# Sound Gesture and Rhetoric. Hyper-cello as an Algorithmic Composer

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## Abstract

Musical practice based on new technologies does not seem to unequivocally confirm the relations of the three elements of the classic semiotic-oriented theory of musical communication (composing, performing and listening). Unexpected interactions between these three poles of communication suggest the idea that rhetoric can be useful in order to describe and produce effective creative processes.

In the 16th-18th centuries composers adapted literary rhetoric to music, towards striking descriptions and organizations of musical forms. The rhetorical figures derived from poetry became a very powerful means to shape well organized and emotionally meaningful compositions, even outside the music-vocal domain.

The motivation behind our recalling of pre-classical contexts stems from the assumption that technologies are involved in a process of modular reconfiguration of musical cognition and communication. It is not just the social roles of music-making that are shifting, since the categories themselves seem to be assuming unexplored and overlapping meanings.

By exploring new boundaries within the enhanced experience offered by digital augmented instruments towards a real-time approach to software composition, our project explores concepts belonging to the rhetorical tradition in combination with some semiotic theories of the 20th century. Our aim is to cross different functions internal to the creative musical process, individuating possible trajectories of mutual human-machine listening. Electro-acoustical language has, since its origins, considered the perception and the morphology of sound as constitutive elements of the form. Schaeffer referred to the minimal units of communication as *objets sonores*: gestures which connect the physical world with the symbolic one. The tape now assumed the role of a score, containing organized sound gestures.

Moving from the concept of Hyperinstruments we propose an interactive system of composition that, through the analysis of the structural elements of the sound gestures as they are played live, elaborates a multistratified form in which the composition, the performance and the listening integrate one another according to a modular strategy, a heuristic approach to the analysis of the sensing data, and a compositional self-regulating attitude. A unifying framework is offered by the model of the 'composed instruments' defined by Schnell and

Battier (2002) as digital means possessing the attributes to be instruments and score at the same time. By maintaining a focus upon the context of embodied interactions, rhetoric, with its figures denoting amplification, variation and contrast strategies, can be treated as a new field of research in order to enhance the communication between the different levels of the musical creation and the people involved in it.

# 1. Why Rhetoric?

Semiotic-oriented theories have, since the 1970s, been a very important means in order to describe the processes of music communication and could still now be useful to compose or analyze the interaction between music and new technologies, not only considered from the point of view of the chain 'composer, performer, listener' (which we could call the 'external network'), but also of the inner creative process in which the functions of composing, performing and listening are interrelated (the 'internal network').

## 1.1. Analyzing the "external network"

Frisk and Östersjö (2006) move from the semiological framework developed by Molino (1975) and Nattiez (1990) that holds musical activity as a "concrete act of human communication", as a "total social fact" (Molino, 1975) characterized by three dimensions: the poietic process of the composer who creates the piece; the esthesic one of the listener who reacts to the music; and the material reality of the work (its live production, its score or printed text, etc.; Nattiez, 1990). In this theory music information is not transmitted from the composer to the listener, because the latter reacts to the material reality of the work, developing an autonomous strategy and also interpreting it according to his personal point of view.

But how is it possible to speak about communication, if the composer and the listener do not share the same criteria to interpret the musical process?

Frisk quotes Paul Ricoeur's hermeneutic philosophy (1991) to underline that the common language framework allows a multiple interpretation of the work by the listeners.

Umberto Eco (1990) affirms that it is possible to speak of communication if the composer and the listener share a similar interpretative code, that is when they understand the musical signs within a "cultural convention" to which they belong (Eco, 1968). Developed by social powers, this convention defines the context in which music becomes a symbolic system where the composer, the performer and the listener cooperate in order to interpret the music not in an absolutely free way, but searching for an agreement between the intention of the composer and the reactions of the performer and the listener.

Frisk and Östersjö (2006) affirms that Eco's theory is suitable for the analysis of works in progress, and not only for pieces provided with a fixed score. In the first case the physical world of the sound is explored (often without a paper score) by the performer through specific gestures that allow musical communication if the composer, the performer and the listener share a common context and subculture. This is the result of an interaction and negotiation between two "agents" (this is the term used by Frisk and Östersjö to indicate the composer and the performer exchanging their roles) and their inherent cultural contexts with the aim to coordinate their actions. Frisk and Östersjö underline that the piece becomes a symbol for the culture to which it belongs: "Under a semiotic point of view, the musical work becomes the

sign or the message, the agents the signifiers and the subculture the signified". Nevertheless it develops a new, no longer hierarchic relationship between the composer and the performer, because both agents become "part of a larger system that may also contain many other agents" (e.g. the listener who takes part in the musical process; *ibid.*).

### 1.2. Analyzing the "internal network"

Rhetoric could be useful in order to describe effective communication processes in the musical domain. Encompassing the audience as a part of these processes means to develop strategies related to the analysis of the 'external network' described above (i.e. an 'external rhetoric'). Setting aside for now the aim to concentrate on possible involvements of the public in the interactive works, we consider it here more stimulating to focus on the action of listening as a fundamental element of the creative process, driving the attention by means of dynamics involving the rhetoric of the 'internal network' ('internal rhetoric').

Since the origins of electro-acoustics, when the recording assumed the status of a musical text, the score started to represent a less fixed entity compared to the traditional score of instrumental pieces, and listening (relating to a tape and acquiring the ontological status of a compositional agency) became fundamental in order to shape the form.

Horatio Vaggione (2001) affirms that the composer "always has to approach the process of producing a piece of music as a listener, either in the form of inner listening while writing an instrumental score or the concrete listening in the production of a pure electronic piece". The relationship between the composer and his piece configures a feedback loop, not based on language, but on action and perception. The same happens when the performer plays his instrument: he can react to it easily through listening to its sound or acting on the instrument in order to modify through his gestures the sound it produces (Vaggione speaks of "thinking through hearing" and "thinking through performing"; Vaggione, 2001).

### 1.3. 'Internal networks' and technologies

An implemented system based on internal loops of action-listening, taken as a form-building interactive function, can be exemplified by the 'score follower'. The concept has been developing principally at IRCAM since the 1983, and is suited for authorial works. The score is split into a fixed and a virtual entity. The fixed one notes down more or less traditionally the sound and performance gestures which have to be played by the instrumentalist. In the virtual (software) score are written the salient event-features that the machine has to recognize when specific musical performance conditions are matched. This technique allows to have the electronic chains advanced by means of the human sound-gesture consistently with the music as it is performed live. The system defines the electronic sounds as a virtual performer, whose actions are responses to the actual-human performer. The resulting synchronized chain of actions is due to the listening role of the sensing system applied to the human-performer and to the waiting role of the virtual score. Training and observation steps represent mutual techniques, involving listening actions as a structuring system of musical development[1].

Some unexplored conceptual shifts lie beneath the idea of a listening and 'form building' machine. The theory of the 'composed instruments' could help to explain the hybrid roles of the machine, and to contextualize a definition of the 'internal network'.

[1] See http://imtr.ircam.fr/imtr/Score_Following_History (last accessed 10/14).

Digital means are generally considered as machines that blur traditional behaviors through their hyper-textual dimensions. Starting from the consideration that composition, performance and instruments are traditionally differentiated entities, the theory of 'composed instruments' underlines the fact that "computer systems used in musical performance carry as much the notion of an instrument as that of a score" (Schnell and Battier, 2002). The active and hyper-textual qualities of digital scores appear ubiquitous considering composition environments such as Csound, Max/MSP as well as many compositional algorithmic systems.

If in digital instruments "the two main components of a musical instrument, the sound producing part and the gestural performance part, are decoupled" (*ibid.*), the other part of the 'composed instrument', the score, owns at the same time a representative and an active function. In the same direction Magnusson (2009) underlined, among others, the essential quality of the digital instruments as "epistemic tools", cognitive extensions of the human in a sense obscuring the embodied relationships implied in the technology of the acoustic instruments. "The primary body of the digital instrument is that of symbolic instructions written for the meta-machine, the computer" (*ibid.*), built upon designed interfaces and structured-scored representational means of interaction.

Starting from these assumptions we could recall the opening semiotic scheme of this paper, and raise the hypothesis whether computers could be seen as instruments possessing the attributes of a semiotic 'active' neutral level. Some considerations about these shifting functional roles of creation and their possible communication and rhetoric corollaries in the field of interactive music environments will be further developed as a working in progress algorithmic compositional research.

The theory of 'composed instruments' does however not appear to be exclusively digital, but more broadly speaking, technological. In fact "technologies allow the implementation of environments operating at the same time as musical instruments, machines and representation" systems (Schnell and Battier, 2002), suggesting that computers intensify a process already existing in the field of compositional approaches to technology.

### 1.4. Schaeffer, the *objets sonores*

Since the advent of electronic music, composers have focused their attention on musical timbre independently from the origin (recorded or synthetic) of the sounds, in a sense decoupling physical causes, functional techniques and language. Pierre Schaeffer defined the *objets sonores* (Schaeffer, 1966), fragments of sound typically in the range of a few seconds, as perceptual units. The conceptual attitude was to disregard the original context of these sounds and to concentrate on the their straight timbral features, calling this approach "reduced listening" (*ibid.*). Starting from this scenario, electro-acoustical composition developed listening strategies based on not-obvious relations between physical causes and sound.

Schaeffer worked in the direction of building a "music grammar" by extracting sound shapes organized in typologies, whose original idea represents the basis of currently developed directions, as in the case of the spectromorphology, and its complex vocabularies of tangible and integrating compositional schemes relating physical dynamics, their listening-based analysis, and their musical forms directly shaped on "tape" through models of distribution in the actual space. In a more interactive context, the definition of the body-gestural-formal implications of the *objets sonores* (Godøy, 2006), as well as their inscription in an organic and auto-poietic idea of formal developments (Thoresen, 2010), tend towards an idea of

autonomous entities, whose formal qualities require different means of organization with respect to the fixed and phonetic-based language of the traditional score.

*Objets sonores* may be found suitable for use in compositions produced through actions on the instruments or on the natural world, with which we interact. Nevertheless, in order to reflect on the ephemeral nature of musical sound, we have to conceive the *objets sonores* as 'intentional units' constituted in our mental activity and to recode them as stable images in our minds (Schaeffer, 1966). The composer has to listen accurately to them in order to understand and shape the *objet sonore* as a part of his composition. If we define the musical gesture as an ensemble of observable features building a bridge between the domain of the musical intention (cognition, composition, musicology) and the physical one (the frequency spectrum), we can also say that the *objets sonores* have a strong gestural dimension and can be analyzed by detecting and relating together different envelopes for each parameter we want to describe in its temporal development (Godøy, 2006).

Although just one *objet sonore* alone can influence the form of the composition, if the composer coherently develops its gestural features (for example deriving other compositional parameters from its amplitude envelope, e.g. the increasing or decreasing density of the sound texture or the rising or falling direction of the pitch register throughout the whole piece), it is also important to organize the sound elements of a composition by building a strategy in order to make its form clearly understandable and convincing for the listeners and to achieve an effective communication with them.

### 1.5. The "Gesture of the form" (Dalmonte *et al.* 1981)

Challenging the idea of an abstract system imposed on the material, the *objets sonores* can be superimposed or connected in series according to the principles of the repetition, variation and contrast in order to build a form giving the idea of stability (continuity), transformation or discontinuity. The discussion about a semiotic framework of the electro-acoustic music was recently raised by Basanta, arguing that the syntactic relations between sound events, the aural evolution of the sound, can be inscribed in ecological models of signification: the articulation of syntax (more than the single sound events) as signifier defines the idea of a natural morphology of sounds upon which the compositional discourse is organized (Basanta, 2010).

The tension obtained by the contrast and the distension achieved through the repetition and the variation of the sound events determine a particular envelope that characterizes the piece and, because it builds a bridge between the symbolic domain of the musical intention (in this case the formal development that the composer wants to achieve) and the physical one (all the musical elements comprising the form, also those analyzable in terms of frequency spectra with one specific amplitude envelope for each partial), can be defined as a musical gesture concerning the whole form. Some theorists defined it as the "gesture of the form" (Dalmonte, Lorenzini, Azzaroni and Frasnedi, 1981), in order to indicate the tension/distension process, considered throughout the duration of a piece or of a section. Being able to describe it (with the help of computer analysis) constitutes a very important aim for the listeners, who could thus better understand the formal gestures of the work, but also for the composer, who becomes aware of the potentiality of the *objets sonores* and the formal strategies used in his composition.

## 2. Principles of rhetoric and its applicability to the analysis of compositional processes in electro-acoustic music at the level of the 'internal network'

We spoke above about form and gestures, that have to be clear and convincing for the listener. These terms refer more or less directly to the rhetoric, which between the 16th and 18th century played an important role as a basis for musical composition in order to build effective configurations characterized by clear relationships between the elements. Vocabularies of defined musical-rhetorical figures, working at formalizing levels, were derived from literary ones (e.g. *anaphora* indicates the exact repetition of a motive, *paronomasia* one that is varied, *antithesis* the contrast between two motives following each other and so on), with the aim to convince the listener and let him feel, think or do something imagined by the composer. Rhetoric configures itself as a means whose structures induce an action (virtual or concrete) performed by the listener, and in this sense it was also considered pragmatic (Geißner, 1975). If in the 16th and 17th centuries the listener was considered passive, during the 18th century he is regarded as more reactive and able to elaborate new ideas (if not technically involved) or new musical works (if it were a composer). A multilayered ideal feedback is therefore implied as a dialogue between the composer and the listener. In this fashion the ideas of the composer are proposed to the listener in order to achieve an intellectual confrontation and an exchange of points of view, according to the dialogic culture of that time (Fauser, 1991).

It is possible to analyze the communicative processes of music by means of modern rhetoric (Benzi, 2004), in particular the 'nouvelle rhétorique' of Perelman and Olbrechts-Tyteca (1958) and of the Groupe μ (1970 and 1992). The former affirm that rhetorical figures are fundamental not only when writing literary works or special discourses, but also in our whole daily life (including, we might say, composing music). Without rhetoric we cannot convince our listener; therefore we need the *loci topici* as frameworks in order to use the rhetorical figures and let the listener feel emotions and react with new ideas and actions. Also in this case the rhetoric assumes the double role of organizing the language in a convincing way and stimulating the reaction of the listener in order to develop a dialogue between the latter and the composer within an effective communication process (Kopperschmidt, 1975).

The Groupe μ, moving from literature, extends the rhetoric principles to other arts. A communicative process, that can be described as rhetoric, bases itself on the regularity of a message structure (called 'isotopy') which the emitter of the message can interrupt through an unexpected irregularity ('allotopy'). The listener, who is able to detect the allotopy and to understand why the emitter introduced it, can elaborate a scheme in which the allotopy is resolved in a new regularity, as in the everyday case of understanding a joke. After that, a laughing reaction can reestablish a 'normal' communicational situation. Recognizable allotopies build the figures, the most important element in the rhetorical play. Applied to music, we could say that the composer introduces some allotopies in the regular flux of sound information (isotopy) when he wants the listener to pay particular attention to specific dynamics of the musical work. If the listener recognizes the allotopy, and more importantly resolves it in a wider comprehensive scheme, he is able to take part in the rhetorical play.

How can we apply rhetoric to the analysis of compositional processes in electro-acoustic music at their different levels (from the works for fixed-media to the interactive setups where the functions of listening, performing and composing are matched together in a multiple and not unequivocally defined way)?

### 2.1. Works for fixed-media

In works for fixed-media the composer can dispose the *objets sonores* in order to achieve the form he desires, taking all the time he needs for the development of his piece. While composing he has always to listen to his work, in order to judge whether the *objets sonores* and the rhetorical figures based on different configurations of isotopies and allotopies he put in it guarantee a well organized form and are effective in an emotional way. In other words, he can reflect for example on whether the *objet sonore* sounding like an explosion can be better related to the next one when followed by an absolute silence (*aposiopesis*, Bartel, 1997) or by its identical or varied repetition (*anaphora* or *paronomasia*, *ibid.*). In the first case the form will be blockwise, based on the principle of contrast; in the second case variation will be the formal rule of the piece. In judging it, the composer assumes alternatively the function of the listener. He is also a performer, if he develops a system in order to spatialize his work (like the *acousmonium* of François Bayle).

But what, then, is the advantage of analyzing the creative process of a work for fixed-media through rhetoric categories? The answer could be almost the same as that of the Baroque era. The Middle-European composers of this time used rhetoric companions about music in order to develop well-organized and emotionally effective music and then concentrated on other particulars in order to make the piece even more effective.

According to Perelman and Olbrechts-Tyteca (1958) we always use rhetorical figures in everyday life, sometimes in a not conscious way, with the aim to communicate with the humans with whom we live. The composer who listens to his piece in order to understand whether it is organized in a clear and emotionally effective way develops a play with himself through which he can even better know and manage the sound materials that he transforms. In the works for fixed media we do not have a paper-fixed score of the piece (with exception of some technical "realization scores" conceived more for the technicians of the Studios than for the musicians, e.g. *Studie I* and *II* by K.Stockhausen), because the tapes (or the fixed-media) are itself the score.

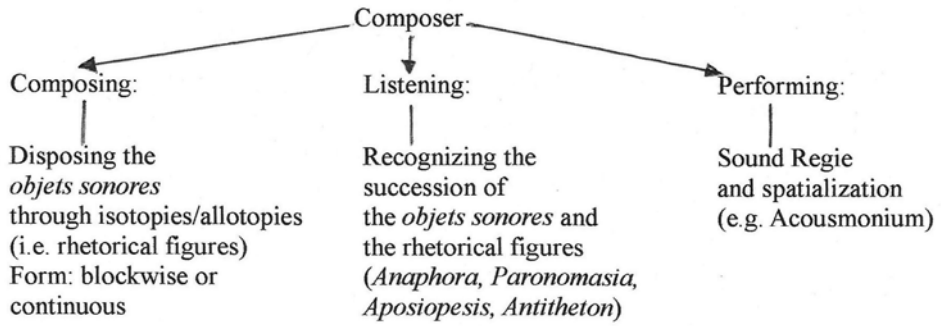


**Figure 1:** Internal Rhetoric in electro-acoustic pieces for fixed media

### 2.2. Electro-acoustic works with live electronics

In a piece with live electronics (e.g. the last works of Luigi Nono) the composer writes a score for the instrumentalists and for the performers who have to take care of the electronic transformations of the instrumental sounds. In this case the instrumentalists and the live electronics performers are both interpreters of the piece, independent from the composer

(except in the case of the composer who also takes care of the live electronics, as Stockhausen often did in his concerts). The composer alternates in his piece isotopies and allotopies in order to achieve a clear form, but the performers could interpret it in a different way than that of the composer. Also in this case, the composer has to act as a listener in order to understand whether the isotopies and allotopies and thus the rhetorical figures of the piece are effective, since it results from the interaction between the decisions of the composer and the interpretation of the performers. The rhetoric play in the compositional process ('internal network') is characterized in electro-acoustic works with live electronics by at least two simultaneous processes: that of the performers and that of the composer, although intimately related. Certain relationships between instruments and electronic elaborations are configured as rhetorical figures: if a gesture of the instrument is exaggeratedly amplified, repeated and spatialized by the sound transformations, the figures of the *anaphora*, *multiplicatio* and *hyperbole* characterize the piece and could be very effective and impressive to the listener, not only at a formal level, but also at an emotional one.

Live electronics exploit multiple scores and multi-layered systems of information in different ways and with different degrees of autonomy between the composer and the performer. Since the final sounds are always dependent on the live musical gestures of the performers, the composer cannot truly fix the 'material reality of the work', its semiotic neutral level: this level can be seen in terms of functions and correlations. Applying rhetorical figures in this context means to synthetically amplify roles of communication between stratified levels of composition, no longer reducible to a one-to-one classical semiotic model, inscribing instead processes of negotiations in a wider environment of internal rhetoric exchanges between multiple agencies (human and automatic). By skipping from one level to another one produces allotopies and also rhetorical figures; the alternance between allotopies and isotopies builds the basis for an internal rhetoric interplay involving, at the same level, physical gestures and music representation.

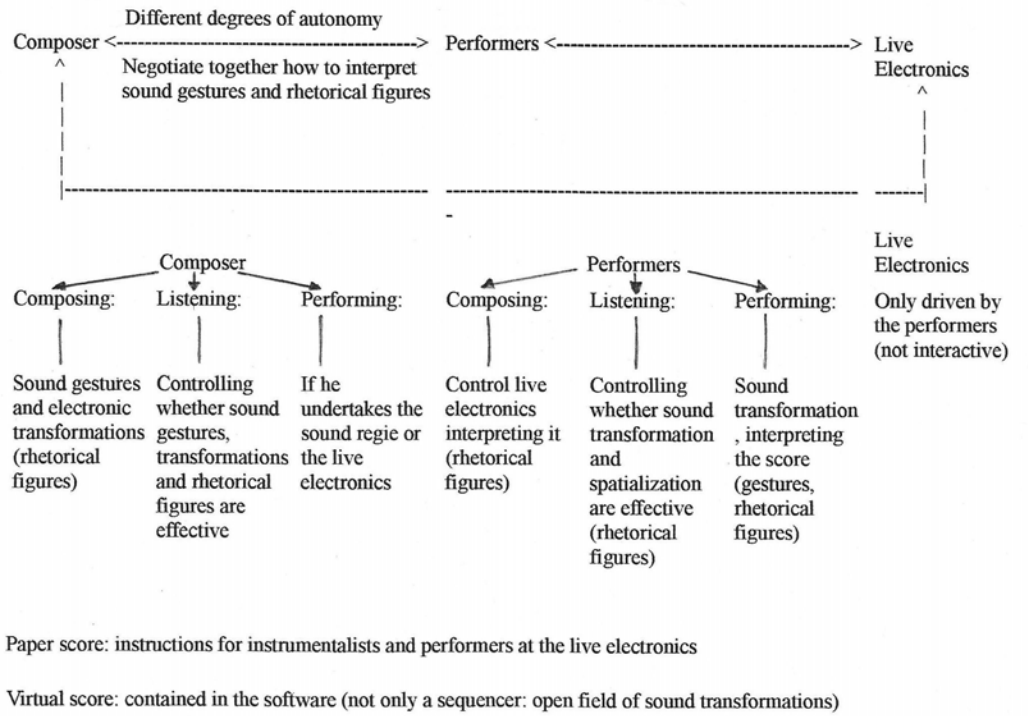


**Figure 2:** Internal Rhetoric in electro-acoustic pieces with live electronics

### 2.3. Electro-acoustic interactive works

Multiple stratifications are even more present and complex in interactive music. The example of the score follower was briefly presented(see section 1) and some further examples will be later discussed. The creative process in electro-acoustic interactive works is very complex because the function of listening, composing and performing belong not only to the figures instantiated by the composer and interpreted/modeled by the performer. The internal procedures of negotiation involve the machine as it is programmed, allowing multiple stratifications. The 'internal framework' of interactive pieces can be described in terms of semiotic-rhetorical processes acting at many levels at the same time, where the isotopies and allotopies and thus the rhetorical figures are not only present in the score prepared by the composer and interpreted by the performers, but also in the behavior of the electronics, which can produce new music as a part of the performance itself.

Since the electronics is capable of producing allotopies and thus rhetorical figures (e.g. it could amplify and exaggerate or contrast the instrumental gestures corresponding to figures such as *hyperbole* and *antithesis*) if we assume the instrumental gestures of a specific moment of the piece as isotopy, the performers then have to react to the electronics too, proposing in turn other figures (isotopies or allotopies) in order to build the form of the piece in strong interaction with the electronics and the instrumental gestures played before.

The composer, who could also be the instrumentalist and the programmer of the electronics, has also to listen attentively to the results of the interaction between the performer and the electronics; he can even compose parts of the work after having listened to the different possibilities offered by the interactive system and so imagining new musical situations in which its gestures can be amplified, interrupted, shifted or even destroyed during the time development of the piece. In interactive works there can be a paper-fixed score or not; in the first case we could speak of a more or less distributed authorial approach, in any case referring to a central score, instantiating rhetoric exchanges with sub-scores and multilayered functions. In the second case we could find agreements between the performer and composer in order to achieve specific interactions with the electronics, and in this case improvisation could have a significative role, maybe partially negotiated though graphics or verbal scores. In interactive works the functions of the composer, the electronics and the performer are no longer separated, but connected to each other in a modular network, operating in different ways as compositional 'agents' (Frisk and Östersjö, 2006). The interactive software could be considered like a second "invisible" score, or from a more radical point of view a networking system functionally scattering the concept of a score at multiple levels, playing the role of a metalanguage potentially organizing and developing an infinite number of compositions under the same system. The semiotic-rhetorical structure is characterized by multiple levels of mutual interaction.

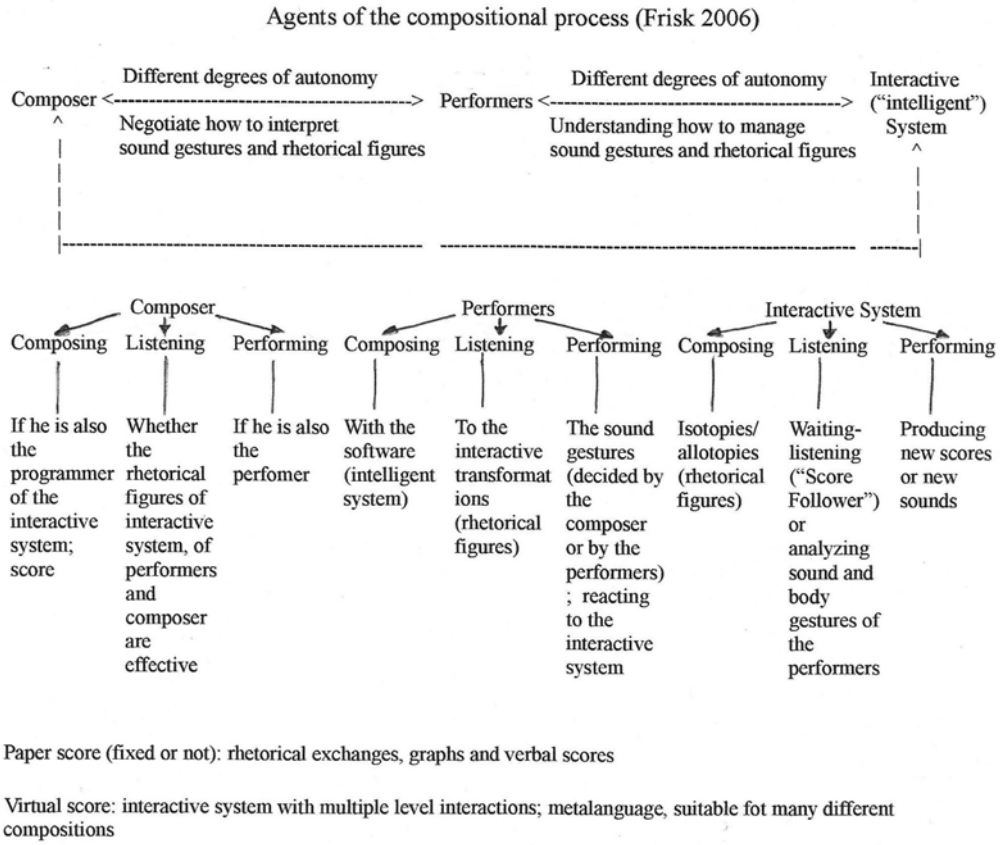


**Figure 3:** Internal Rhetoric in electro-acoustic interactive pieces

## 3. Examples of music interactive systems

Without the intention to exhaust the field we recall here some previous lines of research important to introduce our musical approach. Rowe (1993) defines the music interactive systems as owning three functions: 1) sensing (how the machine detects and analyses the input from the performer); 2) processing (how the machine interacts, i.e. through algorithmic generations or transformations linked to the input); 3) response (the output actions and sounds).

### 3.1. Composer/performer and human-machine interaction

From a technical point of view it could be helpful to recall the taxonomy of the interactive systems functionally described by Rowe in terms of score based vs. performance based inputs, and instrumental vs. compositional system response (*ibid.*). It induces us to orient the investigation around the question as to whether a machine is able to only react or whether it can be programmed in terms of 'intelligence'. Putting the question in other words, at which levels do the programmed machines offer logical but not-predictable responses due to the complexity of the functions, and in which terms could we operate through top-down rather than bottom-up approaches. As a consequence, crucial for our work, inside this scheme we can define a continuum of different degrees of rule-based vs. creative approaches, and afford through different solutions the compositional issue of how to intermingle language-based and

sound-based approaches, as underlined by the previous claim about a gestural conception of music form.

Chadabe's position considers the building of an interactive musical system as a true action of composition; in this case the machine is created in order to offer partially predictable responses, consistent with the context of the musical outcomes sought for, therefore acting as a 'living' composer assistant. As a corollary Chadabe considers the paradigms of performance, composition and instrument as blurred concepts (Chadabe, 1997).

### 3.2. Machines and environments

Di Scipio focused on the concept of 'composing the interaction', considering sound as the result of iterative and adaptive processes inscribed inside the machine, and producing feedback responses between the system and its physical (or instrumental) environment: ecosystems are thus intended as mutual automatic listening processes (Di Scipio, 2003). In a sense this approach recalls Tudor's works conceiving the creation of an analogue circuit as a score, owning the right to be a complete and written system of rules. This score is automatically performed by the assembled machines whose sound outcome can never be really predictable in spite of the determinism of its construction, because of the mutual influences of internal and external causes (Viola, 2004). Lucier's works, in some ways parallel, assemble or invent analogue technologies and simple music machines, sometimes represented by classical instruments, in order to reveal or amplify natural sound phenomena. Here interaction – and again 'composition' – are conceived as conceptual machines able to orient a focused listening dialogue, revealing some inner and undiscovered poetry of Nature, making the real world respond like a musical instrument (Lucier, 1995).

### 3.3.Interactive approaches

Different crucial lines of research involving performance as a structuring process are currently developed by Eigenfeldt in the domain of environmental approaches to real-time-composition (Eigenfeldt and Pasquier, 2011). The growing role of generative systems, also including the domain of real-time strategies, are discussed, among others, by Collins (Collins, 2009). InfoMusLab at Casa Paganini in Genoa investigates the social non-verbal expressive communication of emotional content, mainly inside ensemble interactions on stage, by means of high-level gestural descriptors and multimodal systems (Camurri *et al.*, 2000).

Within the realm of musical interactive systems many related topics were discussed in the inspiring paper collection n° 2 of *Organised Sounds* "Interactivity in Musical Instruments". The discussion involves topics, among others, relating low-level *vs.* high level descriptions, fuzzy-logic, the idea of narrative emotional mappings, data-driven *vs.* model-driven strategies, data-driven *vs.* model-driven strategies, and sub-symbolic approaches implying 'less-logica' states and connections between units learned and replicated by machines (Whalley, 2009). Statistical and global modeling implementation, in our opinion, definitely helps the composer in the direction of avoiding conventional music solutions.

## 4. Context of research

We recall now the above mentioned role of the machine as an instrument and a score at the same time, and the roles of listening as a structured strategy internal to the act of composition,

contextualizing in this sense the idea of blurring categories between composition, performance and listening. Our previous analysis focused on sound as a form-building morphology, on the gestural attributes of sound, on the negotiating roles of composer and performer, on the machines as systems able to sense, interpret and symbolically process the reality, modularly interacting with it.

We consider interactive systems as environments able to listen and respond to the physical world (nature as well as human input) at different degrees of auto-poiesis, depending on the internal tasks inscribed in the system by the composer-programmer. The mutual strategies of poiesis and listening were above commented as complex rhetoric exchanges, mainly as internal processes between humans and between the different layers of musical creation.

Rather than attempting to define rhetoric loops inscribed in the networking semiotics of these systems, the final part of this study will present a concrete music research upon which to trace some possible theoretic lines, starting from the frameworks discussed above and the following brief description of the technologies involved. The mutual chains of human and automatic listening designed in our compositional environments suggest and propose a field of pragmatic exploration of human-machine rhetoric strategies.

Our context of research is based on interaction and oriented to develop new social collaborative environments based on the idea of a continuity between acoustic performance and electro-acoustic sound. Though concert-based and inscribed in a classical-acoustic framework, this research is sonically and conceptually linked to the tradition of electro-acoustic music, and to the union of performer and computer in terms of a sensing, interactive and auto-poietic environment in its whole. The actual works can show different degrees of authorial or performing freedom, although they are based on an algorithmic approach to composition, conceiving the role of the performer as a gestural composer in real-time. The possible dialogues between the performer and the system are designed as a dynamic meta-composition. Machover's stimulating image of a chamber-electronic (Machover, 2006) music between traditional performers and new technologies represents a significant motivation to work in the area of the hyper-instruments.

### 4.1. Why Hyperinstruments?

Our approach individuates Hyperinstruments as a broad field of research and production possessing the potentials to intensify the frameworks above delineated, and non-invasively integrating new technologies within a Western-Classical experimental scenario. Machover's research on Hyperinstruments started at IRCAM in 1981, pointing towards technologies able to offer an intermediate layer connecting the physical and ephemeral character of the instrumental gesture with the architectural approach of a score based composition. A set of techniques for motion and sound analysis in real-time therefore enables the tracking on the fly of the acoustic instrumental gestures during the performance. From the 1990s the subtlety to track the physical gestures and the audio features drastically improved, giving rise to Machover's pioneering *Hyper-string Trilogy*[2].

This work represented the first realization of a complex motion tracking system allowing score-based interactions between the string-performer and software compositional layers based on the principle of continuity from gesture to sound to structure. The active role of the

[2] See http://web.media.mit.edu/~tod/video.html?vid=Studio7TodYoYo-hi (last accessed 10/14).

performer implies interchangeable levels inside the hierarchies of the interaction and influencing shifts inside the domains of micro and macro structures (Machover, 1992). Collateral researches regarding the description of the string-bow performance gestural contents (Young, 2011) and the real-time analysis of sound and spectral features in accordance with their psycho-acoustical dimension (Jehan, 2005) where subsequently conducted at the MIT media lab: further musical developments followed in the fields of interactive theater and new interfaces for active involvements of the audience. Different centers of research are currently developing sensing means allowing the performers to actively interact with chains of electronic sounds, controlling their flux by means of their acoustic and instrumental gestures (augmented instruments).

### 4.2. Music and techniques

Our line of research mainly points towards a distributed authoriality, and sees scores as plural local entities to be shared as hyper-textual messages, and/or software functions, more or less hidden or apparent, without excluding the use of interactive common notations and graphics. Our compositional approach is grounded on a link with the electro-acoustic music in the sense of the Schaefferian tradition, therefore based on timbre and listening, and seeking minimal units of language already morphologically complex. This is the sense of the opening mention of an idea of 'gesture of form' orienting the interaction towards generative algorithmic strategies interleaving with timbre shapes, and seeking strategies of live-performance navigation between micro-meso and macro levels of creation. True 'sound objects' could be seen as a controversial idea in the domain of real-time, and in terms of analysis they behave as complex vector streams. Yet we consider analysis as an act of interpretation compositionally oriented to algorithmic segmentation and flux distribution in order to build hypotheses of music communication.

A rigorous but not-score-oriented methodology of composition in Max/MSP, in our opinion can be justified by recent implementations of more complex and powerful systems of sensing and data treatments, moving in the direction of high-level descriptors and data distributions. This means exploring more reliable lines of connection between the domains of global human perception and sensing descriptors appearing as monitored complex shapes, unified in structured modules. In our work we combine FTM[3], MIT[4] and CNMAT[5], MAX-objects in order to modularly distribute the complex spectral shapes, adapt them to the specific input instruments, focusing data to the software processes. Moreover the ongoing collaboration with Centre for Speckled Computing[6], University of Edinburgh (Orients Motion Tracking); is oriented to the detection, description and modelisation of bowing styles and dynamics, in order to define functions ready to be played. Input data are sent to Max/MSP through the OSC protocol. Machine learning, statistical analysis of the shapes of complex vectors, and time-based data interpretation are currently easy-to-find and already implemented Max packages, upon which we build and search communication through music. The following concluding discussion will show some concrete applications and works, aiming toward global strategies to gestural-sound descriptions, and interactive approaches to algorithmic composition. The idea to inscribe this hermeneutic methodology in a rhetorical framework is motivated by

[3] See http://imtr.ircam.fr/imtr/Software (last accessed 10/14).
[4] See http://web.media.mit.edu/~tristan/ (last accessed 10/14).
[5] See http://cnmat.berkeley.edu/downloads, (last accessed 10/14).
[6] See www.specknet.org (last accessed 10/14).

different considerations, including the cited condition of overlapping categories and multiple structures of interpretations, implicitly recalling pre-classic frameworks. A line of response could be pragmatically afforded with new terminologies, figures and rhetoric strategies. As a consequence we are searching for an idea of timbre-space (as like whole-functional gestural spaces) oriented to non-linear, generative, conversational, affective unconventional mapping and shaping strategies.

### 4.3. Towards a discursive approach to interaction

From our everyday experience we note the need to overcome the pragmatic difficulty to find effective musical words and images to be communicated to the performer, because of the extremely technical language of technologies. For instance, how can we make a classically trained flautist, not experienced in music technologies, aware of his enhanced musical power of interaction, in the absence of any strict score or rule-based instructions? How can we transform, the monitor image of his spectral roughness, and the time shapes of his centroid, mapped to electronics processes into a tangible feeling? It is possible to map and shape algorithmically complex vectors of spectral analysis to electronic sounds as hidden functions, but in our experience the problem of transferring these concepts in a musical performance environment needs appropriate terminologies and synthetic emotionally oriented figures of compositional strategies. Moreover a compositional approach aiming to interlace low-level sound or gestural descriptors to high-level quantities (in order to shape consistency between flowing numbers and human cognition acting as agencies of some music language) over and above its computational aspect, shows in many cases unsolved questions: questions of meaning-transfer between different domains of knowledge, which is solved more by empirical and compositional practice, rather than, unfortunately, by a systematic system of explanation. Considering pitch tracking and envelope follower as an interface (as in the case of the Score Follower) show robustness. But shaping communication (and by no means provocatively) through the spectral skewness as like the bark-bands tracked in real-time, implies a compositional work conducted upon the ‘plausible’, rather than the ‘verity’, again a rhetorical domain. The following closing section will detail some concrete compositions.

## 5. Case Studies

A brief discussion of some recent productions and works in progress exemplifies here the trends of research above delineated. Most of the works here cited exploit instrumental timbre-space as a means to interact with electronics. The aim is to realize an ‘electronic chamber music’, so the data influencing the software are numerically complex entities, possessing clear perceptual identities from the point of view of the listener and the performer. These clear sound identities are programmed in order to influence macro levels of composition (such as the choice and mixing of virtual sounds, spatialization, time distributions and pattern generations, synchronizations or harmonic layers) as well as micro levels and local nuances. This kind of interaction is made possible by the use of global software objects (such as machine learning), and by the assemblage of multiple vectors of data streams, leaving straight one-to-one determinisms at local levels. The more or less strict detail of interaction is a performance choice in terms of virtuosity or in terms of leaving autonomy to the machine. No external control from a live-electronics performer is needed after a detailed calibration regarding microphones, room and instrumental peculiarities.

The sound electronic palette, the modes of interaction and the means of real-time sound analysis are pre-defined as Max/MSP modules. Sound analysis is calibrated on the specific instrument required. The composition represents a metaphor upon which the performers can build their own personal music inside the designed environment. In a sense the system could be intended as a meta-composition open to limitless possible structuring choices of the performer/composers and individual tracts of self-regulating adaptive behaviors, justifying the idea of internal figural communications between performer and system.

### 5.1. *K, three short novels by Kafka for the hyper-cello*

A first musical example shows the composition *K, three short novels by Kafka for the hyper-cello*, by Nicola Baroni[7]. The first movement, inspired by the very surprising novel *Vor dem Gesetzt*, is built on the machine learning system of Gesture Follower[8] (GF). The Max object GF, doesn't track physical movements, it is instead filled with five streams of the following sound-spectral data: 1) frequency, 2) amplitude, 3) periodicity, 4) highly compressed kurtosis (in order to empirically track lightness vs. stark saw-tooth-like bowings), 5) density (a compound parameter tracking transparent vs. intense string timbre).

The initial constraint to the performer is the task to invent 80" of music segmented in four phrases lasting 20" each. Every phrase must possess a clear and specific sound identity, radically different from the others, and it also has to be shaped with a characteristic music temporal development, to be remembered and more or less strictly later recalled. The first part is therefore only acoustic and represents the interactive seed of the following structure of the work.

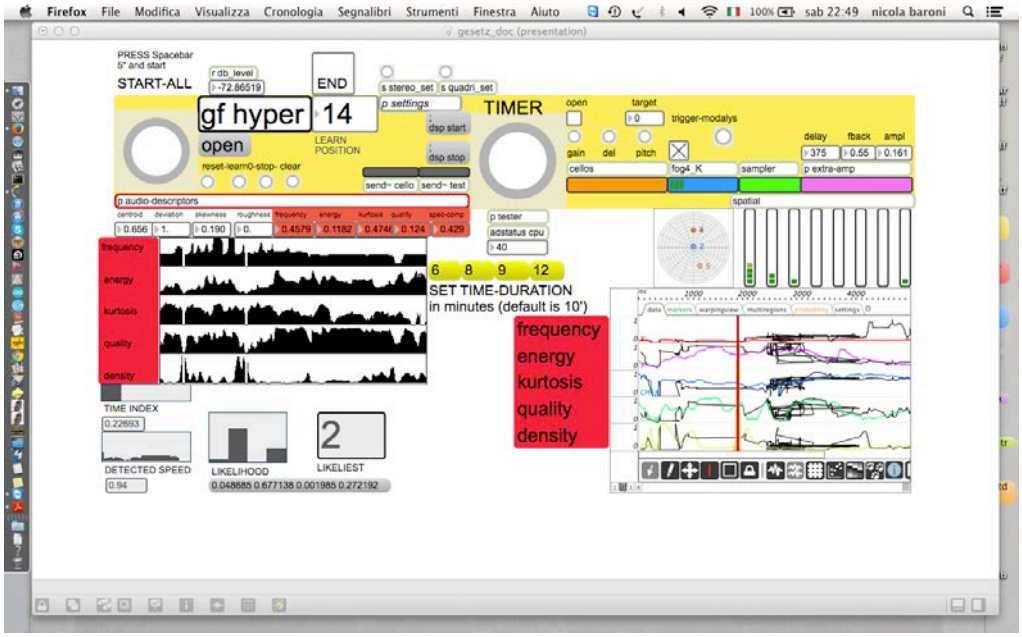


**Figure 4:** MAX-patch "Vor dem Gesetzt". Machine learning is embedded in the object 'gf hyper' Upper-left side: the streaming vector of sound descriptors. Bottom left: the states showing the current states of recognition (the second phrase is the "likeliest"). Upper-right side: the four virtual instruments (cellos, fogs_K, sampler, extra-amp). Bottom right: the data-monitor of the currently selected phrase.

[7] See https://www.youtube.com/watch?v=oYtNHMdA3F0 (last accessed 10/14).
[8] See http://imtr.ircam.fr/imtr/Gesture_Follower (last accessed 10/14).

GF is programmed in order to segment the four phrases (corresponding to four machine-learning steps) and to record-store the shapes of the five streams of descriptors. After that the GF will be automatically set in 'follow' mode, while the player continues to perform with the free task of recalling his/her previous phrases, choosing different degrees of similarity with his/her initial music. During the musical continuation the role of the GF is to attempt to recognize which phrase is in action, which part of the phrase is currently operating, and at which speed compared to its original (see Figure 1). The index of the phrases during the recognition has the task of sending messages to the four virtual instruments designated, in this way starting the dialogue between the performer and the electronics through an interplay between the current performance and the memory of the already occurred music. Different parameters of the GF are mapped to timbre and time developments of the electronics, as well as many real-time spectral features of the current performance, in order to instantiate multiple influences between the performer and the electronics. The octophonic spatialization in this case is not directly driven by the cellist, but instead by a system of spectral auto-analysis of each virtual instrument upon itself. The default duration of 8' can be differently set by the performer. Some excerpts of live recording are automatically stored in the Hard Disk, in order to be recalled as memories during the following second movement *The Wish to be a Red Indian*, which works on a more algorithmic fashion by means of live-sampling strategies. In the second movement long chunks of granulation (at a note time-level) are globally driven by the cellist by means of real-time note detection and pitch tracking, overlapping with multiple more subtle timbre interactions.

The third movement *Odradek* is a reflexive environment, whose time length and section segmentations are interactively controlled by the performer. The task is to greatly expand some hidden overtones of the open strings by means of extreme filtering and additive synthesis mapped to the cello spectrum, and split into ten output channels. The attempt to gain a real-time tracking of the amplitudes and frequencies of the first 20 partials is obtained through the FTM-IRCAM-Gabor library (Schnell and Schwartz, 2005). Envelope follower, spectral roughness and periodicity are the means to control an extremely complex and segmented form building process. The ambivalences of the virtual-timbre interleaves with the actual-acoustic overtones that the player is invited to enhance by means of special techniques described in the verbal score of the piece.

As a brief example relating to Figure 3 (section 2.3. of this paper), we can inscribe the above structuring functions in an analytical framework recalling rhetorical figures such as repetition (*anaphora*), variation (*variatio*), contrast (*antithesis*), personification (*prosopopeia*), *hyperbole*, and multiplication (*multiplicatio*). In absence of a fixed score similar figures are conceived as strategies of expressive communication (verbal, written as well as graphic-interactive) also involving the performer.

### 5.2. *Shaman's Wires*

A further system oriented to an indirect and global dialogue between cello timbre and electronics, divided into ten virtual instruments spatialized and driven by multiple vectors of cello timbre is created for the duo-project Shaman's Wires[9]. In this case Self-Organizing-Maps (SOM) were mapped again to multiple streams of cello timbre description. SOM are based on the theory of resonance (Smith and Garnett, 2012), therefore the behavior of the

[9] See http://angelinayershova.com/shamanswires/ (last accessed 10/14).

system indirectly follows, as a resonance, the input data (see Figure 5). The Max object is set in order to react very slowly in comparison with the timbre flux, giving rise to the construction of an organic macro-form based on a sort of dynamic 'insistence' of the cellist upon pre-defined timbres and input sound qualities.

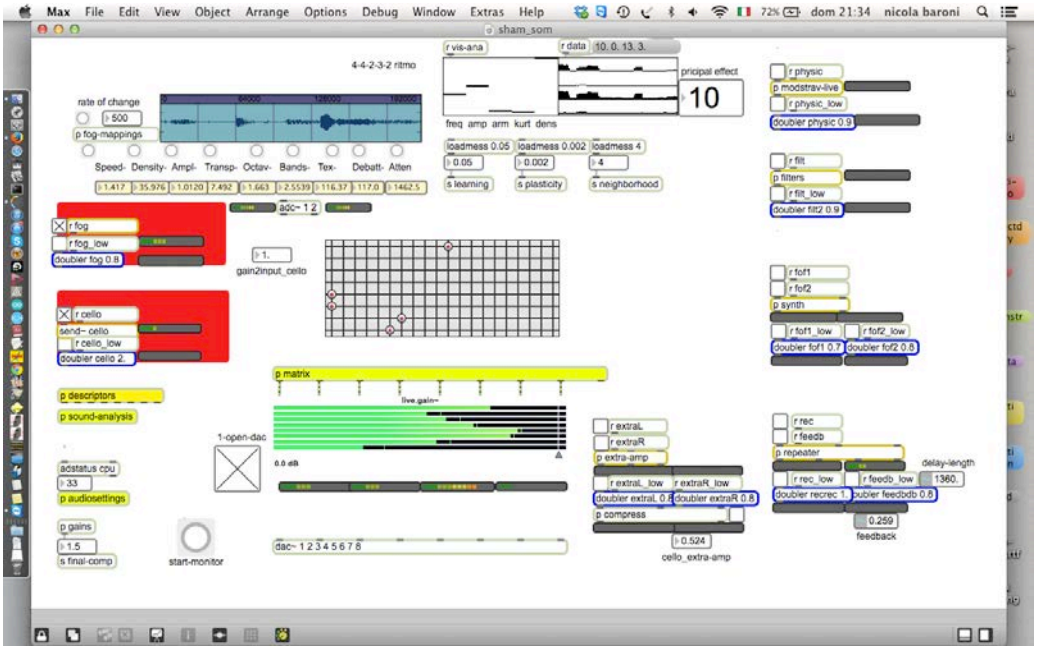


**Figure 5:** Max-patch "Shaman-SOM"

The reactivity and continuity of the Self-Organizing-Map mostly depends on the parameters of learning, plasticity,neighborhood. The overall mixing and spatialization are driven by the cello sound, through five streaming sound descriptors feeding the SOM (upper monitor)

### 5.3. The Harp Quartet *Awakening*

As a conclusion we will mention a more determinate but networking environment represented by the harp quartet *Awakening* designed by Nicola Baroni and performed at the FORFEST[10] in the Czech Republic by the Adria Harp Quartet. The overall design is a physical and metaphorical space, based on the interdependency of roles and mutual sound awareness, in an eco-systemic fashion. The different actions, mostly improvised with respect to the contents, are functional choices of which the performer is fully aware regarding any detail in terms of system response. The music discourse is conducted through mutual dialogues with laptop screens acting as messages, monitors and moving scores. The audience is given projected cues in order to be aware of the main processes. The first harpist acts throughout as a "mixing console" (see Figure 6); even if every message to the ensemble comes from her harp sound and from an inertial sensor placed on the right wrist, her role is a full functional-routing improvisation distributing the electronics and the spatialization. Moreover the harpist auto-processes herself and sends messages which transform features of her sound-analysis into a graphic score for the third harpist. A second player exploits the natural resonances of the harp through highly expanded/compressed amplification and integrates these sounds with voice and wind-instruments exploited as a complex language whose timbre and morphological analysis process the other two harps in different organized fashions. These two harpists

[10] See www.forfest.cz/data/doc/programy/forfest_2014.pdf (last accessed 10/14).

follow interactive graphic notations and interactive common notation sent as messages from the sound of the other harpists and decoded as a conventional score appearing in real-time by means of the BACH system Max environment (www.bachproject.net). The implied task is to collaboratively feed a concert-based self-regulating human-based 'ecosystem' grounded on sound enhanced-awareness and non-linear communication strategies between the performers.

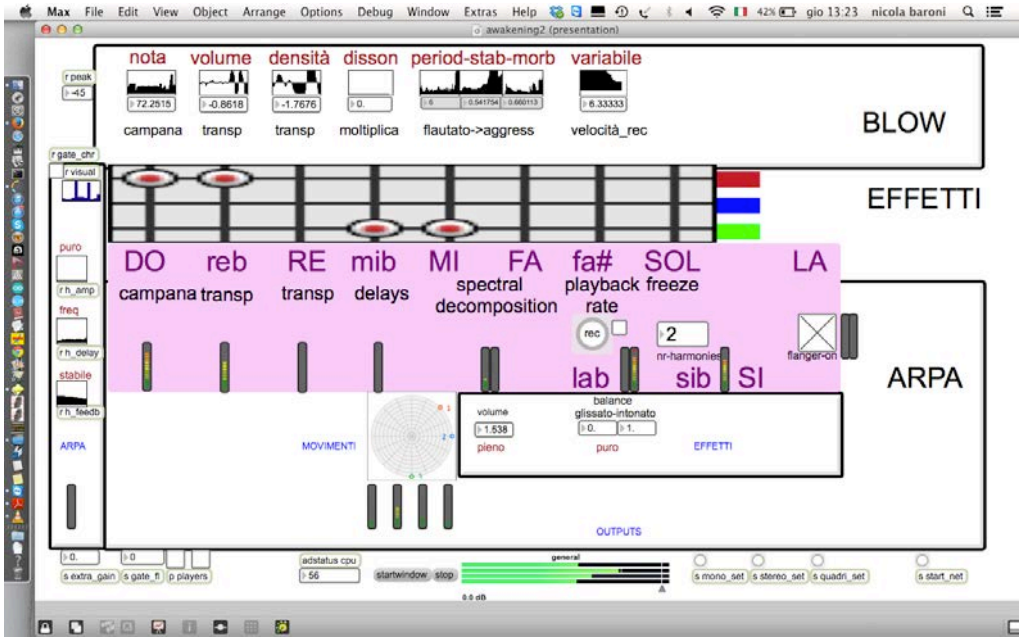


**Figure 6:** MAX-patch "Awakening2" (feeding in network the interactive score on a different laptop) The monitor is shared by two performers called "Blow" and "Arpa"

## 6. Conclusion

The interconnectivity of these systems does not generally appear to be a burden to the performers, even though not experienced in electro-acoustic contexts. Augmented reality, networks and navigation are ubiquitous; therefore hyper-textual behaviors in live performance are mostly seen by musicians as intriguing means to escape the normative rules of fixed scores, enhancing instead creative personal contributions.

These systems are in progress and awaiting the next outcome involving a cello quartet based on interactions by means of bowing styles motion tracking and a more interleaved system of interactive scores. Moreover the two writers are involved in a common activity in live electronic ensembles and teaching in the same institution (the Conservatory of Bolzano), therefore this paper could be seen as an experimental step towards future documentation and projects.

These systems are proving to raise interest also in traditional-performer contexts mainly because of the smooth interaction with the sound analysis of their own musical actions allowed by the monitor streams, and the creative and structured interplay with them. Similar systems could also be developed in pedagogical contexts, contributing to a sensitive awareness and auto-analytical feedback.

The role of the designer, in a sense a meta-composer defining plural strategies and sound-rhetorical figures, involves the implementation of imaginative possible trajectories of

navigation between the nodes of interaction. The search is towards listening, surprise, emotional and meaningful ways to be connected with the monitored acoustics of the instruments, their numerical descriptions, the response of virtual sounds and the structuring potentials of morphologies and gestures sought through the creativity of the performer. A main challenge regards finding strategies of description and communication of the physical aspects of sound and its transfer through the different levels of interaction. The need for appropriate words and graphic streams includes the implementation of rhetorical figures as a pragmatic compositional strategy. This experience again reveals the need for a focus on discursive approaches and the definition of shared terminologies.

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