Musical Creation Process and Digital Technology: "the Supra-Instrumental Gesture"

Claude Cadoz

Musical Creation Process and Digital Technology
"*the Supra-Instrumental Gesture*"

Claude Cadoz
ACROE and ICA Laboratory, France
E-mail: Claude.Cadoz@imag.fr

Abstract

Considering artistic creation as an emblematic enactive process and the artistic creation process as deeply linked with technology, we propose a conceptual framework allowing to give signification to the concept of artistic creation tool in the context of digital technology. We start from a very simple (theoretical) situation, which is a kind of primordial musical instrumental experience where we characterize the main phases of the creation process under an enactive point of view. Then, we discuss briefly some needs to which technology evolution brought certain solutions and the new functionalities it introduced. After that, entering in the "new technology" era we show in what the introduction of the digital technology in the field of artistic creation is not simply an evolution but, though not yet accomplished, a deep revolution. Finally, through a brief presentation of our own research and its correlated musical creation activity in the laboratory, we introduce two important concepts: the first concerns the use of the mass-interaction physical modeling paradigm for the musical macrostructure creation, the second, closely related, is that of "Supra-Instrumental Gesture". Both correspond, in the case of musical creation, to an extension of the enaction point of view from the multisensory-motricity level to the scale of musical composition.

1. Introduction

Evoking artistic activity, we can start by posing the problem in terms of communication. Indeed, there is at least, at a given moment and a given place, between several people, some objective intermediary produced or influenced by the ones, and perceived by the orther. And at the minimum, this intermediary is a physical phenomenon, for example an acoustic wave, or a light flow.

Of course, a lot of other conditions are necessary for the existence of artistic creation situations, but focusing on the natural conditions in which the human being can produce or modulate phenomena for the senses and perceive the phenomena given to its senses, before introducing any technology, we can bring in the enactive considerations.

Let's recall it through four primary remarks:

1) There is a dissymmetry between the ways to produce and the ways to perceive: Hearing is able to treat a much larger variety of acoustical phenomena than what the voice can produce. The human being is the source of the acoustical energy the voice produces and which reaches the hearing, while an external source of energy (light) is necessary in the case of the sight. Body behavior, face expressions and purely semiotic gestures [1] are visually perceptible, but ergotic [1] gestures phenomena (mechanical forces, deformations, displacements…) are not propagated and suppose a direct physical contact to be perceived by the tactile / haptic sense.
2) There is no perception without production and no production without perception. Production / perception processes are loops. For example, in a vocal (musical or not) communication, the following flows are concerned:
    a. Vocal production to hearing of emitting subject.
    b. Vocal production to proprioception of vocal organ of emitting subject.
    c. Vocal production to hearing of receiving subject.
    d. Body and face action-movement to proprioception of emitting subject.
    e. Body and face action-movement to sight of subject receiving subject.

    Of course, there are loops at higher levels, in natural communication situations, where the subjects are more than two, and where the phenomena are for example complex structured audio stream related to speech or song.

Proceedings of ENACTIVE/07
4th International Conference on Enactive Interfaces
Grenoble, France, November 19th-22nd, 2007

3) Not more than it is possible to completely separate production and perception, it is possible to thoroughly separate our senses, or our way of production. This is the reason why enactivity is strongly associated with the idea of system of "multisensory-motor loops".
4) And finally, it is necessary 1) to distinguish between "production" (in the sense of producing or modulating phenomena for the senses) and "action" (in the sense of physical action on, or by, a material object), and 2) to consider that, again, they cannot be absolutely separated.

While technology intervenes, changes concerning dissymmetry can occur: for example, in the case of music, a musical instrument can be viewed as a means to increase the variety of acoustical phenomena that the human being can produce, as well as a way to allow the ergotic gesture to propagate. In the same time, a musical instrument can extend the spatial era where the communicational process can take place, since, for example, we can ear its sounds at a longer distance than those of the voice. However, these advantages are not free. When technology intervenes, there is a transaction, a kind of "deal" and the new situations are at the same time more than, less than, different from, the previous. For example, according to its material constitution, the musical instrument has its specific affordance, imposes specific gestures, and has its own vibration modes. In fact, it reveals the action of the instrumentalist by revealing itself, indissolubly, adding, losing, and transforming certain things.

This is this question of "transaction with technology" that we discuss in an overflight along these few pages, from the "primordial" instrumental situation to the advent of the digital technology in the field of the musical creation. The question being actually to try to characterize the strong discontinuity between the "classic" and the "contemporary" (digital) technology. Recalling the main topics and previous results of the research in our laboratory, we will then propose some prospects which, while being established on a major form of continuity, brings new latitudes truly possible only with the computer and the enactive systems.

2. Musical creation process and "Classical technology"

2.1. The "primordial" instrumental situation

The musical instrument is the first stage of technology in music. We define it, here, as a material object with which we can physically interact through ergotic gestures and in which, as a consequence of this interaction, take place vibrating processes that produce acoustic phenomena. So, a musical instrument converts a gestural energy into acoustic energy, a physical **action** into an acoustical **production**.

We said above that the musical instrument enlarges the variety of sounds that the human being can give to hearing, at the same time as it allows the (ergotic) gesture to propagate or, in other words, the gesture to reach the ear. Taking into account the laws of the physical universe, it can do it only according to certain types of protocols and thanks to certain categories of physical process. This has as consequences 1) that the physical structure of a musical instrument presents a prototypal chain of physical components, and 2) that the gestures we can do respond to a precise typology (*excitation / modulation / selection* gestures [2]), and has specific morphology (hitting, rubbing, scraping, bowing, blowing, plucking, etc [3]).

What is very important in this "primordial" instrumental situation is that there is a continuum of energy from the gesture to the sound. So, quantitative (amplitude), but also qualitative (timbral aspects, etc.) properties of the heard sounds are directly linked to the human sensori-motor capabilities, the physical laws of the universe through the material forms that the instrument can adopt, and through the physical contingencies of the man-instrument system.

The creation and communication processes (envisaged not only at the level of the individual, but in their historical and social dimensions) are, then, specifically determined and we can, again, adopt the enactive point of view to characterize them.

Let's start with an hypothetic primary situation where we are using for the first time an object about which we just know that it is a musical instrument, but nothing about what gestures we can apply, what sounds it can produce and what is the link between the gestures and the sounds. The only possible attitude in this situation is to explore, i.e. to act in order to perceive, and to perceive in order to act. Starting from scratch (which is never from scratch), the exploration is done according to strategies determined by our physical (biological) capabilities, the mechanical properties of the instrument, the physical possibilities and properties of the man-instrument system, the intrinsic affordance of the instrument, and our previous… enactive knowledge, i.e. previous situations where some aspects of the present one were similar.

Doing this exploration, something new happens, i.e. production, for example, of sound events, which we don't know before. So we get a new enactive knowledge linking the actions and the produced effects. But here we have an actual creation process, in its simplest form but in its very essence. Creation because we brought to the existence something which did not exist (for us) before. Is this corresponds to something we imagined before without being able to give it tangible (perceptible) form? May be yes, may be no. The fact is that now we know it and how to

produce it. Is this corresponding to something, which is relevant? Beautiful? Meaningful? According to what judgment? If we judge that this is the case, then, the most important is that we can now propose it to the perception of other people, as often as we (they) wish it. The experience of other people with this event may correspond to something completely banal or completely new. In the last case, we can say that the individual creation is also available at a more collective level. Let's emphasis here how enaction and (artistic in this case) creation are deeply linked. Quite the same concept, but at different levels. Acting and perceiving, we are always creating, and creating we are always perceiving and acting.

Having sufficient (direct or indirect) instrumental experience, we may become able to achieve such exploration and creation process to a certain extent at a purely mental level, without any actual sensori-motor concretization. It is interesting here, without enter in details, to envisage a loop representation of a more global creation process where, at an upper level, the poles of the loop are the actual sensor-motor loop and the "mental loop" themselves.

2.2. Musical notation and "classical" composition

Painting can be presented like music, with notions of material intermediary, gestures, production and perception of phenomena. However the things are quite different. For example, the ergotic gesture is not transformed in energy for the senses (sight). But a major difference is that the material intermediary (playing the role of the instrument in music), i.e. brushes, canvas, etc. is at the same time a physical object that allows to preserve the result of the creating process over time and space. Painting, which is an "autographic" art [4] has *de facto* a natural spatio-temporal extension, beyond the moment and place where the creation process occurs.

In music, the sound phenomenon is fugitive. It disappears as soon as the action on the instrument ceases. This is the reason why music is "allographic" [4], i.e. it needs, beside the instrument and the human memory, an external physical permanent support in order to get a wider spatio-temporal (socio-historical) extension.

The music notation was invented during Antiquity, by the Chinese and by the Greeks, but it actually developed in Occident only from the Middle Ages, from the *neumes* [5] which were graphical signs allowing to transmit songs associated to religious texts from masters to disciples. The development of occidental music is strongly determined by the musical notation which main principles are very stable until contemporary period.

But musical notation, which is not dissociable from technology (of its supports, markers, etc.), supposes a certain relation between "musical facts" and graphical symbols on the support. The questions are then 1) what are the "facts" that are submitted to notation? And 2) what are the properties (affordances) of the graphical symbols themselves, in relation with what they represent, and intrinsically?

In fact, the relation between the musician and the score, through musical notation, must be considered itself as a specific creation process. It is of a completely different nature than the instrumental process. And more: the creation process – "composition" - in occidental music, is of a specific nature while combining, in particular contingencies, instrumental experience and formal representations.

3. Contemporary technology

3.1. The early new technology situation

Traditional musical notation is unable to transmit anything concerning the fine properties and details of the sound as our hearing is, however able to discern it. Indeed, in traditional notation, the sounds are defined only as pitch, duration, intensity and timbre (the last being evoked by reference to the instruments).

One of the important technological revolutions in music, at the XXth century, is due to the advent of sound recording (T. Edison and C. Cros invented the phonograph in 1875, the magnetic tape recording was invented in 1931). It gave rise to the "Musique Concrète" in 1948 [6].

It is simply obvious that the musical creation process, in "Musique Concrète" or in "Music for Tape", is completely different, when sounds events, once fixed in a permanent support (the magnetic tape), became "sound objects" (*Objets Sonores*) according to the famous term from Pierre Schaeffer. The tape-recording, in fact, beyond the possibility to "capture" the sound and to "replay" it identical to itself indefinitely, establishes a specific correspondence between time and space: a given duration of the sound corresponds to a proportional length of the tape. Then, transposing our acts from instrument playing or score writing to tape cutting, inverting, pasting, etc. we get a way to work, "by proxy", on the temporal dimension, by working on the spatial one. The creation process is of course very new and includes the possibility to transform the sound, to go through time, and even in its reverse direction.

But in the same time (here are the terms of the transaction), the music became "autographic", that is the height! Indeed, the tape is the permanent object that gives to the music (for tape) its spatio-temporal extension, and (but) it is no more necessary (possible) to note it. And as a consequence to "compose" it, … in the traditional sense.

3.2. The coming on of computer and digital technology

Less than ten years after "Musique Concrète" and "Electronic Music", computer entered in music domain with Automatic Composition and also Digital Sound Synthesis [7].

Automatic Composition, which used computer to mechanically perform formal processes corresponding to rules that "classical" musical composition used, became soon "Computer Assisted Composition" (CAC). This also inaugurated a very new type of creation process by introducing a kind of meta-level of dialogue: between the composer and his system of rules.

Digital Sound Synthesis, as for it, is closer to the senses. It could be introduced thanks to the invention (at the Bell Laboratories, in USA, in 1956) of the Digital to Analog Converter. This is by this device that a link between the electronic representation and manipulation of numbers in a computer and the ear (through electronic amplifier and loudspeakers) could be established. However, the important way that Max Mathews and Jean-Claude Risset [7] opened, followed by a lot of people, did not give a place to the instrumental (ergotic) gesture. This was of course because of the duration of the calculations, which did not allow producing each second of digital sound signal in less than one second. But a deeper reason was (and remains, despite the advent of real-time), that the algorithmic processes to calculate this enormous amount of samples were conceived as formal rules derived from the signal theory and processing. While gesture, when performed, has, cognitively only very little to deal with the Fourier Serial Decomposition or Transform.

The creation process within the digital sound synthesis is founded on the bridge that Pierre Schaeffer anticipated [6], and that the early works of J.-C. Risset (on the digital synthesis of trumpet sounds, for example) allowed him to theoretically well pose, between the physical description (whatever it is) of a physical phenomena, and what our perception does with it. The Psychoacoustic became then a constitutive loop of the musical (digital) creation process.

It is fundamentally new and powerful. It allows, as J.-C. Risset said, to compose not only the sounds together, but also the sound itself, in its intimate structure. It introduced also a revolution in the technology for music, allowing giving an objective and completely formalized counterpart of the instrument through models described in the MUSIC V language, and gathered in shareable catalogues.

We would like now to take support on this overflight of what we consider as important transitions in the technology for the music, to justify the orientation of our research, since its starting point in our laboratory.

4. Computer as a system for representation

4.1. The multisensory interactive simulation of physical objects

We started our research considering 1) that the instrumental experience, as we defined it above, is primordial in the musical creation process, not only envisaged at the individual level, but at the scale of the human evolution, and 2) that the digital technology revolution is likely to make us reconsidering the things at a fundamental level.

A simple fact leading us to say that is, in the case of music (that we can apply as well to other arts) the absolute rupture of the energy continuum between the gesture and the sound phenomenon when we use computer for sound production. Indeed, the computer is a system of symbols, of dynamic symbols, of inter-operating dynamic symbols and we communicate, manipulate, treat these symbols through transducers and interfaces, but in any case we can consider our relation with a computer on the same level than the relation with a physical object. We must consider, in the case of music, that there is no possible assimilation between a musical instrument and a digital sound synthesis system, even in real-time, even with the best possible resemblance between synthesized sounds and real ones, even when the gestural control and every other perceptual aspects of the instrumental relation are restituted. Even in this situation, the computer is not an instrument, but a "representation" of an instrument.

And this is in this role that it plays its more fundamental function, which is a deep revolution.

This is with this major positioning that we introduced the principle of multisensory and interactive simulation of physical objects [8]. We used the computer and its input/output devices in order that all the multisensory-motor conditions corresponding to the primordial instrumental interaction can be **simulated**. This is a kind of iconic representation, in the sense that we try to establish analogy between perceptible aspects of the original and of its representation. But this iconic representation is "integral", in the sense that the analogy concerns not only one perceptive aspect (shape, colors, etc.), but all the sensory channels, all the action (gestural) channels and the dynamic correspondence between the former and the later during interaction.

So, we introduced the CORDIS-ANIMA language [8] that allows to describe physical objects as an assembly of basic modular components, and to simulate them. Then, we introduced the Force-feedback (TGR) systems [8] allowing manipulating in real-time these virtual objects while we perceive in our

hands their mechanical behavior and properties and we hear and/or see their movements, displacements, deformations. Thereafter we developed the GENESIS environment for musical creation with physical modeling, the MIMESIS environment for the animated images and movement creation, and, finally the TELLURIS and ERGOS systems for real-time multisensory simulation [9].

With GENESIS and physical modeling for musical creation, more than ten years of experimentation in laboratory research context and through multiple artistic teaching and creation situations allowed us to create a large "instrumentarium" of physical models for music, and to several composers to create a certain number of musical pieces.

In 2001 [10] we demonstrated that the physical modeling with CORDIS-ANIMA was not only available for the creation of sounds but also for creation process at the level of the macro-temporal musical structure. The basic idea being that physical models of objects that present time-constants on the scale of the gestural behavior can be used, in interaction with physical models of acoustical vibrating objects, to generate sequences of events that can correspond to musical phrases.

We want now present the most recent results and prospects on this way.

4.2. "Supra-Instrumental Interactions"

From the simulation of physical objects at gestural time-constants scale, we deduced several coordinated principles we discuss below.

4.2.1. Gestural time-constant models as simulation of instrumentalists

We call "gestural time-constant models", in the CORDIS-ANIMA representation, the mass-interaction models presenting at least one particle that moves in the frequency range of the gesture, i.e. from 0Hz to about 20Hz. One of the simplest model is an oscillator with, for example, a modal frequency of 1Hz. It can be considered as a (very simplified) simulation of an instrumentalist (a beater), and we can use it to "play", i.e. to hit another (audio frequency tuned) oscillator.

According to this principle, we can build models of complex instrumentalists, and more, of complex instrumentalists interacting between them and with simulations of complex sets of instruments.

Doing that, and looking for adequate parameterization, it is possible to obtain sound sequences of which we can speak, and on which we can work, as musical phrases and musical structures.

In order to avoid here a severe misunderstanding, let's emphasis the fact that it is not question to replace real instrumentalists by simplistic and naive simulations. The stake is much more important and subtle: we have, by this method, a way to model the behaviors and the structure of entities that produces phenomena of the category of the instrumentalist gesture. Then, this becomes a tool to represent, understand, treat, communicate, and teach the gesture. This does not prevent to use it for musical creation, within a physical modeling sound synthesis environment like GENESIS.

The instrumentalist model can be elaborated in order to try to correspond to a real performance, a real gesture, but, conversely, a "gesture" produced initially by a model can be used to inspire new real gestures.

And we can build situations involving real instrumentalists, real instruments, virtual instrumentalists and instruments, in a real-time situation, where these four categories of protagonists can interact (6 ways for interaction are possible between 4 protagonists), in a musical real-time experience or in non-real-time situation where they can together enter in a new kind of creation process.

And finally, retaining only the macro-temporal scale of the phenomena in these types of models, without any obligation of correspondence with the gesture domain, we can develop, consequently, a specific approach of the musical macro structural construction.

4.2.2. The "Supra-Instrumental Gesture"

Let's now introduce something which relates to an enactive approach, no longer at the low multisensory-motor level, but at a completely new scale, and that can be envisaged only in the context of computer and enactive interfaces.

As one can understand, the general framework in which we can work, with mass-interaction physical modeling paradigm, through the CORDIS-ANIMA language associated to TGR (force-feedback devices), allows us to represent complex worlds where real composers, real instrumentalists, virtual instrumentalists, instruments and other kinds of virtual objects, can interact.

To resort to realistic metaphors is a good support to work, and particularly to learn the properties and the potentialities of the system. But one realize very soon that it is yet much more interesting and fertile to escape from the reference to the real world.

A very pertinent situation occurs when we want to produce and control sound phenomena that correspond, may be, to possible natural sounds, but not at all at the scale of the human being. Let's say, for example, the sound of storms, violent winds, sea waves, and telluric catastrophes or, at the opposite scale, sounding microscopic objects.

For such sounds, we have to build models that are generally made of several superposed and interactive

layers, at different scales. For example, for a gigantic sea wave, we have to take in charge the sound production at the level of the drop of water, but at the same time, the huge water movement at the scale of the entire waves.

Doing such multiscaled model with GENESIS, we can obtain a convincing result, but we have to imagine a huge gesture, a "supra-gesture" that "plays" the huge amount of water. This doesn't correspond of course to any possible real gesture and we have to enter in an imaginary poetic universe were we can conceive ourselves as being some giant or mythic personage like Aeolus.

In fact, we have this capability and, even if we don't have any possible experience of manipulating huge quantity of matter, or blowing huge quantity of water, we are able to conceive such action, as if we had a supra-enactive knowledge, and to conceive physical model doing that.

This, as a lot of various other situations that we could define and describe in these terms, is imaginable and feasible.

To finish, after having transpose such scenes in the virtual word of GENESIS, where we have to model large structures (with a very large number of components) that, consequently can be run only in non-real time, we propose the reverse situation. That is to implement on real-time multisensory interactive platforms such models on which we will play by applying a real gesture on a TGR interface.

Then the concept of "Supra-Instrumental gesture" can be understood from these metaphors, and according to its two facets:

1) In a non-real time context, as the "gesture" produced by a large-scale virtual physical system, interacting with a complex and multistructured virtual vibrating system.

2) In a real-time context, where the gesture is real, actually applied through a gestural transducer to a physically consistent virtual object. In this case, the model may correspond to a very large (or very small) physical system (like the previous huge waves) in its structure and in the nature of interaction between its components, but transposed thanks to a kind of "sensory-motor macro or microscope" to the scale of the human manipulation. We can imagine tuning the parameters of the model in order to have the feeling of manipulate a gigantic wave or a nano-object in the hollow of the hand.

5. Conclusion

We introduced, on the base of a quick overflight of important revolutions in the technology for music, the necessity to guaranty an enactive interaction while we are in relation with a computer. This is done, in our research, thanks to the technique of the multisensory interactive simulation of physical objects and the TGR (force-feedback devices) which preserves the ergotic function of the gesture.

Then, we discussed the application of these concepts to the case of the musical creation process through the GENESIS environment and propose an extension of the enactive concept from the normal sized multisensory-motor loops to other scales, thanks to the notion of "Supra-Instrumental interaction" and "Supra-Instrumental Gesture".

These concepts have been applied for the creation of *Gaea*, a musical piece from the author presented in the Enactive 07 conference concerts and we are now prospecting for implementation of real-time "Supra-Instrumental Gesture" experimentations on TELLURIS and ERGOS platforms.

References

[1] Cadoz, C. "Le geste canal de communication. La communication 'instrumentale'", Technique et science informatiques. Volume 13-n°1, pp. 31-61, Hermès, Paris, 1994.

[2] Cadoz C., Wanderley M. "Gesture-Music" – in "Trends in Gestural Control of Music", M. Wanderley and M. Battier, eds, pp. 71-94 -2000

[3] Kojs, J. "*At and Across*: Physical and Virtual Action-based Music" this volume, Grenoble, 2007.

[4] Goodman, N. "Langages of Art", Hackett Publishing Comp. Inc., Indianapolis/Cambridge, 1976.

[5] Duchez, M.-E., "Des neumes à la portée – Elaboration et organisation rationnelle de la discontinuité musicale et de sa représentation graphique", Revue de musique des universités canadiennes, n°4, 1983.

[6] Schaeffer, Pierre. *Traite des Objets Musicaux*. Paris: Seuil, 1966.

[7] Mathews M., Miller J. E., Moore F. R., Pierce J. R. & Risset J. C., "The Technology of Computer Music", MIT Press, Cambridge (Mass.), London, 1974.

[8] Cadoz C., Luciani A., Florens J. L., "Responsive Input Devices and Sound Synthesis by Simulation of Instrumental Mechanisms : The Cordis System", Computer Music Journal, 8, n°3, pp. 60-73. M.I.T. Press, Cambridge Mass. 1984.

[9] Florens J. L., Luciani A., Cadoz C., "A real-time workstation for physical model of multi-sensorial and gesturally controlled instruments", ICMC 1998.

[10] Cadoz C., "The Physical Model as Metaphor for Musical Creation "pico..TERA", a piece entirely generated by physical model", Proc. of ICMC – Goteborg – 16-20 sept. 2002.

Aknowledgements

This research work has been performed with the support of the French Ministry of Culture and the FP6 NoE Enactive Interfaces.