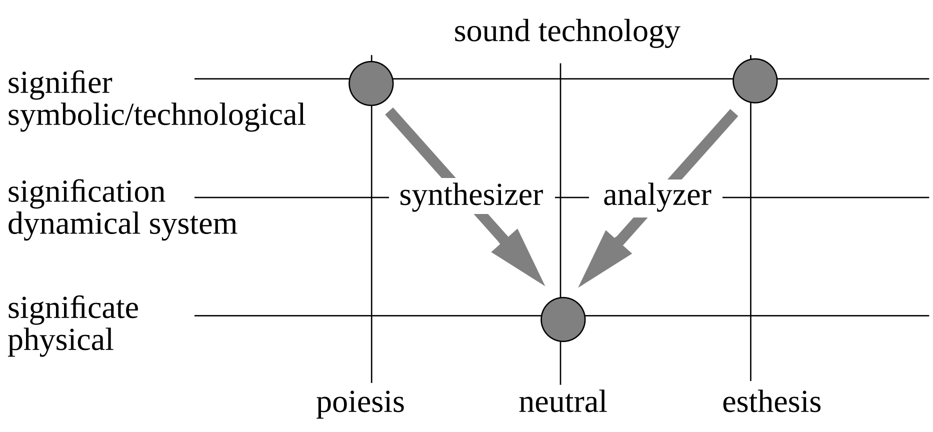



Figure 41. Sound synthesis and analysis are processes of synonymy across the topographical cube. Both, analysis and synthesis create signifiers pointing at an identical physical significate.

*5.2.1.3 Physiological Methods*

Physiological methods of poietic and esthesic levels are investigations of the vocal tract, and various response measurements of the cochlea [8], of skin and muscle parameters, such as temperature, sweat, conductivity, and electromyography. Cochlear models of sound analysis are often used as an approach to the meaning of harmonical phenomena, such as consonance and dissonance [44], [113]. Note however that the cochlear level is filtered and transformed through at least five neuronal relays stations, and that the output description in the auditory cortex and the archicortex is not known. Cochlear theories are, semiotically speaking an identification of acoustical signifier and cognitive significate. In this sense, they are reductionistic (see 5.1.1.1 A.) and do not take into account that acoustics cannot represent the cognitive universe.

*5.2.1.4 Neuromusicology*

Neuromusicology deals with the behaviour of neuronal cell populations in the archi- and neocortex as a response to musical stimuli. Classically, surface [90] and depth [69] electroencephalogram (EEG) show significant responses to symbolic music structures. Single cell derivations for tonotopy [125] and qualitative responses [17] to musical stimuli have been investigated. Again, the risk of reductionism must be taken into account. For example, the measurement of a specific firing rate of a neuron in response to a Mozart composition cannot—as it was suggested by [17]—be interpreted as a "Mozart cell". Reduction of cognition to firing rates of single neurons is a logical and physiological mistake. Also is it dangerous to measure EEG without music against EEG during music stimuli and to conclude that the specific difference of EEG-response is due to the *musical* quality of the acoustic input. It could as well be an effect of the acoustic input without any reference to its musical structure. Both of these errors are of semiotic nature: a significate is attributed to a signifier without taking into acount the variety of possibly underlying significations.

Neural nets were used to simulate human behaviour in response to harmonic and other musical inputs [62]. The simplified analogy of neural nets with the human brain should not be confused with the dynamical system of the auditory cortex. The brain is neither stratified into layers as is the perceptron model of neural nets, nor is the dynamics of a perceptron comparable to the neuronal interaction, this is evident from the differential equations of simple realistic models of neurons, see [47]. The semiotically most significant fact concerning neural nets is the widespread belief in "emergent properties" of neural nets: It is contended that these constructs are in state of producing some type of "understanding" of the specific phenomeneon for which it was programmed. However, understanding subsumes semantic activity which is not part of neural net's construction principle as machines of statistics. This is one of the reasons, why semiotic research should aim at making very precise and explicit what it means to create meaning: Is it mainly a behavioral process and/or does it involve other specific structures? Because of the highly differentiated semantic structure of music, neuromusicology is an excellent research area to test the hypothesis whether semantic processes can be modeled by computer programs.

### 5.2.2 Psychogically Oriented Methods

#### *5.2.2.1 Psychological Reductionism: Connotation Instead of Denotation*

Nonwithstanding that the psychological reality of music is only one of several aspects, it is often tried to view psychology as being the distinguished semantic concern of music and musicology, for example in the isomorphism hypothesis of emotions and music 4.2.4.3. In a similar vein, Riemannian harmony was criticized [28] from a psycholgical point of view as if mental significates should be based on psychological evidence. This is not only due to the slim theoretical status of exact musicology, it is above all due to the dominant semantic role of psychological reality in music, see section 4.2.

As it was shown in 2, psychological semiosis is based on a complex system of performance signs which are built around Predicates, i.e. psychology is merely the connotative 'terminal' of a complex antecedent denotation process. As it has been discussed in 4.2.4.3, there is no chance to reduce music to relatively diffuse categories of emotions, at least not on the basis of an structural isomorphism. Psychological reductionism is a many to one relation of semiosis and its suggestion of fully representing musical structure is an unscientific illusion. The same error, when applied to mathematical thinking, would immediately destroy any mathematical discourse.

#### *5.2.2.2 Methods of Music Psychology*

For an overview of psychological methods in music research, we refer to [22]. According to what has been said in the preceding section, music psychology has a tendency to overestimate the connotated psychological meaning of music with respect to the denotated system. From a semiotic point of view, music psychology does very rarely deal with the signification process that leads from Predicates to psychological significates. This is a serious methodological lacuna. For example, research on cognitive strategies in building the harmonic judgement or on the question of how similarities of melodies are recognized, is still in its very beginnings. The same is true for experimental paradigms which are well-known from linguistics, such as the commutation test. For example, knowledge about the cognitive strategies in musical syntax could be improved by commutation tests such as the permutation of parts of a given composition [21].

This defect is mainly due to the lack of an advanced structure theory of music. Without a precise language for the Denotator level, commutation tests cannot be applied since it is not clear which units should be selected for commutation. Even the very definition of a melodic motif is not clear from the traditional musicological point of view. Therefore, psychological investigations lack of the structural background to ask the precise questions. Research on the classification of rhythm phenomena on the basis of psychological methods makes evident the lack of structural knowledge about a) rhythmical structures on the Denotator level (give a precise definition of rhythm on the level of the mental score!) and b) the deformations of these structures in performance (what is a tempo curve/hierarchy? see [73], [79] on this subject). As a result of this deficiency, psychological classification is a very coarse (masculine, feminine, loneliness/sadness, relaxedness) one with a problematic scientific value [20]. As a consequence, many psychological investigations, in particular tests, such as Seashore's "measures for musical talent", are based on blurred musicological prerequisites and reveal more about the status of musicology than about the probands.

Summarizing, psychological methods suffer from a deficient structure theory on the system of Denotators and their performance. It is not possible to circumvent the defectous knowledge about the denotative level by an *overestimation* of the connotative significates, regardless of their admitted importance: Trying to understand semiosis without understanding its *signifiers* and—a fortiori—their transformation process of *signification* is a serious methodological drawback.

### 5.2.3 Mentally Oriented Methods

#### *5.2.3.1 Score and Text Normalization*

In contrast to the linguistic standard situation, musical scores and—to a certain degree—also texts of music theory pertain neither to a lexical nor to any other standardized code (Saussure's *langue*). For this reason, normalization processes have to be introduced in musicology as a basis for comparative studies between dia- and synchronically dispersed documents. These processes are directed by either the search for *invariants* or the detection of *transformation* rules.

##### *5.2.3.1.1 Diachronic Normalization and Historical Sources*

Along the diachronic axis, the main intertextual concern of musicology is the extraction of diachronically invariant meaning of musical and musicological signs and its trace on the historically evolving variety of score forms. Without such a semantical constancy, a diachronic analytical discourse on scores and music theories would be impossible. Due to the missing standard, it is impossible to infer identity of significates from identity of diachronically distributed signifiers. How is analytical orientation possible in a sign system of fundamentally instable semantics? Recall that a similar problem was already encountered (5.1.1.3) regarding musical polysemy as a possible subject of scientific investigation. We learned that polysemy is not an obstacle against scientific precision: The question was in fact to search for mechanisms of polysemy (such as global compositions) and to investigate and classify them.

When dealing with diachronic variability of significates, the problem is not a conflict between different significates, but the *absence* of explicit data on possible significates. For instance, when dealing with a note symbol in an early medieval score, it is not clear which parameters this symbol was intended to point at. For one reason, these parameters were not yet known (such as partials of instrumental realizations), for the other, it is not clear what was exactly meant by pitch. So the obstacle to invariance is relative semantic incompleteness (relative to the interpreter's exigencies). This is precisely the problem of dealing with open semiosis in the context of paratextual Predicates (see 2.6.1). As a Denotator the object may contain a character string “C#” without any further precision of what this pitch symbol means. Its paratextual meaning may be open to more specific signification, for example in the context of a particular historical tuning system. In this perspective, dealing with open semiosis means to be in search for semantic completions of open instances in such a way that the given text may appear as a coherent and consistent organism.

However, the problem is to find consistent semantics and not to refrain from semantic interpretation. In this sense, invariants are possible solutions of semantical lacunae. Mutatis mutandis, this reflexion applies to the investigation of treatises of music theory such as the classical counterpoint theory as it is traced in Fux’ “gradus ad parnassum”. Searching for invariants of music theory means to construct models of common conceptual ground in order to lay the material basis for historical musicology: history has to be history of something, of a *persistent* subject whose history is traced, see [19], vol. 10, p. 40. Searching for semantic invariants of diachrony is the attempt to contribute to the missing standard and lexicality.

Note that the historical evolution cannot be unidirectional towards expanding signs which progessively incorporate every possible musical meaning. Neither do musical scores aim at quasi-complete tracing of their intention, nor is it possible to incorporate every existing aspect—not even on the autonomous performance level. Such an illusive program marked the ideology of electroacoustic music: It was contended that scores of music works would end up in one-to-one representations of the music’s physical performance significate [30]. This redefinition of the score was a confusion of mainly semiotic character: the reduction of signs of complex connotational structure to plain acoustical meaning.

#### *5.2.3.1.2 Synchronic Normalization and Ethnomusicology*

Synchronic text normalization prominently deals with the (re)construction problem of a mental score from performance. This is typically the case within ethnomusical situations. The fundamental difference to diachronic normalization is that it is not clear whether a radically different ethnic context can be put into relation to one’s own coordinate system *at all*. More technically speaking, one is given a performance and wants to reconstruct a mental score together with its Predicates as discussed in 3.2.7 and related chapters. The problem is that it is not clear whether the "interior score" underlying pracically every musical epression can be reconstructed. This is a prominent example of experiments in the humanities. Whereas the "interior score" which manifests itself through a given performance is a poietic unknown of the system, the esthesic reconstruction of a score has to be confronted to the poietic version in a comparison of "model" and "nature".

*5.2.3.2 Analysis of Mental Structures*

This is the method spectrum used for neutral identifiaction 3.1.2.2.

*5.2.3.2.1 The Conflict of Form and Content*

Classical musicology shares an underestimation of neutral identification tools since the urge for transcendental semantics of music, e.g. with the tetraktys symbol in Pythagorean tradition [68], has created an underestimation of detailed structural investigation, the latter being purely formal and thus not capable of 'deeper' semantic content.

But with the advent of computers, the quantitative analysis of structures has become a realistic research field, and hence, non-trivial results of detailed structural investigations are more likely of intervening in deeper semantic processes. The Hjelmslev articulation scheme 1.2.2 now offers a natural means for building semantic depth without loss of precision.

*5.2.3.2.2 Horizontal Poetology According to Jakobson*

Jakobson's poetical function [51] is a standard tool in musicological syntactics to analyze semiosis by syntagmatic distribution of paradigmatic equivalence. The neutral analysis proposed by Nattiez [86] is a typical application of this approach: Collections of notes, of Denotator instances as discussed in section 2.1, are said to be equivalent if the relate to each other under a system—ideally a group—of transformations, the *paradigmatic theme*. The Nattiez approach was made precise and generalized in [43], [67], and [70].

Jakobson's approach does not relate different strata of equivalence, it is a method tied to a determined equivalence and does only involve "horizontal" comparison of syntagmatic positions. In Nattiez' context of paradigmatic themes, this means that the system of paradigmatic themes is not investigated as a generator of connex among different strata of Jakobson functions. We come back to this perspective in 5.2.3.3.1.

*5.2.3.2.3 Local and Global Analyses*

Essentially disjoint grouping of local structures were applied to syntagmatics in [48], with reference to Schenkerian abstraction. But such a theory of grouping which is based on essentially disjoint units must refrain from the control over the inherent ambiguity of musical semantics and is thus forced to take inadequate a priori decisions. In musical syntactics, the formal description of the syntagma cannot be reduced to an essentially linear juxtaposition. Units are grouped, and groupings build a hierarchy of different levels. But these groupings are not successive partitions of the syntagmatic sequence into intervals of contingent units, they are *quite generally overlapping coverings*, see also 2.3.1.3. This radical passage from local to global analysis is a major progress in syntagmatic analysis. Global structures in musicological analysis were explicitely introduced by Graeser [41] and then systematically applied in [67], [70]. They make Jakobson's theory of the poetical function more precise: The syntactical units to be compared under equivalence criteria are not isolated from each other but organized as overlapping coverings and described by combinatorial nerves, see 2.3.1.3.

##### *5.2.3.2.4 Intervals and Harmony*

Intervals of simultaneous tones and chords are classical signifiers of harmonic signification. Classification of these structures has always had a double scope: to distinguish the signifiers and to understand their classifying role with regard to harmonic signification.

As remarked in 5.2.3.2.1, the search for contents has inhibited signifier description and classification. In classical western theory, harmony is viewed as an abstraction from physical parameters (mediated by supposed cochlear normalization of sound analysis, see 5.2.1.3) to produce a mental representation on the basis of just tuning, i.e. simple fequency relations of Pythagorean provenience: 2:1 for the octave, 3:2 for the fifth, 4:3 for the fourth, 5:4 for the major third, etc. Based on the numerological magic of these simple fractions, semantics of harmony is constructed, see [120], [120]. It marks basic triadic chords as fundamental harmonies and deduces harmonic semantics of the chord syntagtma of a musical composition. Following the terminology of Rameau, the semantic units are termed dominant, tonic and subdominant in case they function as signifiers for tonality.

By use of this (incomplete) semantic constructs, intensional meaning of harmonic structures is used for analytical discourses on harmonic syntax. The absence of a structural reference for the—only partially defined—intended meaning has made from this type of harmonic analysis a unreliable discourse restricted to special type of harmony in European music and, in fact for this reason, abandoned as a scientific basis since the advent of atonal music.

Only recently, harmonic elements (intervals and chords) qua Denotators (see sections 2.1, 2.2, 2.3) have been classified [34], [43], [67]. Extensions of these signs to global structures with category-theoretic methods (Yoneda techniques [70]) have been described and classified for a construction of intensional semantics of harmony on the basis of signifier theory [87]. With these methods, paradigmatic relations between signifiers have provided reliable, complete and operational criteria for semantic determination.

#### *5.2.3.2.5 Counterpoint and Melody*

As a formal system of interval syntax, the classical Fuxian rules of counterpoint [37] are relatively elaborate, however, their systematic justifications refer to basically non-mental paratextual semiosis. Usually, the fundamental rule of forbidden parallels of fifths is deduced from psychological and esthetic categories: as perfect intervals, their immediate repetition is qualified as being “boring”.

The consonance-dissonance dichotomy of intervals in counterpoint differs from the synonymous distinction in physically-founded harmony. The former is a dichotomy and classifies the fourth as dissonance, whereas the latter is a polarity with gradual transition levels, and the fourth is far from dissonant. Only lately, it was recognized [18] that the contrapuntal role of the fourth as dissonance could have its justification in compositional mechanisms of intervall syntax. This point of view has led to systematic research on contrapuntal interval syntax as an expression of the consonance-dissonance dichotomy [70]. It could be shown that the intrinsic characteristics of this dichotomy including markedness of the consonant half can be expressed by means of purely formal properties [70], [87], and that the rule of forbidden parallels of fifths is a canonical consequence of these characteristics.

Similarly to harmonic analysis, melodic analysis has a strong tradition targeting at connotational (paratextual) meaning, and focused around a strong parallelism to the role of nouns and pronouns in language. Motifs and melodies are analyzed as signifiers for musical subjects. In contrast, the denotational description and classification of melodic gestalts has not been developed until very recently [77].

#### *5.2.3.2.6 Metrics and Rhythm*

Metrical and rhythmical analyses typically refer to global structures in the above sense. Metrical units are hierarchically organized and express the connex of time markers [72]. They are present on the neutral mental level, but can also be investigated on the esthesic level of foot tapping. The latter is a reconstruction of mental time regularities from performance [25].

The difficulty of traditional musicology with concepts of rhythm and metrics is that distinction between Denotator spaces, i.e. their forms and the instances or substance is not clearcut. Metrics as a regular segmentation of space is not identical with rhythm as a realization of time gestalts by Denotator substance. Topographically viewed, the difference between music as thought and music as material is vague in this conceptual framework. This difficulty is evident in the metrical analysis proposed in [48]. This one is based on bar lines which are abstract segmentations of time rather than a result of the material composition. This a priori grid can provoke artefacts in metrical analysis since it is not built on effective onsets.

#### 5.2.3.3 *Vertical Connex: Between the Connotational Levels*

It was shown that switching between different connotative levels is important and critical for musical semiosis. It is therefore worthwile concentrating on this aspect from the methodological point of view.

##### *5.2.3.3.1 Vertical Poetology According to Posner*

Whereas Jakobson's poetical function covers the distribution of paradigmatic equivalence on the syntagmatic axis, it does not specify the connections between different paradigmata which are involved in the poetical function. According to Posner [91], Jakobson's "horizontal" poetology has to be completed by a "vertical" complement, a connection between different horizontal "Jakobson layers" of phonlogical, syntactical or semantic specification. For example, the phonological equivalence "fly" - "die" in corresponding syntagmatic rhyme positions, is is connected to the associated semantic paradigmata of flying and dying. The point of this vertical coupling is that as a matter of rule, it generates metaphoric meaning, i.e. a connotation significate. In our example, fly and die connotate death = freedom, eternity.

Together with horizontal Jakobson poetology, this vertical Posner poetology yields a standard construction not only for linguistic situations but also—even more profiled—for music. Horizontal musical poetology was already discussed in 5.2.3.2.2; vertical poetology in music is essentially built from the local-global analysis on the Denotator and Predicate level. More concretely, syntactical metrical/rhythmical (5.2.3.2.6) and paradigmatic melodic (5.2.3.2.5) analysis are *vertically* connected with semantic harmonic (5.2.3.2.4) analysis to yield a connotated meaning of a work of music. This amounts to the thesis that musical meaning is successively constructed in the vertical from elementary ingredients of horizontal poetical function.

##### *5.2.3.3.2 Circular Semantics of Metaphors*

As a surrogate for precise and detailed denotational analysis concepts, traditional musicology has developed an extended metaphoric discourse. For example, the lack of structure theory of chords in harmony has been compensated by anthropomorphic metaphors of chord attributes, such as "driving force" [105]. Such metaphors are used to construct syntactical rules of harmonic progressions without recursion to the denotated objects.

This type of discourse on connotated metaphoric semiosis tries to construct a semantic feedback from metaphors to Denotators and to circumvent precise description and analysis of Denotators.

##### *5.2.3.3.3 Dialectic Musicology and Knowledge Hiding*

Dialectic musicology is a discoursive prototype in European musicology, see [19], Vol. 10. The discourse does not evolve from elementary, simple facts or hypotheses but it is supposed that "everything is known", and that the discourse has to focus on selected topics of the universal knowledge. This focus is not constructive but limits to pointing at “universally known” facts. Argumentative development is replaced by a network of knowledge-pointers. Semiotically, the dynamics of this discoursivity is based on an undeclared switch from denotation to connotation of circular semantics (5.2.3.3.2), a standard method according to the tradition of Hegelian dialectics.

Viewed as an information flow process, this dialectic pointer discourse is an uninterrupted knowledge hiding. Every pointer simulates and suggests (universal) knowledge, however, it systematically postpones it in favour of the next pointer. The semantic output of this discourse of dialectic rhetoric is a labyrinthic knowledge and controlled by a secret authoritative orientation. The reader cannot learn from the text, he/she can only be impressed—or confused.

### *5.2.3.4 The Poietic Analysis*

More than in other sciences, in musicology, the subject plays a fundamental role. This section summarizes this critical phenomenon which in a certain way contradicts standard definitions of scientific discourse.

#### *5.2.3.4.1 Sign of I — The Shifter*

As a classical shifter, the pronoun “I” changes its semantic charge with its user. But it is more than a normal shifter: Its meaning instanciates the core of individual ontology in existence. Composing and above all performing music bears, as we have seen in 4.2.5.1.2, a basic shifter component of ontological instanciation. In this sense, the I of the composer/performing artist is a reinforcement of the normal I within an artistic context. This takes two aspects: first the physical instanciation of a performance, and, second, the fact that the poiesis of a musical composition is an individual creation of an artifact far from exterior nature.

#### *5.2.3.4.2 Science of I—The Subject Is the Message*

This has suggested some musicologists to view music as being based on the shifting instanciation of the composer’s/artist’s I [29]. Such an approach implies that lexical ingredients of musicology and music reduce to accessory attributes. Objectivity becomes a secondary effect of understanding music because *the shifting I paradigm is the prima causa of any musical and musicological activity.*

In this way, music becomes a secretion of I, and its scientific description reduces to a countability of a secret personal emanation. This construction is built in the spirit of the 19th century paradigm of the genious whose poiesis is the source and (!) essence of music. Consequently, this approach degrades musicology to a historiographical collection of anecdotes of the I’s emanations.

This type of poietic reductionism is based on two factors: the subjective character of dialectic knowledge hiding 5.2.3.3.3 and the historical belief of a supremacy of (the social significate of) the outstanding individuum. It is, however, not limited to the description of the artist's I but includes the scientist's I and absorbs all the objective fundaments of musicology [29].

# 6 TRENDS IN SEMIOTICS OF MUSIC AND THEIR ROLE IN MUSICOLOGY

We shall discuss two aspects of semiotics in musicology: First, the critical review of musicology from the semiotic point of view. Second, the reception of this critique by traditional musicology.

Summarizing, this discussion reveals a *massive critiqu*e of the scientific status of musicology, an impressive semiotically oriented spectrum of *workable proposals* to escape the manifestly disastrous situation, and a set of *concrete projects* which do realize these proposals.

## 6.1 The Role of Semiotics within the Critical Review of Musicology as a Science

For many semioticians, the prescientific status of musicology and music theory has been a major reason to review its conditions as a system of signes. In [86], Jean Jacques Nattiez cites Pierre Schaeffer [103]: “Dans son ensemble, l’abondante littérature consacrée aux sonates, quatuors et symphonies, sonne creux. Seule l’habitude peut nous masquer la pauvreté et le caractère disparate de ces analyses (...) Si toute explication se dérobe, qu’elle soit notionnelle, instrumentale ou esthétique, mieux vaudrait avouer, somme toute, que *nous ne savons pas grand chose de la musique.* Et pis encore, que ce que nous en savons est de nature à nous égarer plutôt qu’à nous conduire.” This critique is not only true on the scientific level but also yields an explanation of the historical averting from tonal composition: (tonal) harmony which does not control the universe of chords cannot work as a basis for composition.

Critics of musicology as a science have in particular investigated musicological terminology (phrase, period, theme, motif, tonality, rhythm, etc.) (e.g. [67], [86]) and conclude this [86]: “Que constatons-nous? Une multiplicité de critères aussi flus les uns que les autres (...) On nous renvoie à une définition toute subjective de la signification d’un fragment musical.” In [15] Eric Clarke and Charlie Ford blame the “mystified relation between subjective experience and objective analysis” in traditional musicology for lacking of any relevant theory of meaning in music. Such a regress to the subject is a prototypical case of the “science of I” as it was discussed in 5.2.3.4.2.

The majority of semioticians of music agree with Nattiez and Schaeffer in this fundamental critique. It is, however, essential that these criticism is driven and articulated by the very concepts of semiotics [86]: “Ce qui est en cause, dans la terminologie de la musicologie classique, ce sont ces faiblesses que la sémiologie a la possibilité d’expliquer.” The same methodological power of semiotics can be observed quite systematically within all subjects of critique.

On a more metasystemic level, Nicolas Ruwet confronts musical composition and analysis with the dichotomy of code/message (resp. langue/parole) [101]. With respect to successful linguistic research he describes the corresponding dichotomy of the analytical model: message ~> code vs. the synthetic model: code ~> message. In such a model, analysis should be built on declared rules of how to discover the code behind the message(s). Comparing this project to the status quo in musicological analysis, Ruwet concludes that a) the distinction between these two models was never made, b) no analytical model has ever been made explicit, c) no analysis (even the best ones, such as Boulez' work on Stravinsky's "Sacre du Printemps") has ever declared their criteria for discovering the code. And on the side of synthesis, when "material" has do be constructed from abstract code, the implicitely presupposed analyses are not unveiled. In the overview [83], Raymond Monelle concludes that "musical metalanguage, in a nutshell, is unscientific". If such a metalanguage is unscientific, it is not possible to verify or to falsify a theory in the sense of Popper; this remark of Nattiez [86] shows the trend in semiotics of music to refuse the poietic approach (5.2.3.4) as an unscientific deviation.

The fascination of music and musicology for semioticians is a double one: One one hand, it is commonly admitted that music deals with meaning and signification processes, that music is a system of signs. Nattiez puts it quite generically as follows: "La sémiologie musicale a pour objectif d'expliquer la nature et de décrire les *phénomènes de renvoi auxquels la musique donne lieu."* The word "renvoi" means "reference" and is a basic feature of the sign structure: *aliquid pro aliquo*, something is stated for another thing *and* shows the way back to the referred to *aliquo*.

On the other hand, it seems straightforward that the association music—language should imply that linguistic semiotics, one of the most successful branches of semiotics, could be applied to investigate the associate of language. Already in 1932 Roman Jakobson pointed out this challenge in his short review "Musikwissenschaft und Linguistik" of Gustav Becking's analogy of the pairing phonems/phones with the pairing notes/tones [49]. He recommended to profit from the linguistic research in order to better understand music.

This double fascination is, however, also a major challange for all its contractors since the subject of music is not a standard application of known results from general semiotics or linguistics. This is why in [122], Jaroslav Volek insists on a high competence in semiotics before dealing with its application to music and musicology. It is indeed a danger to "grasp the next handbook of general semiotics" [122] in order to deal with the subject. Nor is it recommended to to the same mutatis mutandis with musicology. For example, the contribution of Richard Norton [88] shows that poiesis and esthesis should be distinguished independently of the semantic investigation. Norton succeeds in differentiating three types of semantic charge (what the author calls "function") of music: referential, emotive and aesthetic. The latter is called "tonal gesture" and means the "self-referential", autonomous meaning of music which is realized as a pointer to "tonality". This is a legitimate—albeit not very precise—approach to semantics of tonal music. However, it is blurred on the level of Molino's communicative dimension: Norton positions the tonal gesture as being a "hint of the composer" to the auditory. What seemed to be an analytical approach to autonomous meaning of music turns out to be a question of hypothetical poietic expressivity. This latter is neither verifiable from Norton's vague usage of the concept of tonality, nor is it verifiable as a historical fact of poietic significate. This is a prototype of what Nattiez criticizes as unscientific approach of poietic analysis.

But even a naive application of semiotic concepts makes it easier to localize the critical points in a musicological argumentation. This point is the concept of “aesthetic function”: What does it mean to be self-referential? In Peter Faltin’s comparison of music to language [32], this point is analyzed. It is concluded that music mediates meaning but rather than in the discursivity of language, music mediates in an “aesthetic” way. The significate of music is viewed as “aethetic ideas”, realized within the sounding organism of music. The main characteristic of such an idea is its purely syntactic nature; it is an organism of syntactic relations [31]: “Das ästhetische Zeichen ist ein genuin syntaktisches Gebilde, dessen Bedeutung seine intendierte und wahrgenommene Syntax ist.” This was also pointed out by Jakobson in [49].

This insight is less dramatic and new than it seems: mathematical signs are of the same nature (strangely enough, no allusion to this fact has been made among semioticians of music). And—after all—Hanslick’s definition of musical content as “tönend bewegte Formen” is the same statement in nuce, see also 1.1.1.3.2. However, such a “formal” explanation of musical meaning does not meet all needs for semantic aspects in music; Faltin is to normative. He does not accept the psychological effect of music as a semantic process; when we hear music, this is the sounding aesthetic idea—emotional reactions are only *sied-effects and cannot be of significative relevance*. This is a reason for the critique of conservative musicology ([19], vol. 10, p.133): It is not accepted to reduce meaning to syntactical autonomy of abstract ideas. The same critique is pronounced from non-European perspectivs of music, see 4.2.2. Therefore we have introduced different connotational strata to differentiate signification of music in a non-exclusive approach.

One of the most significant progresses in semiotics of music is the investigation of *typology and mechanisms of signification* of music. The typology is includes a) intrinsic polysemy, b) poor codification c) syntactic, pardigmatic, and semantic mechanisms of local/global and hierarchical nature d) denotational/connotational stratification e) ontological segmentation.

### 6.1.1 Intrinsic Polysemy

This has been recognized by all authors as being a positive characterisitic of music, and not an obstruction of music semiotics. Volek [122] even characterizes signs of art as being “fuzzy” in a positive sense. In Clarke’s and Ford’s model of implication processes for musical semantics [15], implication is never unique. Their implication mechanism is built on a hierarchical stratification from denotation to connotation. Typically, the lowest level is the “foreground”, the tones of a piece. The ascending hierarchical levels consist of abstractions of successiveley more global groupings, and finally yield the “background” of a style system. Such hierarchies which are also considered within the analytical grammar of Jackendoff and Lerdahl [48] are intrinsically variable, analysis is subjected to interpretation much as performance is. This is a pronounced point in Jaroslav Jirànek’s project agenda [53]. He explicitely envisages the infinity of semantic interpretations (“gehaltliche Deutung”).

### 6.1.2 Poor Codification

Poor codification of music signs is widely recognized. Faltin [32] points out the individual character of “aesthetic signs”, they are rather “parole” than “langue”, there is no “aesthetic vocabulary”. This is quite the same as Jakobson’s remark on a specific difference of music and language in [49]; he views the musical “langue” as being restricted to phonological units, the notes (“System-Ton”), and lacking of a “vocabulary” (the etymological distribution of phonemes).

The complex situation in using poorely codified musical signs to produce meaning is described by Gino Stefani [110]. He defines musical competence as the capability to produce “sense” (“Sinn”) through music. His approach identifies competence as a network of codes of different levels. The model includes five levels: AC = general codes, GP = social practices; MT = musical techniques; St = styles; We = (musical) works. Stefani deduces the polysemy of musical objects from the combinatorics of the five levels. In particular, he describes different types of “projects” and “disciplines” (“Fachrichtungen”), from Adorno’s “ideal listener” to “total improvisation”. These typology is defined by the selection of a subset of levels and connections (a graph with vertices in the set {AC, GP, MT, St,We}) together with a distinguished head-level, see Figure 42.

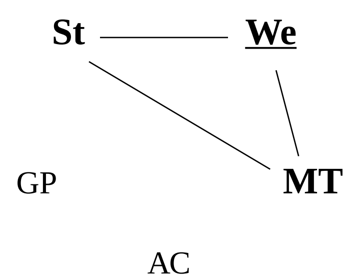



Figure 42. Stefani’s competence model for Adorno’s “Ideal-Hörer” selects three levels St, We, and MT, together with their indicated connections and the head We.

Within this context of poor codification, the work’s neutral level within Molino’s communication string, as elaborated by Nattiez [86], gains a prominent role of clarification. The neutral level is less an established fact than a program of objective description of the work’s analytical identity (see 3.1.2.2). The latter has also been a concern of Nelson Goodman in the context of the work’s identification by means of the score concept [40]. Among the known objections to such a neutral identifications, the problem of detailed and adequate description of musical objects seems a subject of ongoing controversies. This deals with the question whether musical objects can be described by verbal concepts. Faltin discusses this topic in his description of the “aesthetic signs” [32] and concludes that any verbal description would end up with an infinity of “languages”, including open “vocabularies” and “syntactical rules”. In fact, as he argues, aesthetic signs are basically syntactic relationships, and we would have to describe every motif, every chord sequence, every rhythms, and so on. And this in every combination preferred by the individual listeners—whence the suspected infinity.

This is however wrong for two reasons: First, many of these objects are not infinite in number, but simply large sets. For example, motif classification shows 119'032'295 classes of 10-element motives [36] (modulo 12 in pitch and onset). Second, it is not required to generate an infinity of concepts to describe an infinity of objects, this is the success of Peano's axioms to describe the infinite set natural numbers, for example. In particular, it is possible to set up a language that controls all possible interpretations within a wide range of structural frames, see 2.3.3.1.1 or [70] in the case of mental classification, and 3.2 resp. [72] for the performance level.

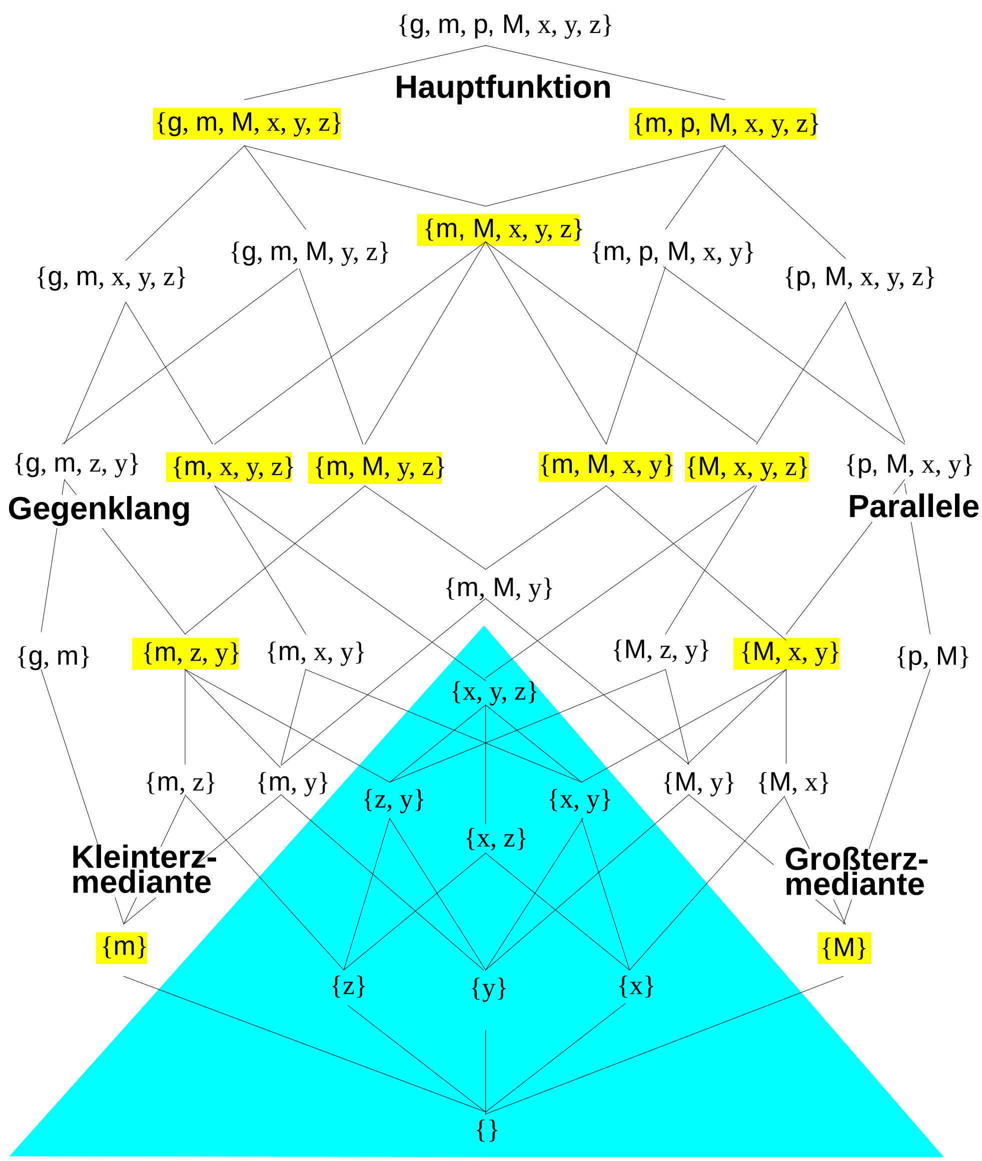



Figure 43. The X-major morpheme in Noll's morphology of classical western harmony [87]. This is a complex system of generalized "fractal" tones. Its substructures are the allomorphs; for example, the parallel morpheme is shown in the right half of the Figure. The chord {x,y,z} of traditinals tones tonic x, third y, fifth z and its subchords appear as special instances in the lower triangular region.

### 6.1.3 Syntactic, Pardigmatic, and Semantic Mechanisms

Syntactic, paradigmatic, and semantic mechanisms of local/global and hierarchic nature have been developed to describe the precise signification processes of music signs. Already Wolfgang Graeser [41] had proposed to define a contrapuntal structure as being “a set of sets of sets (of tones)”. Several more or less special variants of this grouping principle (“groups of tones” are “segmensts” or “sets”, not mathematical groups) have been proposed and used in musical syntax, for example by Ruwet [100], Nattiez [86], Mazzola [66], Clarke and Ford [15], Jackendoff and Lerdahl [48], Noll [87]. In the full generality of building “global atlases by local charts” of musical objects, including unrestricted overlaps, this approach was described in [70], see also 2.3.3.1.1 or [67] for the classification problem.

In Volek’s discussion [122] of inner structure of music signs, he distinguishes elementary signs from composed supersigns, and within the elementary signs the subsigns, the morphological units which constitute these signs. Volek stresses the difficulty to exhibit such morphological elements. That exact semiotics in this sense can succeed in an explicit and operative construction of semantical instances has been demonstrated on different occasions for the theories of harmony, counterpoint, rhythm and melody, see [75]. A model of classical counterpoint was introduced in [69], including the morphology and semantics of contrapuntal tension between two successive intervals, see 5.2.3.2.5. In the same vein, Thomas Noll has constructed a morphology of Riemann’s theory of harmonical functions [87] and shown that the delicate polysemy of classical function theory can by explicited and operationalized by use of techniques of mathematical music theory. This is not a model for an existing theory, since the Riemann theory never existed beyond the torso of a program. Rather is it the first time that such a theory has been constructed as completely as it was intended, see 5.2.3.2.4. Figure Figure 43. shows the major tonality morpheme in Noll’s theory, together with specifications of allomorphs.

One of the major conributions to paradigmatic analysis of music stems from Ruwet and Nattiez and was built around Nattiez’ concept of the “paradigmatic theme” [86], see 5.2.3.2.2. This is a exemplary synthesis of the imprecise concept of “similarity” or “association” of objects in musicological analysis and a semiotical perspective as introduced by Saussure in the dichotomy “rapport syntagmatique/associatif “. The paradigmatic *theme* is expressis verbis the conceptualization of the set of conditions and criteria for associative comparison in analysis.

### 6.1.4 Denotational/Connotational “Hjelmslev Stratification”

This was mentioned by Volek [122], stating that in music, connotation is often encountered without the necessarily underlying denotation. He proposes the nomenclature meaning/content/sense of connotational layers defined by successive globalization and integration of signs. The system of Clarke and Ford [15] suggests a Hjelmslev stratification which is articulated parallel to the successive displacement from “foreground” to “background”.

### 6.1.5 Ontological Segmentation

This has been mentioned by several authors, however without systematic approaches. Nattiez and Faltin claim that music is an autonomous symbolic system, but they do not work out the transition from this ontical layer to physics. Faltin declares that “form is the materialized idea” which thereby can be heared as a sound event. The transition mechanism—together with the ontical ingredients of form and idea—and all the consequences of performative character (see chapter 3) are not made explicit.

In this context one should mention the precise approach of Kari Kurkela [58] to the analysis of music notation as a semantic system. The work concentrates on a precise description—quite in the spirit of the Denotator/Predicate schemes (see 2.1 and 2.4)—of a formal language for representing classical western music notation. It is claimed that “a note represents a sound event or a set of sound events.” ([58], p.7). In the description of what a note symbol’s duration means, no distinction is made between physical and symbolic (mental) duration, as it was described in 1.1.1.1, or else psycholgical duration. The author’s concept of “sound event” does not restrict to physical reality, it includes sound imagination as a psychological experience. But it does not establish an autonomous mental ontology of musical objects. “Sound is something that can be a distinctive object of an auditory experience.” In other words, a sound object is a “set of possible individuals” ([58], p.76/77). The author recognizes that the status of this approach should involve a deeper ontological discourse.

In his typology of musical signs, Volek [122] explicitely asks for ontological criteria that may specify the existentiality of signs. However, he restricts the ontology of signs for musical structures (not meta-musical signs) to the physical or imagined sounds. He does not accept Nattiez’ symolic view: Notation is not a musical structure but “metasemantical notation and mapping” ([122], p. 249).—The discussion on ontology of musical signs is in its very beginning; the cube of musical topography is likely to contribute to these aspects.

Interestingly, the aspect of *deixis* in music has been practically neglected. It seems that many of the semiotic discussions of music have focused on the dichotomy langue/parole and thereby diagnosed a poor codification in situations where the phenomenon rather shows deixis versus lexematics. It is of course true that the poverty of lexicalized code indicates a strong speech component, such as documented, for example, by the primordial role of the individual contributions of composers, and by the standard German terminology of “Klang*rede*”. The contrary of lexicality is not speech but deixis. A discussion of the role of deixis in music has not been carried out; the discussion in 2.5.3 and 3.2.4 is meant as a contribution to this subject.

## 6.2 The Reception of Semiotics in Traditional Musicology

In historical (end of the 19th century [3]) descriptions of the organization of musicology as a scientific discipline, the overall segmenation into historical and systematic musicology shows references to linguistic disciplines such as grammar, metrics, and poetics. They appear as subsidiary disciplines within the systematic division for two classical reasons: The association of music with language, and the status of music as a field of poetical expressivity. Compared to this historical state of the art, the present 'traditionalistic' classification of musicological disciplines has not moved substantially. In fact, the cited historical segmentation describes four parts: Music theory (harmonics, rhythmics, melodics), aesthetics, pedagogics/didactics, and ethnomusicology. The present traditional segmentation of systematic musicology—see [19] for a representative reference—includes: Music theory, music sociology, and music psychology. Allusion to semiotics is solely traced in a short paragraph within music sociology ([19], vol. 10, p.133).

The disastrous neglection of music semiotics within traditional musicology has several deeper reasons which have already been described in the preceding chapters, see 5.2.3.4., for example. On the argumentative surface, the objections ([19], vol. 10, p.133) concern the “slow advances” in sociological implications of the semiotic analyses. One of the most important motors against scientific research is in fact the “ubiquity” of musicological knowledge claim. It is not yet admitted that in musicology too, knowledge has to grow step by step. There is the implicit attitude that the competence/knowledge of the individual scientist has to distribute over the *total* reality of music, and that any fragmentation of research and specialization to exact subjects would destroy the very identity of musicolgy. Suffice it to recall that mathematics is partitioned into roughly 3500 fields of specialization [65] without any signs of loss of identity.

If there is no valuable metalanguage for music analysis, the very program—such as proposed by Ruwet and Nattiez—to construct a theoretical corpus for neutral analysis cannot be accepted by these conservative musicologists since it necessarily postpones applications of analyses to music sociology of psychology to a later date.

On the other hand, all attempts to investigate the “neutral level” and the “autonomous symbolism” have been simply ignored, in spite of their manifest results. The a priori arguments against any explicit, precise and operational investigations are these:

Either it is contended that no substantial insight can be produced by use of “formal” methods since the form is *by definition* not capable of producing contents. There are two confusions in this argument. First, *abstraction is not formalism*. The abstract ontology of Predicates or Denotators is related to mathematical existence, a semiotic fact as it was discussed at length in this article. The second confusion is that *production of contents is not a monolithic affaire*, it is highly stratified and distributed among many levels of semiosis.

Or else it is contended that any more explicit and precise description of musical objects immediately leads to “infinity” (see also Faltin’s conclusion cited in 6.1.1). The truth is that it leads to more or less large numbers of object classes, but never to uncontrollable infinity. And even infinity, if it appears within the selected subject, does not imply that research has capitulate. The question is not about the number (finite or not) but about the conceptual power over the variety of numbered objects. Last but not least, with the advent of information technology, the power of control over large numbers/lists of objects has been substantially improved and the very “horror quantitatis” can no longer be accepted.

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