Meaning in Musical Gesture

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> How does it come that when someone voluntarily listens to a song with ears and mind, he is also involuntarily turned toward it in such a way that his body responds with motions somehow similar to the song heard? (Boethius, 1989: 8).

Introduction

Technique and technology are two cultural aspects that have been deeply involved with music, not only in relation to its production, but also in relation to the development of its theory and to the establishment of its cultural role. Since the beginning of the twentieth century the relation between music and technology became more intense due to a series of reasons, among them, the increasing knowledge about sound physics and sound cognition; the access to low cost electricity; and the use of electronic and digital technology to artificially generate and manipulate sounds. Before that, musical sounds were produced only by mechanical means. Although musical instruments, such as the violin, the piano or even the human voice, represented a wide variety of forms and mechanisms, all of them were based on the same principle of sound production, that is, the mechanic vibration of an elastic body. However, the appearance of electrical technologies and the use of electromagnetic signals brought the possibility of generating sounds without using mechanical devices.

Although the sound waves coming either from a clarinet or from the electronic oscillators inside a synthesizer have the same nature, their processes of production are quite different. On one side there is the concrete, visible and mechanic universe of the traditional instruments where the body of the instrument and the body and movements of who is playing that instrument are intrinsically related to the qualities of the sound they are producing. On another side, in the era of electricity and electronics, we start listening more and more to the sounds of invisible bodies contained in the electronic components of synthesizers, samplers, and computers.

For many centuries, people learned to listen to sounds that had a strict relation to the bodies that produced them. Suddenly, all this listening experience accumulated during the long process of musical evolution was transformed by the appearance of electronic and recorded sounds. When one listens to artificially generated sounds he or she cannot be aware of the same type of concrete and mechanic relations provided by traditional acoustic instruments since these artificial sounds are generated by processes that are invisible to our perception. These new sounds are extremely rich, but at the same time they are ambiguous for they do not maintain any definite connection with bodies or gestures.

Until the development of sound recording systems early in this century, the contact with music occurred only trough the performance. The listener, even if not involved in the sound production, participated in the music realization by mentally reconstructing the connections between the sounds and the physical and cultural context where the music was taking place. When recording technologies became socially effective, they brought about two different alterations.

Listening

The first alteration refers to a shift from the prominence of music production processes (composition and interpretation) to the prominence of listening activities as cultural experience (Mowitt 1987). Here one can easily note that now the number of people who are *listening* to music is much larger than the number of people who are *doing* music. This fact shows more than a statistical aspect. It also reflects a cultural transformation: music is primarily produced to be listened to and not to be played or sung and the process of composition and performance becomes the means to propitiate it.

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This projection towards the listener is reinforced by the processes of reproduction that imposed new models of reception. When the phonograph was invented about one hundred years ago, music reception was based on the listening model of that time, that is, the listening of a live performance. The main goal of those recording systems was guided by the term *fidelity*, which in that case would mean that the better a recording could reproduce the sound qualities of a live performance the better it would be considered (Thompson 1995). But what we experience today is a different situation. The live performance cannot be a listening model anymore since, for most of us, listening to music means listening to the music reproduced by a device such as radio, or CD. Gradually, this new context based on recording and reproduction becomes the model for music reception and music production. The term fidelity, which presupposes some relation of similarity, is still in use by phonographic and audio industries, but its meaning became reflexive and inappropriate: the fidelity of a recorded sound is not based upon the original sound itself but it is established as a function of the available recording technology. This leads to a paradoxical situation in which more and more musicians try to reproduce in their live performances the same sound qualities of their records, specially in pop music. In a stimulating essay, John Mowitt observes that:

> "If recording organizes the experience of reception by conditioning its present scale and establishing its qualitative norms for musicians and listeners alike, then the conditions of reception actually *precede* the moment of production. [T]he social analysis of musical experience has to take account of the radical priority of reception." (Mowitt 1987: 176-77)

Gesture

The second alteration is related to musical gesture. Although music has always been strictly related to gesture, only in the past few decades this issue has deserved some attention by musicologists. This concern seems to emerge when it became possible to record and to reproduce music and the role of performance was replaced by a listening situation mediated by new technologies such as the radio, magnetic tapes, or CDs. As Roland Barthes says, there is one music one plays and one music one listens to. The music one plays is

> "a muscular music, in which the part taken by the sense of hearing is one only of ratification as though the body were hearing [...] a music which is not played 'by heart': seated at the keyboard or the music stand, the body controls, conducts, co-ordinates, having itself to transcribe what it reads, making sound and meaning, the body as an inscriber and not just transmitter, simple receiver." (Barthes, 1977: 149)

This *musica practica* has been replaced by a passive and receptive music. Electronic technology brings this situation a step further by eliminating the traditional role of the performer from the chain of music production. However, it seems that at the same time that electronic technology stresses this shift from the idea of a *music to be done* to the idea of a *music to be listened to* (Chanan, 1994; Mowitt, 1987), it also points to the conflict between the physicality traditionally involved in music production and the absence of concrete objects in the virtual environment of today's digital studios: "It is precisely this physical absence that is naturally compensated for in music by reintroducing a concern for body, gesture and space" (Chabot, 1990: 15).

Indeed, the interest in gesture's related subjects has been developed by different fields related to human communication and cognition due to different reasons: the concern with the body in cognitive sciences as an agent of knowledge (Johnson, 1987; Minsky, 1986; Varela, Thompson, & Rosch, 1991); the growing interest in non-verbal forms of communication in semiotic and psychology studies (Kendon, 1981; Nöth, 1990; Poyatos, 1983); the development of studies in sign languages of the deaf, especially American Sign Language (Kendon, 1981: 31); the studies in Human-Computer Interaction promoted by the large expansion of digital technology that brought the possibility of simulating physical phenomena in "virtual" environments (Barfield & Furners III, 1995; Carr & England, 1995; Laurel, 1990).

Gesture is taken here in a broad sense. It does not mean only movement, but a movement that can express something. Therefore, it is a movement that embodies a special meaning. It is more than a change in space, or a body action, or a mechanic activity: gesture is an expressive movement that becomes actual through temporal and spatial changes. Actions such as turning knobs or pushing levers, are current in the use of today's technology, but they cannot be considered gestures. Also, to type a few words in a computer's keyboard has nothing to do with gesture since the movement of pressing each key does not convey any special meaning. It does not matter who or what performed that action, neither in which way it was performed: the result is always the same. However, the situation is completely different when a musician plays something on a piano keyboard: the result, that is, the musical performance, depends in many different ways on the player's gesture. Pressing a key or sliding a bow during a performance are movements that hold a meaning in themselves: they establish how a sound will be produced, they determine some

characteristics of that sound, they set up connections with previous sonic events, and, at the same time, they furnish an articulatory path to further sounds. Obviously they are more than simple movements, they are meaningful gestures.

Gesture in music performs a fundamental role in the generation of meaning (Henrotte 1992; Lidov 1987). In a certain way, we have learned to understand musical sounds with the aid of the gestures that produce and represent these sounds. As G. Kurtenbach and E. Hulteen have noted, the function of gesture in music is proportional to its power to express something:

> "Gestures increase function by virtue of their expressiveness. That is, a gesture may control multiple parameters at the same time, thus allowing a user to manipulate data in a manner not possible by modifying each parameter individually. For example, a conductor simultaneously controls both tempo and volume of the music gesture. The rhythm of the gesture controls tempo and the size of the gesture controls volume. This allows an efficient communication not possible by adjusting the tempo and volume independently ."(Kurtenbach & Hulteen 1990: 311-12)

Gesture acquires its signification through our experience with the signs that surround us. This signification is constructed via the interaction between the brute phenomena we experience during our lives and the way our senses apprehend these phenomena. Thus, the use of gesture in communicating things can be a pre-linguistic act. Before a child can speak or even control his movements he is able to establish relations between the events that occur around him and the consequences brought by those events. From this, the child is able to start building up its own gestural vocabulary.

There is a strong tradition in the literature making an approximation between gesture and verbal language. Linguistics is often taken as a basis to analyze any kind of communication and linguistic theories based on verbal codes have influenced all disciplines involved with communication and language, from information theory to semiotics. Inspiring works by different authors have stressed the connection between gesture and verbal language and speech (Efron, 1972; Ekman & Friesen, 1969; McNeill, 1992) even when they try to define specific traits of gesture (Kendon, 1981; Poyatos, 1983). The classification developed by Ekman & Friesen (1969) started from Efron's theory of gesture and points to five categories of gesture: Emblems, Illustrators, Affect Displays, Regulators, and Body Manipulators. In this classification, only Affect Displays and Body Manipulation are not direct related to speech. McNeill (1992) creates his own classification based on the ideas of different authors. He classifies gesture as follow: iconics, metaphorics, deictics and beats. In the same direction Kendon (1988) points to a continuum in order to build a classification of gesture occurrence – Gesticulation, Language-Like gestures, Pantomimes, Emblems, Sign-Languages -- in which one can note a decrease of the presence of verbal components going from gesticulation to sign-languages (Mulder, 1996).

Besides departing from a "linguistic" point of view, most of these categories are specially related to empty-hand movements that occur during utterance. In a narrow sense, gesture is taken as "bodily communication by means of hands and arms and to a lesser degree by the head" (Nöth, 1990). This narrow sense excludes the possibility of considering other types of body action, such as posture, body movement, gaze and facial expression as genuine types of gesture.

Although this approach can be effective for most HCI applications, we believe that to study the role and functionality of gesture in interactive music systems, one should consider it in a broader sense in order to be able to take some music peculiarities into account. For this reason we take gesture as any type of "bodily movement [...] made consciously or unconsciously to communicate either with one's self or with another" (Hayes, 1966, Nöth, 1990). This would include not only emblematic hand gestures, but also any other bodily movement capable of conveying meaning. This would also include actions of touching, grasping or manipulating physical objects in order to control music or sound parameters.

Besides this conception based on the physicality of gesture, we may also consider a parallel meaning of the term which has a metaphorical sense and has been widely used in music analysis. Many authors have referred to music gesture when describing some dynamic characteristics of musical utterance. Coker (1972) has made one of the first extensive attempts to relate music meaning to gesture in a semiotic context. For the author *musical gesture* "comprises a recognizable formal unit and consists of a selection and organization of sonic and rhythmic properties in sonorous motion, which signifies other purely musical objects or non-musical objects, events, and actions" (Coker, 1972:18). Another classical approach was developed by Manfred Clynes (1977) who used an electric device called *sentograph* to monitor and record finger pressure. In his experiments, subjects were required to press the sentograph in an expressive manner in response to different instructions [Editors' note: see the article by Ungvary and Vertegaal in this volume]. The results of those experiments indicated a relation between some gestural patterns and specific emotional states, such as love, hate, anger and joy. The relevance of a "metaphorical" use of gesture in

music has also been formulated to elucidate other aspects of musical meaning such as in Iwanka Stoïanowa's study on music-graph-gesture (Stoïanowa, 1973) and in David Lidov's text on kinesthetic relations in music discourse (Lidov, 1987).

Although these approaches do not directly assume the term gesture in a sense of physical bodily movement, there is a strong connection between this metaphorical sense and the more physical use of the term in music. François Delalande (1988) indicates three gestural levels, ranging from the functional to the symbolic: the *geste effecteur*, "necessary to mechanically produce sound"; the *geste accompagnateur*, which "engages the whole body" of the player, but may not be directly involved in the sound production; and the *geste figuré*, "an imaginary ballet which constitutes a third dimension of the movement, and which could be related to the metaphorical use of musical gesture we referred above. These three levels are certainly interrelated and they can even overlap in their function. While analytical and aesthetic approaches are more inclined to the investigation of the *geste figuré*, fields related to the development of interactive music instruments and environments rest upon the study of the *geste effecteur*. The *geste accompagnateur*, besides playing an intermediary role between the former two levels, has a more defined place in performance studies.

The idea of a *geste figuré* has a parallel in what Bernadete Zagonel defines as *mental gesture* (Zagonel 1992). While physical gesture (in the sense of *geste effecteur and accompagnateur*) refers to the production of sound as a physical phenomenon, retaining an objective relation between the gesture and the sounds that are produced, mental gestures occurs as an idea or an image that refers to physical gesture. Mental gestures are closely related to the processes of composition and listening. Thus, the composer often starts from an idea or a mental image of sound gesture to compose a vocal or instrumental gesture. The mental gesture is learned through the experience and stored into the memory to be used as a model in composition. At the same time that a mental gesture refers to the corporal actions of a performer or to the behavior of a musical instrument, it can also refer to a particular sound structure. For example, an arpeggio can be understood as a gestural movement from one point to another in the pitch space and the movement of a conductor's hand can be seen as a gesture that unifies the temporal and articulatory behavior of the orchestra. What we should emphasize is that the mental gesture always refers to a physical gesture that has been previously learned.

Concerning music, one can say that physical gesture is directly related to music interpretation while composition is much closer to mental gesture: As Bernadete Zagonel stresses, "if the composer goes from gesture to the composition, the performer goes the opposite way, that means, he goes from the score to the gesture" (Zagonel 1992: 17-18). To this statement we can add that the listener completes this chain by mentally recreating the performer's physical gestures while listening to music.

Body

The idea of gesture leads immediately to the body. The body is the instrument through which the gesture becomes actual; it is the interface that translates ideas into physical signs and this can occur in three different ways, depending on how this gesture acquires its signification: by *similarity*, by *causality*, and by *convention*. The determination of these three types of gestural categories was inspired by the triadic categories drawn by the American semiotician Charles Sanders Peirce (1955) and can be taken as an analogy to his sign concepts of icon, index and symbol. Instead of been rooted in linguistics, Peirce's theory offers a more general scope to investigate the way any type of signs can represent -- or mean -- something since he uses logic as the point of departure to create his semiotic theory.

Here, what is important to note is that, according to Peirce, his triadic categories involve a hierarchy according to which the third element, the symbol, comprises the second, the index, which by its turn comprises the first element, the icon. Therefore, a sign rarely would be represented by only one of these categories. Following Peirce's scheme, if we state that a specific gesture belongs to a certain type, it does not invalidate its efficacy in the domain of another type. To say that the signification of a gesture operates by means of similarity, causality or convention means that the gesture is more characteristic of one of these three types but still can be related to the other two types, specially when the same gesture is present in a different context.

One example of gesture that operates by *similarity* is the corporal gesture trying to imitate or emulate the behavior of processes and objects in the world. For example, the fast movement of a conductor's hand to indicate a fast tempo and a sax player bending up and down during the performance as if his/her body were

following the melodic shape of a solo. These gestures operate by creating some temporal and/or spatial relation of similarity with other events: the speed of the movement in the first case; the melodic contour in the second.

On another hand, *causal* gestures are connected to an event through a cause-and-effect relation. Usually these are gestures that operate as a response to an actual circumstance. Bringing the hands in front of the face when we predict a dangerous situation is a direct reaction to this situation. In the same sense one can often relate someone's attitude to a personal characteristic such as in the case of a shy person who has a shrunk posture during walk. In this case the gesture (posture) has a necessary relation with its cause (shyness) and the existence of the former depends on the latter. We may note that, although some authors tend to take the static character of posture in opposition to the dynamics of gesture (Mulder, 1996), we consider posture as an effective and expressive bodily action and therefore as a type of gesture which is extremely important to music performance since it establishes a close relation between the behavior of the performer's body and his/her musical expressiveness.

As we enlarge our gestural vocabulary we also tend to apply arbitrary signification to specific gestures. These *conventional* gestures do not necessarily keep any relation of similarity nor causality but they are constructed, shaped by external factors such as culture and language. They acquire signification by an abstract and functional process and must be learned to be shared by a specific group. For example, the characteristic gesture made by North-Americans with the fingers to mean that something is okay or positive, in Brazil is taken as an offense. The relation between this type of gesture and its signification is totally conventional and can easily change from one situation to another.

These gestural types are generic and can refer to more specific levels of gestural classification. For example, one could associate the categories of iconic and metaphoric gestures drawn by McNeill (1992) as examples of gesture that operate by similarity, while the deictic gestures would be clearly related to causal gestures. In the same way, emblematic gesture would fall in the conventional gesture type. Another relation can be established between Delalande's considerations about *geste effecteur*, *geste accompagnateur* and *geste figuré* (Delalande, 1988) and the causal, similar, and conventional gesture types, although generally they could be related to more than one type at once.

Performance

In a book called "The Sight of Sound: Music, Representation, and the History of the Body", Richard Leppert calls the attention to the importance of the gestural images that are produced during a musical performance:

> "Precisely because musical sound is abstract, intangible, and ethereal [...] the visual experience of its production is crucial to both musicians and audience alike for locating and communicating the place of music and musical sound within society and culture. [...] Music, despite its phenomenological sonoric ethereality, is an embodied practice, like dance and theater."(Leppert 1993: xx-xxi)

The lack of musicological studies taking body gesture into account is in part due to the fact that the body has never been considered as a support for musical expression. When electric and electronic means of musical production and diffusion eliminated the presence of the musician and his instrument we had to change the way we experience music. "Traditionally, to attend a music performance is to apprehend through the sight the intention which is loaded in the instrumentalist's gesture. In the mediation of the technological work, this prediction does not work all the time" (Battier, 1992: 69). The symbiotic relation between the player's body and his instrument plays a special role in the comprehension of the musical discourse. For example, a violent gesture produced by the player reinforces the effect of a sudden sound attack in the same way that the body expression of a singer can lead to a richer phrase articulation.

The musical background and the daily experience with the objects that surround us help to establish connections between physical materials and the types of gestures that will produce specific sounds with those materials. Through our experience we can also establish patterns and links between sonic events and the materials that could produce these sounds. Of course, the perception of these relations is not precise in specific terms (for example, it is difficult to determine how loud is the sound of this book falling on the floor), but this perception is extremely sophisticated in relative terms (for example, one can easily say that rolling a pencil over a wood table produces a softer sound than hitting the table with that pencil). Moreover, part of music's expressive power is given by this proportional scale through which one can mentally build relations among materials, gestures and sounds. It is at this point that lies part of the attraction music exerts on us. Indeed, among the objects that surround us we don't know of any which would allow the production of such amazing sounds as we can get from a musical instrument. Our perception tells us that an

ordinary piece of wood, about 50 centimeters long, would never produce a sound with the same quality, power, brightness and regularity one could hear from on a violin, for example. Also, ordinary objects usually don't allow a precise control of the sound produced by a specific gesture. Thus, musical instruments subvert our expectations about the sounds that such devices would produce. What a musical instrument allows to do in terms of sound production goes far beyond what our common sense would expect from any other ordinary object. It establishes an almost magical relation between gesture and sound and, in this way, the musical instrument is not only the medium for the musical idea, but also part of this idea.

Our experience provides the first step to create perceptual models that correlate classes of gesture, instrumental properties and sounds. The construction of a gestural vocabulary starts from these intuitive models and grows up as we enlarge our musical experience. What is important to retain is that instrumental gestures, that is, the physical gestures the performer applies on an instrument to produce or transform sounds, are extensively determined by the instrument properties. Traditional instruments are subject to mechanic laws and when someone plays a piano or a trumpet his/her gestures are constrained by these laws. Certain types of musical phrases can be more characteristic of a particular instrument just because its design makes it easy to produce that chain of notes. All these characteristics are attached to the instrument and are due to a long process of evolution and adaptation. Thus one can intuitively draw stable relations between classes of instruments and classes of gestures. For example, one could say that bowed instruments would favor some kind of smooth and continuous gesture while percussion instruments would lead to more discrete and definite movements.

Obviously, each instrument offers a different level of control and interaction. For example, the mechanism of a pipe organ works almost automatically in a way that the performer's gestures have very little influence over the process of sound generation. On another hand, some acoustic instrument families, such as bowed strings, reed or blown instruments, and percussion, generally will allow the control of very subtle sound characteristics through the interaction between the player's gestures and the structure of the instrument. As Richard Moore points out,

> "With such instruments the microgestural movements of the performer’s body are translated into sound in ways that allow the performer to evoke a wide range of affective quality in the musical sound. That is simultaneously what makes such devices good musical instruments, what make them extremely difficult to play well, and what makes overcoming that difficulty well worthwhile to both performer and listener." (Moore 1987: 258)

Mapping

Due to their mechanic nature, the operation of traditional instruments during performance establishes a close connection with the mechanic of the player's body. This connection works as a clue for the formulation of instrumental models of music perception. Most of time, sounds derived from the traditional orchestra are very clear in relation to which type of instrument they come from and to the quality of gesture that have produced them. But when we consider sounds produced in electroacoustic music these relations are not so explicit.

Firstly because electronic instruments can be seen as black-boxes that produce different sounds as response to external inputs. The process of producing sounds is invisible to musicians and listeners alike and there is no necessary relation between the physical input and the resulting sound. For every new instrument it is necessary to learn how a specific gesture acts on it. The mechanic laws that regulate the components of electronic instruments do not determine how the musician's actions are mapped into sounds. It is a matter of design: this mapping is designed in the same manner that electronic circuits or controlling interfaces are. Secondly, because a new electronic instrument may not be related to any previously known instrumental type. Music history is full of instruments that did not survive because they could not be adapted to a very well established tradition. Exotic or over-complicated instruments did not survive because they were not general enough to satisfy our musical demands. This has changed because today's electronic instruments can be designed without any compromise on an evolutionary process in which each step represents an improvement on the previous one (Lansky 1990). The life of an electronic instrument can be as short as the duration of a composition.

If traditional instruments are constrained to the mechanic behavior of their mechanisms and interfaces, electronic instruments offer no such constraints: they are artificially created by an instrument builder. The relations between the sounds and the gestures that will produce them are also part of the instrument's project. Here we approach some of the most prominent questions in the design of today's electronic instruments: How can we design the artificial relations that will control the sound production in an effective and meaningful way? How can we map specific gestures to control specific sound parameters in a

natural and meaningful way? If we agree that gesture is a meaningful part of music, paying attention to these questions regarding the design of electronic instruments is extremely important to propitiate systems that will allow performers to convey their expressiveness without reducing their role to simply activate and deactivate sound events.

Although the sound generation in electronic music instruments is based on the flow of electrical signals, usually their control still relay on some type of physical activity carried out by the performer's body. While in traditional acoustic instruments the effects of the performer's physical activity on an instrument are already established by the physical properties of the instrument, in electronic instruments this relation must be previously designed. Mapping this relation can be critical for the effectiveness of an electronic instrument.

Three different mapping strategies have been proposed in (Rovan, Wanderley, Dubnov, & Depalle, 1997) to provide a connection between gesture and the control of sound parameters: One-to-One, Divergent and Convergent. The simplest mapping scheme, one-to-one, maps each independent gesture to one musical parameter. In the divergent strategy each gesture is mapped to more than one musical parameter, while in the convergent mapping many gestures can be mapped to one musical parameter. As the authors have observed, expressivity increases from the one-to-one to the convergent strategy and we may also note that the difficulties to implement these strategies increase in the same proportion. Thus, in the design of a new instrument or musical environment there may be a compromise between the expressivity allowed by the system and the obstacles imposed by its implementation. We would add that traditional acoustic instruments usually operate according to a forth layer -- which is a combination of the former three -- in which many different gestures control different parameters.

Of course, there is a counterpart to this scheme. When expressivity diminishes, as in the case of the one-to-one strategy, it becomes easier to get a finer control of specific parameters, and this is one of the keys for the success of most commercial electronic music systems, from the MIDI protocol to the most recent commercial keyboard synthesizers.

Conclusion

Electroacoustic music forces the appearance of new listening models, which are more extensive and unsteady than the ones that support traditional music. As Dennis Smalley points out, until recently the listener expectations during a concert were limited by familiar models which had been determined by music tradition and repertoire:

> "Prior to the electroacoustic era [...] the listener could automatically assume before even listening to a piece of music that it would be rooted either in the instrumental gesture model, or human utterance, or both [...] So, traditionally, the indicative framework and boundaries of a musical work were not only pre-determined but, as far as culture is concerned, permanent." (Smalley 1992: 544)

On another hand, in pure electroacoustic music there is no such limitation to instrumental or vocal models. The composer is stimulated to create new sonic fields and the listener to develop new listening strategies. The absence of performers, instruments, and visual and gestural references provides a radically expanded experience: "everything remains to be revealed by the composer and discovered by the listener" (Smalley 1992: 545). Since the first works of electroacoustic music works deviated the focus from instrumental gesture to acousmatic listening, music has often lost the expressive and dramatic power conveyed by the gestural realization of the performer. Since then, to reconstitute these characteristics became a challenge in pure electroacoustic music composition.

During the 80's, when technology made it possible to reintroduce the participation of the performer in the electroacoustic practice the debate around the role of gesture in music emerged under a different perspective. The performer's action in electronic interactive music contribute as a visual and physical reference during the performance (Iazzetta 1996). However, many real-time systems for sound controlling and processing usually do not provide any explicit relation between the gestures performed by the musician and the resulting sounds. Rather, computers and other digital devices disorganize the causal relations between gesture and sound. A digital music system can calculate very precisely the trajectory of a sound parameter and use it to recreate that sound, but "it lacks the anticipation of the effect, because the results can hardly recover the gesture" (Battier, 1992:69).

Emmerson (1994) suggests that in live performances of electronic music this could be attenuated with a balance between two systems: on one side, what the instrumentalist can control and can be perceived as a relation of a human performer action and sound production (which he refers to as *local* control); on the other side, the control of an environment where the results are related to the context in which the

performance takes place (which he calls *field* control). Emmerson refers to local/field controls as two complementary systems that might be taken in the research agenda of musicians working with electronic systems. The balance between local and field controls could help in "reassembling some of the 'cause/effect' chains which have been broken by recording and computer technology" (Emmerson, 1994: 31).

Indeed, one of the most powerful features of an interactive computer music system is the ability to constantly reorganize its configuration. While it opens a large spectrum of musical possibilities for sound production, it also avoids the constitution of stable connections between performance actions and results. The absence of a unique gestural mapping prevents the performer from deeply exploring the system's controlling mechanisms at the same time that it prevents the listener from connecting visual input and music. While the acousmatic effect in pure electroacoustic music tends to put the sound in evidence by breaking (or at least by weakening) its connection with its source, interactive music renders this connection very unstable. As composer Dennis Smalley says:

> "[...] we can arrive at a situation where the sounding spectro-morphologies do not correspond with perceived physical gesture: the listener is not adequately armed with a knowledge of the practicalities of new 'instrumental' capabilities and limitations, and articulatory subtlety is not recognized and may even be reduced compared with the traditional instrument." (Smalley 1992: 548)

Since the 90's, instrument designers and musicians have to face the particularities of new electronic devices for music production in order to create effective interfaces that would allow the expressive control of sound. Mapping gesture into controlling parameters is not a simple task. The manipulation of tape recorders, synthesizers, and computers eliminates the materiality of sound. Differently from the sounds produced by mechanic instruments, electronic sounds do not embody any kind of gestural relation to the devices that produce them. It represents a great autonomy and freedom in terms of compositional strategies, but at the same time it means a loss in the symbolic and meaningful dimensions that can be present in a musical work. In the last 50 years electronic and digital technology expanded the possibilities for creating music in a very significant way, but this expansion also brought the risk of restricting the semiotic connections conceived during the performance and listening. Today's musical activities based on the production of pre-recorded or electronic generated music have deviated from the embodied practice of performance to artificial processes of composition and diffusion. In these processes the loudspeaker replaces the performer, thus eliminating visual and gestural references that traditionally composed a significant dimension of musical language. In which way contemporary musical practices such as electronic interactive music will restore this dimension is something that still has to be elaborated and can be seen as a challenge that will entertain, for some time, composers, performers and listeners alike.

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