Music and Interaction: Consequences, Mutations and Metaphors of the Digital Music Instrument

Paulo Ferreira-Lopes , António de Sousa Dias , Daniela Coimbra

Z.K.M. | Zentrum für Kunst und Medientechnologie Lorenzstr 19 , 76135 Karlsruhe – Germany
CITAR | Centro Investigação Ciências e Tecnologias das Artes – Universidade Católica Portuguesa
Rua Diogo Botelho, 1327, 4169-005 - Porto Portugal
pfl@zkm.de

Centre de Recherche Informatique et Création Musicale (CICM) – Université Paris VIII - 2 rue de la Liberté
93526 Saint-Denis Cedex France
sousa.dias@wanadoo.fr

CITAR | Centro Investigação Ciências e Tecnologias das Artes – Universidade Católica Portuguesa
Rua Diogo Botelho, 1327, 4169-005 - Porto Portugal
dcoimbra@porto.ucp.pt

ABSTRACT - In the present article we observe the significations and the dimensions of interaction between instruments and performers in musical performance. This will lead us, firstly, to consider interaction as a phenomenon non-exclusively correlated with the use of numeric technologies. Then, still within the realm of interaction, we describe some of the transmutations introduced by digital music instruments in the domain of musical performance.

Index Terms — Digital Music Instruments design, Musical Performance, Interaction.

I. INTRODUCTION

In the last few years, expressions such as interactive music, interactive music with computers [16] or musical interactive systems [9] achieved the status of a subject on its own, specially due to the direct influence of the different developments of electronic and computer music. Most of the literature regarding interaction in the midst of music activity, specifically concerning musical composition, is centred [4] on the relationship between the performers and the means to realise musical works: the instruments [9] [1]. Despite the aesthetic dimensions of computer interactive music [5], we believe that the discussion is not ended, in particular concerning the existence of a genre we may call "interactive music". In this article we evaluate how the introduction and use of numeric technologies in music creation/performance allow a link to be established between interaction and musical genre.

Along the same lines, we will also attempt to verify the extent to which one can consider this musical genre, "interactive music", as an exclusive result and a causal-effect of the use of digital technologies.

II. TECHNOLOGIES AND CREATIONS: INTEGRATIONS AND RUPTURE

The diffusion of the word *Interaction* and the references to interactivity as a notion or a process associated to the different domains of artistic creation [15] became one of the biggest phenomena of expansion during the eighties. Within the context of music application, the meaning of the notion of interaction expanded to new fields and connotations, thus contributing to the creation of a new vocabulary. Such a vocabulary aimed to express new contexts and relations. Amongst a wide spectrum of situations, realities and aims, it is possible to find aesthetic positions, and, at the same time, different levels and technological orientations that attempt to embrace composition, interpretation and the expression of musical phenomena towards new dimensions in relation to the traditional positions. After the eighties, there was an outbreak of musical genres and musical expressions, directed *grosso modo,* according to two principles:

- The integration of tradition and technological means;
- The rupture and radical denial of all the contexts that cannot be seen as directly deriving from the computer and digital technology.

In the first case, apart from the questions arising from the relationship between traditional music techniques and new technologies, the principle is considered as reflecting a creative attitude that is globally endogenous. This means that the creation process trajectory goes from the concrete realities towards an external space, based upon an understanding of the adaptation of the technical and technological realities to the needs of creation. On the basis of a research phenomenon lies the motivation to create. This results from the exploration of musical/sonic ideas and their interior weaving. These ideas are based on

a varied, and usually very long learning process. This experience thus consists of a space of transmutations and metamorphoses carrying different technological signs.

In the second case, the creation process relies on an awareness of the technological potentialities as a means to attain an artistic result. Here, the perspective to the approach to the genesis of the conceptual formalization of the creation is established on an exogenous principle. Such attitude leads the creative attitude to follow a trajectory form the external to the internal space, in which the technological realities determine the process of creative conscience. Both the ontogenesis and the artistic fecundation of this perspective are anchored in notions conceptually derived from strict technological realities. Figure 1 below represents these two approaches.

Endogenous Creative Trajectory

Instruments
↑
Musical Idea
↓
Instruments

Exogenous Creative Trajectory

Instruments
↓
Musical Idea
↑
Instruments

Figure 1

Draft model of an endogenous and an exogenous creative trajectory

III. INTERACTION, METAPHORS AND INTERPRETATIONS

Is it possible that the classification of a genre, or the definition of interactive music results exclusively from an undifferentiated usage of numeric technology, both in musical creation and interpretation? Is it possible that the use of the computer in musical creation and interpretation, facing a principle of integration between numeric technologies and traditional instruments, leads in direct proportion the content and the structure of the work to new dimensions of interaction and interactivity?

An exact answer to these questions demands: firstly, to limit the number of subjects[1] that may be directly and indirectly affected by the understanding of the question. Secondly, to consider the different points of view according to which one considers the computer and its use, since the computer allows the transformation and generation of musical realities becoming simultaneously a musical instrument, an interface, an instrument of composition or an almost autonomous performer. For within the perspective of creation and musical performance computers are not only "number-crunching" devices but are also "interactive partners" [13]. Looking at the procedures taken by performers during a musical

---

[1] The music instruments design, the informatics, the techniques of instrumental execution, etc.

performance – limiting the subject for a moment to the domain of the use of traditional musical instruments – one can see that the ultimate aim of all the procedures around musical performance converge towards a global stage commonly called musical interpretation.

Musical performance, as a reality, arises from the symbiosis between man and instrument. Therefore, it exists as a network, where multiple chains are linked by means of complex operations. This network, an alliance deriving from the relationship between performer, instrument and musical text, assumes innumerable configurations in the form of singular, yet variable geometries. However, it is always sustained by a kind of *gravitational interaction* in which the limits of its tension force are marked by a triangle with the variables – cognition, motor control and perception. (See Figure 2).
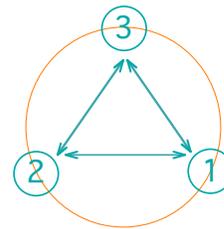

Figure 2.

Gravitational Interaction of Cognition, Motor Control and Perception

Within this universe, man and instrument thus form a unity and a chain of communication, in which the performer is simultaneously a trigger and a transmitter of actions previously converted and controlled by the senses of sight and hearing. This reality was acknowledged by Clarke [3] for whom both body and mind converge to a whole where its individual components are not independent. Furthermore, he argued that the mind is neither driving the body, nor confined within the head. In such a chain of communication all human impulse/action aiming to generate instrumental sonorities is preceded by two processes of conversion (here designated by *meta-translations*). These are ordered and composed according to a sequential mode, even though the triangle cognition, motor control and perception leads us first to an "action/perception feedback loop" [13]. The first action of conversion is the translation of a symbolic representation, the score, by means of sight. The purpose of this *meta-translation* is the survey of impulses, or the control of biomechanical actions on the musical instrument [10]. The second action of conversion regards the use of acoustic control, subjected to a qualitative dimension of the sonorities transmitted by the instrument.

As previously described, the production of the acoustic phenomena in which the musical instrument is placed directly at the origin, in the quality of a sound source, is

also the consequence of a manifestation of intelligibility formulated in the form of a source of stimuli and of the physiological actions of the performer. In that sense, a musical performance depends on high-level creative skills ranging from technical control of the instrument, to expressive and interpretative awareness and ability [12] .

This *meta-translation* is based upon the performer actions by means of a multiple bodily capacity (the mouth, fingers, limbs etc.) and on what the performer understands, enables him/her to perceive, and at the same time to follow the continuity of the acoustic phenomena arising from the biomechanical action on the instrument. This process would fit onto Woody's model of musical performance in which musicians need three types of mental representations: goal imaging, motor production and self-monitoring [19].These actions are guided according to an acoustic ideal which is extremely difficult to synthesise in a single concept[2]. Nevertheless, this acoustic, or rather musical ideal corresponds in brief to the intersections between the personal development of the performer and his cultural experience. In this way, the performer guides the interpretation on the basis of an imagination composed of multiple provenances and influences, or from multiple interactions. Indeed, musical performance results from the convergion of cerebral, bodily, social and historical attributes of the performer [3]. The scale of such influences and interactions is temporally variable and includes the following parameters:

- The lexical timbre of the instrument;
- The rigour of intonation;
- The range of the dynamic chromatism;
- The variation and the connection between the macro-temporal and the micro-temporal;
- The articulation of the motor capacities.

The combination of all these parameters correlated under a triangulation interaction between the cognitive aptitudes of the performer, his motor control and the acoustic properties of his instrument originate a highly complex acoustic reality.

The most important aspect is characterised by the direction and management of the multiple influences these parameters, processes and phenomena exert both directly and indirectly on each other, on a micro-temporal scale. The main aim is to achieve an acoustical or musical performance by means of a musical instrument. This could be represented by a scheme in which performer and

instrument coexist in the same gravitational space, the acoustic phenomenon ruled by the laws of physics, as shown in Figure 3.
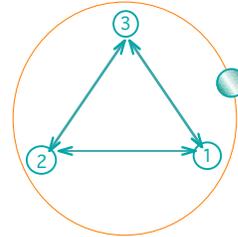

Figure 3

Representation of Performer (inside circle), Cognition (1), Motor Control (2) and Perception (3) (in the triangle) and instrument (in orbit) sharing the same gravitational space.

IV. INSTRUMENTS, PERFORMERS AND COMPOSERS: THE SPACE OF INTERACTIONS

Taking into account that the use of the computer may have a similar status to that of a musical instrument, both in the space of creation and in the concert room [12], composers and performers are led to develop aptitudes and research *meta-techniques of execution* adapted to the characteristics of each instrument. This attitude simultaneously allows the composer to articulate his musical ideals according to the realities and to the limits of the instrument and the performer to manipulate the instrument and interpret an electronic work in a concert situation with the same implications of traditional instruments and concerts. Within this context one can see that the characteristics of the relationship between the performer and the computer in its capacity as a musical instrument, as well as the interactions the computer introduces in a direct relationship between the performer and the musical performance, are comparable, to a certain extent, to the relationship that performers have always established with their instruments. Among the different approaches and orientations, instrumental techniques, musical techniques, aesthetic tendencies, etc., we note that the existence of a musical work, mostly registered on paper, becomes a tangible reality at the time of its performance /interpretation. Its materialization thus results from a very complex cooperation in the form of non-discrete interactions, between the articulation of musical ideas (expressed by a musical text), the physiological, perceptive and cognitive abilities of the performer or his relationship with the musical instrument, in the midst of the meanest acoustic impressions and detailed musical nuances. The musical instrument, the aspects deducted from its use and the skill with which it is manipulated become a tool that enables the embodiment of the music at the stage of its acoustic perception. In the same way, the musical instrument, or a part of the musical

---

[2] Bayle proposes a tri-partition of the listening and cognition phenomena. The analogy established by the author between listening and cognition represents in total two of three stages of interpretation. The next paragraph illustrates Bayles' own words (*translated by the authors*): "Our ear is interested in perceiving the circumstances, the typo-morphologic details, the interaction of subjects. The hearing capacity thus described functions as a detector, limited by a physiological threshold, detectors of salience, attack, contour, … our own being is interested in perceiving the origins and the transformations, the coherences and the distinctions." [2].

instrument, manifests a singular and unique characteristic of articulation between the different stages of existence of the musical work, as well as in its result. Globally, the spectrum of interactions derived from the paradigm "*musical instrument*" proves to be very broad. The musical instrument itself may be at the same time the source of the material motivations of musical composition. Both the limits and the challenges posed by its complexity may direct the contents of the composition of a work. Therefore, the musical instrument may become at the same time the object of the composition. It is not rare that the use of numeric technologies induces the composer to create his own instruments according to a previously established ideal that is developed in a fragmented way, as his work of construction progresses and his instrument takes form, even if it develops in a considerable temporal extension, as in the case of Risset [8]. The musical instrument may, on the other hand, reveal itself as a kind of mirror, by means of reduction or redundancy. This enables access, in a superficial way, to the main contour of a musical reality, as is often the case of the piano, where it is possible to reduce the substance of a work for orchestra [6]. In this sense, the main characteristics of the musical instrument generally assume the constant presence of interaction in the musical performance/interpretation. Therefore, the notion of interaction is presented as a reality common to several epochs and situations, revealing a non-temporal character and *non-reducible* to the structure or to the nature of the instrument. The above means that one may observe the existence of the interaction phenomenon independently of an epoch, an aesthetic or a technology.

V. FROM THE GLOBAL NATURE OF THE TECHNIQUE TO THE TECHNOLOGICAL CONSTRAINTS: MUSICAL GESTURE AND CAUSALITY

By comparing the similarities and analogies established among the different musical instruments, we consider that the qualities and modalities of the interactions, in particular, do change according to the nature of the instruments. In this way, we may delimit and identify a global principle of non-causality between certain sound realities and certain structures of digital music instruments. As has already been seen, there are, at least on an initial approach, three diverging aspects in the use of numeric instruments and traditional instruments, even if their similarities seem very large (especially at a structural level):

- The principle of non-causality between the manipulation of the interface and its repercussion in the musical result, in the sense of the "surrogate" referred to by Smalley [11]);

- The non-temporal synchronisation between the manipulations of the leading elements of the interface, and its repercussion in the musical result;
- The discretization of the musical gesture in relation to the musical contents (already present in the distinction between audio signals and control signals as in Csound [14] or Max/Msp [17]).

On the other hand, even if the proximity of the principle of manipulation and of interaction between the traditional musical instruments and the instruments of numeric music makes them similar to a certain extent, there are constraints and technological aspects that of necessity set up differences from the point of view of the dimensions the interaction may take in the musical phenomenon. These differences result from a different nature of sound production. Performers, using their cognition, motor control and perception must deal with two different gravitational tensions and spaces. One ruled by the laws *of physics acoustic using mechanical tecnologies* in which it is possible to control the interactive process. The other ruled by the intricacies of digital music (informatic technology) in which the interactive process may surpass the control and conscious awareness of the performer. In this context, it should be remembered that the aesthetic realities often derive from a new technological conscience, in the form of a differed principle between a cause and its effect. Similarly, one should also take into account the specificities of the universes and dimensions that the isolated use of traditional and numeric instruments symbolises. The reason is that their substrata reveal themselves (at least quantitatively) very far from each other; consider, for instance, the paradigm of sound synthesis and the universe of timbre as a quantitative comparison of what a numeric instrument may embrace in comparison to the universe of acoustic formalization of the baroque or even romanticism.

VI. CONCLUSION

It has been stated that the understanding and the characteristics of interaction in the domain of musical performance/interpretation denotes proximities, both in the use of traditional elements and in the instruments of numeric music. Within the context of contemporary creations, we observe that the interaction is not a phenomenon exclusively and compulsorily derived from the use of computer and numeric technologies or from the simple integration of the digital music instruments in a musical work. To label a style or a genre as "musically interactive" proves to be incomplete, specially if this label relies only upon the exclusive use of digital technologies, the specificity of the musical performance[3] and the singularity of computer music instrumental technique, live electronics and electro-acoustic music. Finally,

---

[3] One can consider this reductive principle once the in-temporal characteristics underlying the musical performance have been established.

independently of the established analogies between interactions and the instrumental techniques associated to the different musical instruments, the structure of the digital music instrument makes it possible to identify a principle of discretization of the musical gesture as well as a principle of *non-causality* and of *non-temporal synchronisation* between the execution of the instrument and the sound results produced. Even if it is difficult to find a consistent relationship between interaction and musical genre, even if the modalities and typologies of interaction change in a rather sudden way, the above leads to conclude that musical technique in is fact not limited anymore to "the knowledge of the acoustic principle of sound generation and to the practical regulation of their different theoretical uses" [7].

REFERENCES

[1] Battier, M. *Aesthetics of Live Electronic Music*. London : Éditions Routledge, 2000.

[2] Bayle, F. "L'image de son, ou i-son. Métaphore/Métaforme" *La Musique et les Sciences Cognitives*. Liége : éd. Pierre Mardaga, 1988, p. 235-242.

[3] Clarke, E. F. "Understanding the Psychology of Performance" *Musical Performance: A Guide to Understanding*. Rink, J. : éd. Cambridge University Press: Cambridge, 2002, p. 59-72.

[4] Ferreira-Lopes, P. "L'ordre naturel du digital" in : *DOCE NOTAS – preliminares, n°6*. Madrid : éd. DOCE NOTAS SC., 2000, p.112-119.

[5] Ferreira-Lopes, P. *Étude de modèles interactifs et d'interfaces de contrôle en temps réel pour la composition musicale*. Thèse de Doctorat ; Paris ; Université de Saint Denis - Paris VIII - Dép. de Sciences et Technologies des Arts, 2004, pp 117-118.

[6] Garnett, G. E. « The Aesthetics of Computer Music » in *Computer Music Journal vol 25 nr. 1*, 2001, p.21-33.

[7] Manoury, P. « Le stade Pictographique de la Musique électronique doit être dépassé » in Vinet, H. ; Delalande, F. (dir.). *Interfaces homme-machine et création musicale)*. Paris : Hermès Sciences Publications, 1999, p.205-211.

[8] Pecquet, F. et Solomos, M. « Éthique Musicale et Technologie » in G. Assayag, M. Chemillier, C. Eloy (éds.), Troisièmes journées d'informatique musicale JIM 96, *Les cahiers du GREYC*, n° 4, mai 1996. URL : http://recherche.ircam.fr/equipes/repmus/jim96/actes/EthiqueTechno.html,

[9] Risset, J.-C., Arfib, D., de Sousa Dias, A., Lorrain, D., Pottier, L. « De "Inharmonique" à "Resonant Sound Spaces" : temps réel et mise en espace » in *Actes des neuvièmes Journées d'Informatique Musicale*, Marseille : ADERIM-GMEM, 2002, p.83-88.

[10] Rowe, R. *Interactive Music Systems*. Massachusetts : éd. The MIT Press, 1993.

[11] Shaffer, L. H. "Cognition et affect dans l'interprétation musicale" *La Musique et les Sciences Cognitives*. Liége : éd. Pierre Mardaga, 1988, p.537-550.

[12] Sloboda, J. A. "Music Performance" *The Psychology of Music*. Deutsch, D.: éd. Academic Press: New York, 1982, p. 479-496.

[13] Smalley, D. "Spectro-morphology and structuring processes" in : Emmerson, Simon (Éd.), *The Language of Electroacoustic Music*. London : Macmillan, 1986, pp.61-93.

[14] Toeplitz, K. "L'ordinateur comme instrument de concert" in *Actes des neuvièmes Journées d'Informatique Musicale*, Marseille : ADERIM-GMEM, 2002, p. 199-207.

[15] Vaggione, H. "Some Ontological Remarks about Music Composition Processes" in *Computer Music Journal* vol 25 nr. 1, 2001, p.54-61.

[16] Vercoe, B. *CSOUND: A Manual for the Audio Processing System and Supporting Programs*. Cambridge MA : MIT Media Laboratory, 1986.

[17] Weibel, P. "The Art of Interface Technology" in *The Sciences of the interfaces*, Tuebingen : éd. Genista VERLAG, 1999, p. 272-281.

[18] Winkler, T. *Composing Interactive Music*. Massachusetts : The MIT Press, 1998.

[19] Woody, R. H. "The Relationship between Explicit Planning and Expressive Performance of Dynamic Variations in an Aural Modelling Task" in *Journal of Research in Music Education*, 1999, *47*, 331-342.

[20] Zicarelli, D. et al. *MSP: Reference*. Cycling '74, 2001.