Music and systems architecture

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Abstract - In the attempt to make the very high level of abstraction of music a usable approach in different contexts and disciplinary applications, a systemic interpretation of production of musical architectures is introduced. Particular reference is made to polyphonic counterpoint music. Music is considered consistent of ratios among single sounds having singularly no meaning. That is the basis to realize the difference between nice sound and music. That's also the reason why music doesn't need to be translated. Music is intended as the *context* where many high level abstractions may be carried out systemically representing the same kind of abstractions possible in different contexts. In this paper the tentative focus is on considering music as the context where so many dynamic, context-sensitive architectures may be developed that it may be a good way to *represent and simulate* systemic architectures. It is an attempt to try to establish interdisciplinary relationships between music and other disciplines other disciplines and applications, like cognitive science, human-machine interfacing, linguistics, knowledge representation, and semantic processing. The conceptual possibility to not have only music of sounds allows designing new multimedia, virtual, user modelled systems.

Keywords: Human-centred systems, observer generator of *existence*, harmony from *context* sensitiveness

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1. Introduction

1.1. Setting initial conditions and the approach

In order to clarify terminology and approach used in the next paragraphs a list of *open* tentative *descriptions* referred to some items, rather than a list of *definitions* of some crucial terms are introduced. "*Open* tentative descriptions" doesn't mean incorrect, incomplete, non-rigorous, and non-documented, free to be interpreted in any ways. It means that such descriptions, combinations of information, references, and concepts, are input for users *inductive processes*, by generating links to different approaches and *kinds of knowledge* [Minati (1997A); Minati (1997B)]. *Induction* is an inference that from a finite number of particular cases brings to another case or to a general conclusion. For instance from a bird watcher station it has been detected passage of only black ravens, then it is possible to induce that the next raven detected will be black or that all ravens are blacks. In the case of *induction* of a rule or of a result (Res) from a set of configuration (Cn) of elements, because it is noted: C--->Res, C'--->Res, C''--->Res, …, it is possible to try to assume valid the rule C*any*--->Rss.
Example:

- Those pieces come from this box, - case (C).
- Those pieces are white, - (Res).
- All the pieces in this box are white, - (R).

The reference is to the core of the Systems approach: it's possible for instance to speak of emergence, collective behaviour, self-organization, single and double loop, control, growth, development, etc. not only without making reference to a single discipline, but also without using single disciplinary language, formalisation and representation.
After reading the descriptions the reader may be ready with his/her own processed list of links. The list is relative to the observer as *active* (models generator) [Minati (2001)] having standards, initial conditions

processed and not just assumed. Actually, this is what regularly happens even if authors may assume that reader will apply literal definitions more than *use* [Minati (2001); Minati (1997C)] them. This approach is strongly related to the concept of *logical* (hierarchy of reciprocal models between autonomous interacting agents, related to semantic processing processes) more than only *thermodynamic* (permeability of boundaries to matter and energy) *openness* [Minati (1998)]. An introductory description of the concept of *emergence* allows the reader to deeply understand the systemic entries listed in the *open glossary of terms*.

1.2. The concept of emergence

The concept of emergence and of "emergent evolutionism" were introduced firstly by C. L. Morgan in 1923 and in the same years the philosopher C. D. Broad introduced *the concept of emergent properties present at a certain levels of complexity but not at lower ones*. For a long time the topic of emergence has been considered belonging particularly to the context of biology. The attribute "emergent" has been considered synonym of "new", "unpredictable", to underline that in the framework of biological evolution it is often possible to detect the becoming of some characteristics in discontinuous way, unpredictable on the basis of the existing ones. This rough concept of emergence was already implicit in the proposal introduced by L. von Bertalanffy (biologist himself too), of a General Systems Theory [von Bertalanffy (1968)]. A formal definition of emergent properties has been introduced in by [Baas (1997)].

"Let $\{S_I\}_{I \in \mathcal{I}}$ be a family of general systems or "agents". Let Obs^1 "be "observation" mechanisms and Int^1 be interactions between agents.
"The observation mechanisms measure the properties of the agents to be used in the interactions. The "interactions then generate a new kind of structure
"

$$S^2 = R(S_I^1,\ Obs^1,\ Int^1)$$

"which is the result of the interactions. This could be a stable pattern or a dynamically interacting system. "We call S^2 an *emergent structure* which may be subject to new observational mechanisms Obs^2. This "leads to the following definition:

$$\mathrm{P} \text{ is an emergent property} \Leftrightarrow \mathrm{P} \in Obs^2(S^2) \text{ and } \mathrm{P} \notin Obs^2(S_I^1)$$

Property P of S^2 is *emergent* if and only if it is observable on S^2 but not at a lower level, i.e. at S^1 level. For instance, while observing the behavior of a group of people, of cars, the flight path of a group of birds, one might conclude that they respectively form crown, traffic jam, and a flock. But if the property P is not observable by looking at individual behavior, the property is said to be an emergent property of the group.
Here the notion of "emergence" does not mean "unpredictability". However unpredictability in literature is considered indispensable feature of emergence. For example, assembly of a car from details is not emergence because they can predict property P (moving) by knowing details and their interaction (S1) though they could not move. Anyway it is possible to repeat establishment of emergent phenomena even if it's not possible to fully predict the process of emergence, like the birth of a baby. In this case it is only possible to manage some aspects of the process. My be it is worth to define:

"Property P of S2 is emergent if and only if it is observable by Obs ^{2} on S2 with positive but less than 1 probability and not at a lower level, i.e. at S1 level."

1.3. Open (inductive) glossary of terms

The following list of terms is presented in order of citation in the paper.

- Systems architecture

Organization (style, strategy, procedure, and way) of using systems resources. The concept has many disciplinary applications: Architecture intended as the art or science of planning and building structures, method or style of building, Software technology, Hardware technology, Linguistics, Law, Engineering, Music, Chemistry, Biology, Etc. Systems architecture depends on Structure as main variable.

- Structure

Relationships between components of a *set* (i.e. a group of elements having a rule of belonging, allowing to decide if an element belongs to the set or not). A set is structured when there are relationships among components. A structured set becomes a system (a system *emerges*) when in addiction to relationships there are interactions.

- Representation

The process of representing takes place when something stands in place of something else. The process of representing is related to using something in a context with reference to another context. The process of representing is always related to an observer. The problem of representing is a crucial issue in modern sciences, like Artificial Intelligence and Cognitive Science, for modelling and simulation.

- Relation

The concept relates when, considering a *group* (not necessarily a *set* requiring a rule of *belonging*) of elements, a state or parameter is depending from or influencing other state (s) or parameter (s). It is possible to have order relations (i.e. alphabetical order), time relations (i.e. something happens before something else), relations of belonging (i.e. being married to, sister, etc.).

- Ratio

Quotient of a quantity divided per another. The reference is to dynamic processes keeping stable static or dynamic ratios among quantitative aspects of elements like in music among, for instance, time duration and highness of sounds.

- Interaction

Two or more elements interact when the one behaviour affects the other behaviour. A *structured set* (i.e. a set of elements in relations among them) of elements may transform in *system* when elements interact [Minati (1998)].

- Abstraction

The reference is to a process of transforming into higher level of generalization, that's having the possibility to use in many different contexts, any kind of resources (for instance. the ability to measure, to use methodologies and approaches, to identify rules, etc.). The process of abstraction is related to the ability to move from *applying functions* to *invent uses*. The process of abstraction is related to the concept of intelligence. In Cognitive Science *intelligence* is not anymore intended as ability to solve problems, but to make *correspondences*, to *associative thinking*, allowing learning, memory (rebuilding information and not just to store and retrieve), decision making-processes, reasoning, mental processes, perceptions, as expressed by the Cognitive System [Barsalou, L. N. (1992)].

- Dimensionality

A variable considered in spatial geometry, representing position. Geometry may represent spatial dimensions, as well time or physic events as in phase space. The abstraction of using n-dimensional spaces is very used in mathematics and physics.

- Spatiality

The reference is to an abstract n-dimensional space where processes may take place by using variables defined in an n-dimensional space.

- Harmony

It is the study of the simultaneous association of sounds in a general musical context generated by rules. Different approaches and theories have been developed to establish a complete, exhaustive "objectivistic" systematisation. Harmony has been approached with very analytical and technical attention to details (polyphony; counterpoint, tonality, modulation): Vicentino N., 1555; Mersenne M., 1636; Rameau J. Ph., 1722; Riemann H., 1882; Chevaillier L., 1925; Chailley J., 1951; Ansermet E., 1961; just to mention few authors. Different efforts to systematize had always to deal with the need to take in count the peculiar sensitivity of the human being belonging to different civilizations, in time. Harmony in music is based on acoustic, physical effects, but it is not reducible to them. Like a system is based on components, but it is not reducible to them. Like for all emergent phenomena the role of the *observer* is crucial. The observer is not just generator of relativity, but of existence. By considering the *continuity* between the human beings, the context where they live (i.e. from

where they receive information, stimuli to adapt and to learn), the processes of change active and emergent in the contexts, harmony in music may be considered as one of the way by which human beings represent, express such continuity. *Continuity* regarding social systems refers, for instance, to architecture, literature, music, religion, etc., finding the same *style.* Harmony in music for human beings is an essential expression of their *local* (in time and space) sense of beauty, way of thinking, approach to life, etc. The link between harmony and observer is not signal of randomness, of capriciousness, but of context sensitiveness.

- Polyphony

"Polyphonos" (*many-voiced*) and "Polyphonia" occur in ancient Greek with no specific reference to a musical technique and still the term is used in a general sense. The term is "used to designate various important categories in music: namely, music in more than one part, music in many parts, and the style in which all or several of the music parts move to some extent independently." [Sadie (2001)]. The topic of Polyphony is a very important one in music and has been approached in many different ways. An overview of the many approaches may be founded in [Sadie (2001)]. Since the 1200 polyphony has been intended as: (1) multiplicity of parts, contrasting *dyaphonia* and *poliphonia*; (2) several parts of equal importance; (3) equal development of individual parts, distinguishing between polyphony and heterophony; and (4) simultaneous use of several structures. One of the first descriptions of this practice may be founded in the "*Musica enchiriadis"* (late 9th cent.), and then developed into freer forms of countermelody. The fugues and chorale settings of J. S. Bach (1685-1750) in the baroque era are considered by some authors as the epitome.

Boulez defined "polyphony as a combination of structures of which one is answerable by another" [Boulez (1964)]. Polyphony has been intended by ethnomusicologists with reference to diaphony, plurivocal, polivocal, polyphonic parallelism, multiphonic, multi-sonance. For others "true" polyphony is a procedure, which must be multi-part, simultaneous, hetero-rhythmic and non-parallel. To fix the idea it is possible to consider polyphonic music as *independent, but harmonically related musical lines,* as *simultaneous* musical texture of several melodic vocal or instrumental lines.

In polyphonic composition of musical autonomous lines it is possible to recognize, represented, the meaning of emergence processes [Minati (2002)], of the establishment of systems from interacting components.

- Counterpoint

The theory of counter point exists by about 1330. Counterpoint is intended in music as the art of combining simultaneously and subsequently independent melodies. Making reference to the linguistic domain harmony may be intended as the grammar of music, while counterpoint may be intended as the syntax. The term has been introduced by Giovanni de Muris in the 14th cent. and derives from the Latin *punctum contra punctum* (point against point), meaning note against note in the notation of plainsong. The academic study of counterpoint was long based on *Gradus ad "Parnassum* (1725, tr. 1943) by Johann Joseph Fux (1660-1741), an Austrian theorist and composer. The study of counterpoint was formulated into five species-note against note, two notes against one, four "notes against one, syncopation, and florid counterpoint, which combines the other species. In the 15th cent. the great Italian polyphonic composers introduced a free use of the counterpoint (*ricercare*, *fantasia*, *a imitazioni*). Polyphonic forms were later given a most brilliant and sophisticated expression during the baroque era in the works of J. S. Bach. "Counterpoint and polyphony are practically synonymous" [Sadie (2001)].

- Thought

Thought is related to cognitive processing as studied in Cognitive Science. Thinking refers to the process of creating relations and correspondences between items of perceived information and processed information. Thinking is related to *problem solving* activity. See intelligence in abstraction.

- Language

Wittgenstin in his Tractatus introduced the assumption that all languages are used to picture facts [Derek (1977)]. Whorf introduced the hypothesis that it is not the thought generating the language, but the language generating the thought (i.e. *we think what we may say*) [Whorf

(1956)]. Even if this hypothesis has been denied it is very powerful by considering the two approaches working together: *thought generating language* AND (not OR) *language generating thought*. *It applies to music creation and thinking.*

- Inducing

Inducing is intended as a process of inference from a finite number of particular cases to a further case or to a general conclusion. **In this paper the reference is to ways of using musical abstractions to represent, to induce the same abstractions in different contexts**. In such a way in this paper music is intended as *thinking inducer*, i.e. as the context where it is possible to represent processes of thinking, to communicate and to induce them.

2. Systems and Music

1.4. Music of ratios

It is very easy to carry out systems by using languages, behaviours, and physical components. The focus of this paper is on the process of establish emergent musical systems representing not only the dynamics, the processes of the context of the generating *device* (the human being), but the cognitive processes of this generating device, supposed provided with cognitive system.

There has been and there are a lot of disciplinary researches about languages. Researches in Cognitive Science, role of language in cognitive processing, semantic processing and applications in translation processing are some examples. Translation is a problem related to much kind of languages. *Translation* is a process supposed for the same kind of (natural) languages, keeping as much as possible the same *meaning*. *Translation may take place between different natural languages, but also from and to the same natural language, by saying the same concepts in different ways.* For non natural languages, like computer languages, it is more appropriated to speak of *transformation*, keeping as much as possible the same *functions*. Automatic translation has been a very crucial problem for Artificial Intelligence. It has been realized how there is no translation without considering the cognitive model of the translator: different translators may translate the same text in different ways. It relates to the concept of *logical openness* mentioned above, to the crucial role of the observer like in the processes of emergence.

Other aspect is the process of representing concepts, ideas, and emotions in different languages, based, for instance, on words, pictures, and music. Nevertheless music has the particular aspect to don't require to be *translated*. Music may be arranged for different instruments and styles, but it doesn't require to be translated. Phrases of natural languages may be assumed as composition of elements (f. i. words) having themselves meaning. **Music may instead be intended consistent of *ratios* among single sounds having singularly no meaning. This is related to the high level of *formalization* of music and is the basis to realize the difference between nice sound and music *(there is a large, fuzzy interval between the two extremes)***. Phrases of music are discourse of ratios and not of elements like words. Metaphorically speaking and making reference to holism of music, the difference between composing notes and letters of an alphabet is that *in natural languages is possible to express nouns and phrases while in music it's possible to only write books*. Musical instruments have the specific purposes to produce effects (sounds) to be organized by carrying out *structure* among them. Musical instruments are generators of very dynamic and flexible physical quantities to be related, to be in a very complex network of ratio among them. Musical instruments have the specific purposes to produce effects (sounds) to be organised by carrying out *structure* among them. Musical instruments are generators of very dynamic and flexible physical quantities to be related, to be in a very complex network of ratio among them (= *musical structures*). It is why ***silence*** between notes is part of musical discourse, *being music itself*. In this case musical instruments *play* silence and it is to the listener to *change,* to *interpret* it as music.

Anyway music could be based on ratio among other kind of effects, such as colours, shapes, and any kind of properties. The music of ratios among sounds is the more effective and suitable: how to carry out *keyboards* producing shapes, colours and properties? Let's consider *music* constituted of ratios among light rays. Actually, a way to make music constituted of ratios among light rays instead of sounds is already available. Reference is to devices able to display images (= to make emergent images) on video screen by using pixels. As it is well known each pixel may be *off* or *on* at different levels (colour, intensity, duration). Anyway there are some very important differences between *keyboards* producing sounds and optical signals:

1. Each pixel may be activated in **all** the possible states (colour and intensity) while the keys of a piano may produce different graduations of **single** different notes. The keyboard playing pixels plays with different keys (the pixels) the same note and different notes with the same key. The keyboard of pixels plays with different keys the same "cord" and different "cords" with the same key. In theory it is possible (but very expensive) to limit the keyboard of pixels in order to have the same limits of a keyboard of sounds.
2. The **geometric position** of pixels is crucial to allow emergence of a picture while it is not for music of sounds. Emergence of music of sounds takes place by a composition of sounds different from a visual one. Difference between sound transmission by ears and optical transmission by eyes must be considered. Visual perception is not *analytical* like the acoustic one. Also because of the previous point music of sounds cannot be just reproduced by music of light. A transposition like between musical instruments is not sufficient. An arrangement is required. It is possible to have many different arrangements like for translations.

Music of light may be a good way to make available music to deaf people.

1.5. Music and dimensionality

Making reference to the correspondence between ***dimensionality*** and ***polyphonic*** *(simultaneous* musical texture of several melodic vocal or instrumental lines) ***counterpoint*** (the art of combining simultaneously and subsequently independent melodies) technically generated, for instance, by orchestra, organ –having multi keyboards, pedal keyboard, and several registers-, or piano and harpsichord with *dialogue* between the two hands, it is possible to introduce the following considerations. Well-known examples, just to mention a few, are Bach's *Brandenburg Concerts* or Vivaldi's *Four Seasons*, Bach's *Toccata and Fugue* –BMW 565-, Bach's *Goldberg Variations*. J. S. Bach's three sonatas and three partitas (BWV 1001-1006) for unaccompanied violin represent the culmination of Baroque polyphonic writing for a stringed instrument based on instrumental polyphony using *Multi-Stopped Chords* technique.

Polyphonic counterpoint music is n-dimensional:

- Each instrument may be intended as a spatial dimension. Dimensionality is *dynamic* because is depending on the instruments that are playing simultaneously.
- Time also is n-dimensionally represented. Musical instruments (**only human beings had the need to invent such a kind of devices to create music and not just to produce sounds**) follow different times even if in a common temporal structure allowing coherence and therefore harmony.

The more there is multi-dimensionality and the more abstraction is represented, i.e. simultaneous related, associated, processes of thinking. Not *something* abstract. But abstraction intended as a process. That is thinking. This assumption is not assumed in this paper to be right and to be demonstrable by using, for instance, cognitive, philosophic or logic approaches. It is proposed as interesting point of view able to induce considerations, reflections and metaphorical relations like any artistic products. By the way in science we had similar effects with ideas and hypotheses that have been very interesting, making researchers to thinks on them for years even if they have been demonstrated not rue: that for instance the case of the well know Shapir-Worf hypothesis.

In this paper it is proposed to consider a correspondence between

- **Polyphonic counterpoint architectures generating harmony among different simultaneous subsequently independent melodic lines, and**

- **Associative thinking that is at the basis of systems thinking.**

Their architectures present similarities: multidimensionality, *simultaneous independent harmonic processes*, logical openness (*creative* role of the observer, the listener in this case, who is expected not just to enjoy, but to continue the process of thinking, of feeling, induced by the music), structures of relationships, processes as elements (dynamics), collective behaviour of autonomous components, emergence.

Polyphonic counterpoint architectures, like the ones of the Bach's "Brandenburg Concerts" and the "Art of Fugue", just to mention a couple of examples, *may be realized as crystals of ratios, of relations*. Those "crystals" become systems when an observer listens to them *actualised* in music and **processes music making it becoming thinking** (that relates to the difference between **to hear and to listen to).** Music becomes *emergent* with meaning when an active observer processes the sounds, when elements (processes) in relation become interacting.

In this view the "talk" (let's remind what has been mentioned above: "polyphony as a combination of structures of which one is answerable by another", Boulez) between dimensionalities in mental processes (i.e. associative, systemic thinking) may be assumed dynamically represented by polyphonic counterpoint music for the reasons mentioned above. Each musical theme assumes meaning in this becoming of dimensionalities, physical representation of thinking. Gestures and movements of playing also induce reference to multi-dimensionality.

This makes more appreciable the difference between nice sounds and music: music is designed having mental processes, as well emotions, to represent. *Music is man-made.* Music concerns ratios, relationships: it is represented by ratios among sounds. Nice sounds (i.e. birds twitting, water falling, leaves rustling), like very simple musical themes may also be intended represented by ratios among sounds. **But in this case relationships between ratios are very simple, continuously repeated: there is not a complex architecture of them.**

The relation that we want to introduce between music and associative thinking is not one-to-one: associative thinking is in relation with other artistic expressions and it may be represented in different ways, like literature and poetry.

Non-polyphonic music may be assumed to represent other aspects of the human cognitive system, like emotions, memories, images, etc.

It is also interesting to consider how it is possible to have powerful *ways usable to represent without having something to represent*: others may realize that what has been carried out in different situations and in different times, with different purposes, may be very useful to represent something. That's inventing new uses. An example is given by digital coding invented to represent numbers and letters: now it is used to represent any kind of information like voice, image and text. The processing that has been invented to process numbers and letters, has then been improved to process new representations.

Polyphonic counterpoint architectures have probably been created not to represent the specific mental process that we are discussing now. This refers to what has been introduced above in point 1.1 discussing the topic of *language*.

3. Music like a systemic lab

In music it is possible to carry out "shapes" of relationships and architectures of such shapes, especially in polyphonic counterpoint music. Such relationships and architectures are based on dynamic elements, i.e. processes as the emissions of sounds by musical instruments.

Even in concrete achievements to consider objects (bricks, paper, glass, wood, etc.) stable, static is a kind of reductionism. In reality, depending on the *level of representation* adopted, it may be more appropriate to assume this approach or the one based on considering processes of continuous dynamics of relationships. It is important to be aware that adopting the approach based on reductionism is like to consider an orchestra in which every instrument plays a single note. In music the score is

architecture of dynamic elements based on relations among notes played by single instruments: the architecture is on dynamic elements. *Objects* are processes. To consider objects static is just an approximation, very useful when dealing with macro characteristic, by allowing the possibility to ignore micro behaviours and micro characteristics.
Music is the place where it is possible to ONLY carry out architectures of "objects" constituted of dynamic relations.
This correspondence may allow to consider *systemically* such architectures, being music the context where to create and play (i.e. apply) them and other contexts the place where to invent and to apply by using different languages (for instance dancing, movies, theatre and *inducing* ways of thinking).

4. Conclusions

This paper introduced some points about music and a systemic way to consider it:

- Only human beings had the need to invent musical instruments to create music and not just to produce sounds
- The difference between music and nice sounds.
- The difference between to hear and to listen to music.
- Music doesn't need to be translated because may be intended as ratio among sounds produced by musical instruments.
- Polyphony may be intended as a way to *represent* the process of emergence.
- The correspondence between polyphonic counterpoint architectures generating harmony among different simultaneous melodic lines and the associative thinking that is at the basis of systems thinking.
- The music could be not only based on ratios among sounds, but be also based on ratio among other kind of effects, such as colours, shapes, and other physical properties having the possibility to establish ratios.

Systems thinking and arts had not too many significant "interdisciplinary" interactions (example of activities in this direction may be found at http://www.jcrhodes.net/2002/; http://www.jcrhodes.net/asprog.htm and http://www.iias.edu/frameset_start_inters_ann.html).
One way to express inter-disciplinary processes is to say that they take place between disciplines when problems, solutions and approaches may be shared and applied in different forms and contexts.
In this paper the tentative focus is on considering music as the context where so many dynamic, context-sensitive architectures may be developed that it may be a good way to *represent and simulate* systemic architectures. The architecture considered in the paper is the one of polyphonic counterpoint music, recognizable also in other contexts, like in literature and, in science, in the processes of emergence.
One important starting point in trying to establish inter-disciplinary relationships between polyphonic counterpoint music and systemics is the active role of the observer: fundamental in science for processes of emergence and fundamental in music for harmony. This is very related to the concept of *logical* more than only *thermodynamic openness* [Minati (1998)].
Different kinds of musical architectures as well different kinds of composing techniques may be related to processes of thinking and, particularly, to systemic, associative thinking. The purpose is to find representative, significant interdisciplinary correspondences able to carry out useful share of approaches, architectures, schema, and methodologies.
A composer is creator of musical architectures. Performers are singularly and collectively (with the conductor) creators of systems that are *always unique* because of their real implementations in time and because the listener is always *new*. Designing and implementing systems are correspondent activities in different disciplines. The systemic abstraction of unifying these processes is able to induce interdisciplinary thinking. **The possibility to not only have music of sounds is one of the projects allowed by this approach, to be**

considered in the era of multi-media, virtual systems, voice and image processing, user modelling, simulation systems. This approach allows, for instance, to not only create usual *entertainment*, *accompaniment music*, but also *representing*, *multi-media music*, inducing thinking, related to the cognitive model of the listener, of the observer (see for instance *The European Society for the Cognitive Sciences of Music*-ESCOM http://musicweb.hmt-hannover.de/escom/english/index.htm with the many Other interesting servers listed in this web site and the journal "Musicae Scientiae" published by ESCOM).

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