Formal Processes of Timbre Composition
Challenging the Dualistic Paradigm of Computer Music
A study in Composition Theory (II)
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Abstract
The utilization of computers has fostered a variety of approaches to music composition. It is possible to gather them in two general categories, which reflect separate cognitive features in the compositional process, i.e. algorithmic composition and timbral design. These are different attitudes peculiar to a profound cognitive dualism. The most innovative and aesthetically refreshing potential of electroacoustic and computer music composition lies in the possibility of blurring that distinction, thereby questioning the dualistic paradigm of music composition.

1. The Cognitive Dualism of Electroacoustic and Computer Music

Skimming through the pages of computer music publications, either research paper collections like the ICMC Proceedings or textbooks [Dodge & Jere, 1985], it seems evident that the utilization of computers in the compositional process has fostered a number of different approaches and attitudes. It's not oversimplifying to gather all approaches into two main categories: algorithmic composition and timbral design (or timbre composition). Following a former study [Di Scipio, 1993a], this paper explores such distinction, as well as the possibilities of computer music by which that distinction can be significantly questioned.

In very general terms, algorithmic composition involves a strong emphasis on the formal properties of the musical architecture, and on the generative rules of music at different levels of structure. In timbre composition, the emphasis is especially on the perceptual and semantical properties of the sound materials and their associated auditory images. However, far from being specific to electroacoustic and computer music, these two attitudes reflect cognitive dispositions which have run parallel with the development of musical thought along this century. Computer music amplifies the potential of the many possible approaches in between them, and, even more importantly, makes us particularly aware of this dualistic set of our musical mind.

The distinction is also one that reflects two instances of, respectively, formalism - a radical stance of rationalism - and that which has been sometimes called (at least in Europe) materiaut - meaning a special care taken by artists (including composers of electroacoustic and instrumental, especially orchestral music) for the intrinsic aesthetic values of their material, in a radical stance of naturalism.

1.1 Sound Form

Since its inception, electroacoustic music has been the preferential terrain of an unprecedented approach to music composition, one in which the process of composing-the-sound is an activity of invention and design distinct and, at least in principle, equally relevant as the ability of framing the sound materials in an overall structure - i.e. distinct from composing-with-sounds. In a thoroughly-going music of timbres, the new creative environment opened up by electronic and computer technology is one that forces us to consider sound as something composed, something stemming from personal designs, the very result of an act of intent. Sound becomes a result of composition, a artifact rather than a pre-existent object.

This is central in what we call timbre composition. So much so that theoretically we should consider any single sound of a musical work capable per se of triggering subjective processes of apprehension and appreciation, before (or even: rather than - it depends on how radical is the stance taken) being understood as a partial component of an overriding structure. Sound becomes the very object of an appreciator's aesthetic judgement. Philosophers would tell us that whatever we exert acts of appreciation upon cannot but be named form. Thus, taken per se, any sound which is the intended artifact of a creative, individual action must be conceived as a kind of (musical) form. At least, we must say sound aspires to such category, it aspires to being self-consistent form.

1.2 Sound Material

This condition notwithstanding, the tradition of electroacoustic and computer music also shows
that, once composed, a sound is then put in some relation with other sounds. A radical view of timbral composition would be one in which any single sound event is conceived as an individual musical object deliberately designed and constructed. But in any other (less radical) view, sound becomes a musical event if it is conceptualised, if it stands in some relationship with other sounds. And if such relationships (syntxes), psychologists would say, have some degree of coherence and cognitive reality in the subject's mental representation.

Thus compositional sound appears as a preliminary step followed by composing-with-sounds. This latter takes sounds which were the object of invention, design and appreciation (forms) as partial components of a whole gestalt, whose consistency is determined by coherent syntactical links among those constituents. Hence, sound returns to the condition of material.

Indeed, the act of composing-with-sounds essentially negates the sound's own internal tension towards the status of a composed, formed totality. Within the logic of the final artifact, the sound material disappears and vanishes. The formative act which gives substance to perceivable relations among sounds, to a 'musical discourse', is overwhelming with respect to the innermost tension of the individual sound object (the tension which makes it form). The logic of the musical discourse obliges sound to the status of material. Sound material must be neutral enough [Rosez, 1987] not to prompt eccentric and centrifugal forces of its own, thereby dissipating the clear recognition of the act of relation that the composer imposes on sounds.

Thus composing-with-sounds - which is primarily a matter of syntax, of σωματική manipulations - makes "material" that which, by composing-the-sound, aspires to become "form".

1.3 The Dyadics of Sound and Structure in Computer Music

For the traditional dyadics of art, the material sounds as a representative of Nature in the artist's process of invention. In the logos of the artifact thus created, the material is neutralised by the formative process. Its specific strength and features are dominated, or artistically exploited. Finally the trace of Culture is impressed in the material. Within the presence of the artifact, the material is 'not-existent' [Lukács, 1971], its internal forces - the forces of a natural phenomenum - are mediated by the artist's techniques and expressive means, hence negated in themselves. The characteristic potential added to this dyadics by technologically nuanced processes stems from the fact that now sound materials, too, can be intended as cultural artifacts, not only their set up in the overall configuration of the musical form.

Though standing as Nature in the process of art, we should not forget that the notion itself of material is a historical notion. Materials have always been the outcome of human knowledge, hence have always been cultural in essence. So much so that - if one accepts the philosophical definition of 'material' as 'objectified consciousness' [Adorno, 1970] - we can argue that

"by struggling with material, one struggles with society." [Tzederman, 1991, p.97]

Before the inception of electroacoustic music, however, materials had never been an integral part of the compositional process, the outcome of a single individual's knowledge and invention. Today, sound can be form, rather than mere material, exactly because its very existence and morphology are caught within the individual compositional project. Adorno's "objectified consciousness" is now "locally distributed", inherently fragmented. In this sense, technologically based composition makes sound material what the technique of the early avant-gardes of this century had made to the formal system and the conventional rules of composition: the breaking of a common language and the liberation of individual rules and approches.

However, whatever the syntactical principles which give substance in the act of composing-with-sounds, these push the sound back to its older status of something given. By composing-with-sound we try to re-integrate - but faking - the material's older role of the representative of Nature in the process of art. What remains a distinct feature of technologically based composition, then, is the possibility of tighter conceptual links between the structure of sound materials (microstructure) and the structure of sound (macrostructure). This possibility, in fact, has been the propit region (in part a terra nova) explored by post electroacoustic and computer in the last 4 decades.

Ultimately, this dyadics internal to the pitch reflects a profound cognitive separation, in which sound and structure are experienced as different, if not contrasting aspects. Most of today's computer music conforms to such profoundly dualistic action frame, which is in fact overtly manifested in the clear-cut separation that musical system design makes between "instrument" an operating "model of sound material" and "sound" an operating "model of musical structure" (see below).

In practice, however, the distinction between algorithmic composition (where sounds are symbols manipulated by explicit rules, thereby remaining material outside the focus of the
compositional task and timbre composition (where sounds aspire to be self-consistent objects, individual forms) is a matter of degree. Or even a matter of where we enter the compositional process, as Pierre Schaeffer noticed in the mid 60ies:

...pour une séparation assez nette surtout oller l'implication essentielle qui articule les structures du simple au composite, et qui ne fait pas apparaître forcément le simple au point de départ, on aura dans de têtes relations n'importe quel niveau, et on accède alors aussi bien aux étages supérieurs que aux inférieurs [Schaeffer, 1968, p. 32-36].

In computer music the dualism "sound/structure" and the implicit (pseudo)-ontological opposition "form/material" - plus their relative aesthetic attitudes, "formalism" and "materialism" - are captured by the different level at which computation is utilised. In the disposition of algorithmic composition, computation takes place primarily at a level as high as the level of note-to-note relations (note-time and event-time). Then, computed data and relationships among data are given concrete shape with independent, pre-existing sonic material to become audible. (This may be done via instrumental scoring, the control of MIDI tone generators or the call to a software "orchestra").

Differently, in the attitude of timbre composition computation offers the lowest scale of time (control- and audio-time); it yields audible results which are then submitted to autonomous higher-level organisational strategies.

In the former case the emphasis is on the composer's model of musical design, defined as the composer's instantiation of a procedural description for the musical structure. In the latter the emphasis is on the composer's model of sonic material, his/her procedural description aimed at the generation of sound materials, possibly in term of timbral morphology.

Because of this fundamental cognitive dualism and its pendant in the dyadetics proper to the process of composing, computer music research has always followed two distinct directions, often largely independent one from the other. At one level - analysis - scientific research has been addressed to the representation of musical process and the representation of sound signals. At an other level - synthesis - those scientific efforts have given rise to automated tools for computer-aided composition and to sound synthesis and processing techniques.

So we are back to the initial observation concerning the separation between the cognitive competencies of algorithmic composition and those of timbre composition, a separation that in fact computer music publications usually mirror faithfully.

2. Challenging the Dualistic Paradigm

The use of computer, however, can allow us to break the barriers of our musical imagination within which we, as composers and theorists, still work. One of the most relevant challenges of today computer music implies a profound re-working of the modes operandi just described, and inevitably results in a different perspective concerning the relation of material to form, of sound to structure. In this second section, I would like to describe some examples of this alternative perspective. For a discussion bearing on its parallel transformations in the very notion of timbre, musical time and musical form outside the dualistic paradigm, the reader is referred to [Di Scipio, 1993a; 1993b; Dubuis 1991, part II, chap.III] and [Di Scipio, 1991; 1994 (only for Italian readers)]. Important related issues are also treated in [Truax, 1992].

2.1 Models of microstructural composition

Indeed, since the inception of electroacoustic music, we have faced clear signals of new paradigms of music composition. This can be seen, for example, in Xenakis' work with analog and, later, digital means. In some of his musique concrete production (Concert PH, 1958) as well as in successive work with analog (Analogique B, 1960) and digital synthesis (La Légende d'Eer, 1977), Xenakis' approach is one in which relevant features of the compositional project are concerned with the musical structure at the level of the minimal scales of temporal granularity. At the time of Concert PH, similar paths were being explored, with different means and aesthetic aims, by Henri Pousseur (Scambi, 1958) and, partially by

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Later followed the work of Herbert Brün, with his early Infraudibules (1969) and the SAWG-IT project. And G.M.Koenigs See (Sound Synthesis Program) More recently, a similar vein is found in Paul Berg's P.1.8 project [Berg, 1985], in several approaches of granular synthesis [Trux, 1988; Roads, 1991; Di Scipio, 1990; Di Scipio & Tisato, 1995] and the closely related use of TOP synthesis [Rodet et al., 1984]; and, finally, in renewed approaches of non-standard synthesis [Manzoli, 1993; Chandra, 1993], including Xenakis' dynamic stochastic synthesis [Xenakis, 1991] and methods of functional iteration synthesis in course of development by this writer and colleagues [Di Scipio & Prignano, 1994].

What does bind together all such different experiences in composition and sound synthesis? The common point is the fact that the composer's model of sonic material behaves like a model of micro-time sonic design [Di Scipio, 1993b]. To say it with different words, models of sound material and of musical design become inseparable: the compositional process is applied at the scale level of the microstructure of sound and yields the structured organisation of myriad of minimal units (each of which, taken per se could not be perceptually significant).

2.2 Algorithmic approach and microcomposition

The task of microcompositional strategies can be described as one of letting global morphological properties of musical structure emerge from the local conditions in the sonic matter. One must use a microstructural representation of sound signals, either in the discretized 3D space $\Delta f / \Delta g$ of granular representations, or in the discretized 2D space $\Delta f$ (the simple time/sample grid) of non-standard synthesis. The minimal discrete units of such representations are seen as symbols submitted to manipulation by formal processes of the composer's own invention. This embody an arbitrarily devised process and reflect an abstract model corresponding to no generalizable (acoustic) theory. In the compositional implementation of such processes, the composer-structure features primarily compositional - rather than physical or psychoacoustic - parameters. The fundamental point in such approaches lies in the fact that algorithms implementing a model of sound material actually implement ideas concerned with musical form, too. This equals to rule-based approaches in principle, form is operationalised by audio-time processes [Lake, 1985].

Models of standard synthesis are instances of known theories of sound: one utilizes them in his/her own model of musical design. In contrast, non-standard models instantiate a possible theory of sound, one explores them, and learns how they can modulate the sonic structure. So, while for the dualistic paradigm of computer music composition, the coherence of the sonic structure stems from the coherence of the underlying acoustic representation, for the holistic paradigm such a coherence can only be dependent on the concentration of the strategy captured in specially designed algorithmic processes. It becomes the coherence of a musical structure, wrenching sound out of the realm of "natural" phenomena where it still stood according to the former conception.

2.3 Form as the formation of timbre

Indeed, the opposition of composing-the-sound and computing-with-sound, we have seen, resolves a separation in competences and actions bearing on the sound materials from competences and actions bearing on the musical construction, blurring the separation between models of materials and of musical design also means questioning this apparently inavoidable opposition. In fact, each approach of algorithmic micro-structural design proposes a Theory of Composition as a Theory of Sonological Emergence: how to determine a ground-level quotum or process' quantitative organization capable of bringing forth a meta-level system or process of peculiar qualitative, morphological properties.

The resulting objects of such perspective of compositional design cannot be named sound material. On one hand, they may appear as extended, sometimes internally articulated sonic gestures - rather than single, discrete events (the discrete symbols of a "musical discourse"). On the other, we have seen they are the direct result of a creative process extended to a level that we usually conceived of as a "composer-independent" task of sound synthesis. These observations lend themselves to view the resulting sounds as composition as musical form, but in the special attune in which timbre - the qualitative emerging properties of the sonic structure - can be conceived as form. Thus, in this medium form can be described as a process of timbre formation through time. Rule-based (algorithmic) timbre formation is the proper realm of invention of this sonic art, where timbre - the phenomenal appearance of sound composed - comes to be an attribute of the musical structure rather than of the material components of that, the phenomenal attribute of the musical artifact composed is a holistic approach to sonic design.
3. Composing as the exploration of possible formal Theories of Sonological Emergence

One may not need to address his/her algorithmic models towards the composition of timbre in explicit terms, indeed one may not be interested at all in thinking of his/her design task as one concerning timbre. Admittedly, many approaches of non-standard synthesis, up to date, can be situated in the more general context of algorithmic composition, with aesthetic results relatively rich in timbral properties (sometimes really dull, indeed). But this has nothing to do with the dynamics of the creative process of microstructural composition: whether a composer address conceived of his work as timbre composition or not, each local configuration of sonic units that he/she composes has its own morphological reality and brings forth emerging properties (those we say timbre) which reveals a a higher level of existence and can be observed in terms of phase states of a dynamical process.

Thus, a composer's model of micro-time sonic design is a possible instance of a Theory of Sonological Emergence (TSE), that by which he/she imagines and explores possible links between the patterning of atomic details - a ground-level process (glp) - and the sound forms which emerge from them - a meta-level process (mlp).

3.1 Ausbehung

The passage of a system or process from a given structural organisation to a new state of order which is recognised as a function of the qualitative properties of the former, is what we call here a phenomenon of emergence - ausbehung [Wilden, 1972]. Similar phenomena can be described with rules of morphostasis (conservation of coherence, identity) and morphogenesis (dynamical behavior, change) which together capture the main peculiarity of social and living systems: self-organisation.

We have seen that in the holistic paradigm of music composition, where (the materials') timbre and (the music's) form are experienced as one and the same qualitative, emerging conditions in the sonic structure, it may be argued that this process be describable by morphogenetic models, micro-theories of music cognition (each concerned with one work or a set of works by the same or diverse composers). The subject of cognition (a composer, a listener) would be an integral part of this model, even though in actuality he/she always tries to hide his/her active, inventive role and simulate a (virtual) self-organisation of the musical structure.

Here we are only concerned with the properties which are to be expected in a mlp arising from a lower glp. Among them we'll recognise:

- new local configurations of order/disorder
- significative structural innovations (semantics)
- an increased adaptive range (learning)
- the possibility of changing goal-state
- a transformation in the code of communication
- a positive sensitivity to noise

For an external observer of the artifact, the glp may be simply inexistente, since it remains in the background of its synchronous mlp. It is the composer's task to let him/her perceive the epiphenomena in the mlp both as structural qualities brought forth by the glp behind it (i.e. to reveal the his/her techniques of art) and, simultaneously, as a comment to that (meta-)communication.

3.2 Constraints and mathematical models

A most relevant set of extra-compositional constraints which an instance of TSE can be expected to take into account is the one prompted by perception and cognition, particularly as far as issues of auditory scene analysis are concerned [Bregman, 1990]. It's not by chance that dynamical auditory percepts seem to be better characterized in terms of "granular" representations and of "textural constructs" - maybe borrowing the notion of section - the atomic element of texture - from studies in visual field perception [Julesz, 1981]. (For a preliminary application of Julesz's theory to music, see [Gabel, 1993]).

Other constraints on the operationalisation of such a model include the composer's aesthetic and ethical beliefs, as well as other socio-cultural issues which cannot be discussed here.

Finally, a major obstacle could be represented by technological limitations of a particular task environment where the compositional process takes place. Much of the problem is a question of intelligent software design in the implementation of user interfaces and, especially, the control-structure among musical objects and data existing at various scales of time and structure. Except for very few cases (the work of [Scalziti & Habel, 1991] can be viewed as one such exception), it is quite difficult to find computer music systems which let the composer decide where - at which scale of structure - to enter the compositional process. Still today, when this kind of problem has been largely and repeatedly recognised by many...
composers, designers of musical systems and musicians themselves seem to lack this sort of ecological awareness. My opinion is that though everybody will accept that computer programs can be conceived as theories [Simon & Newill, 1970], in actuality very few are prone to understanding music composition as a kind of creative modeling of (promoting a theory of) musical experience.

Fundamental in implementing an instance of TSE is the algorithmic procedure and its mathematical form. Indeed, the core model in this kind of musical undertaking is expected to:

- match the requisites put forth by the composers;
- show qualitative responses involving at least some of the major features of a phenomenon of emergence (see above);
- be computationally feasible and conceptually clear to the composer.

In my experience as a composer, models of nonlinear dynamical systems have proved to be of real use with respect to such expectations. Starting in 1989, I have used simple iterated equations systems as a central feature in the control-structure of granular synthesizers [Di Scipio, 1990; Di Scipio & Trisotto, 1999].

Presently, the same kind of theoretical perspective is taken in order to enlarge the scopes of non-standard methods of sound synthesis to timbre composition; this research is now coming to some results with the implementation and analytical characterization of functional iteration synthesis [Di Scipio & Prigogine, 1994] (that I hope will be the object of a specific presentation to the computer music community as soon as possible). The term functions iteration, was drawn from terminology introduced by one of the fathers of chaos theory [Feigenbaum, 1980], and indicates the iterated applications of different equation systems including nonlinear transformations and mapping.

There is a whole world of multi-levelled structural behavior to be studied in such simple models, and its application in the digital generation of sound seems to give rise to sonorities which fall outside the classes of sounds obtainable by any standard method of synthesis. (An important point: in such kind of musical research one should avoid to use models of deterministic chaos to get a sort of super-oscillator or enhanced quasi generator. The essential philosophy is this kind of application aims, after all, at making plausible a renewed conception of the compositional work; i.e. it would only be misleading to exploit such means within a conceptual paradigm extraneous to them.)

3.3 Subsymbolic strategies of composition

A final observation refers to the fact that in all models which embody some instance of a TSE, the level of the gap, at which the microcompositive process operates, corresponds to the rate of mental information processing proper to a subsymbolic stage of cognition. A sound grain, a digital sample, a texture, etc., are not in themselves significant as percepts, and can hardly be experienced as discrete symbols of a musical structure (exceptions may be found, but they are just exceptions).

Presently, my definition of subsymbolic strategies of composition can only stand for this correspondence with scale and dimension in the emergent structure directly adjusted by microcompositional models. It could be possible, however, to establish a closer link between different cognitive rates of music information processing, the subsymbolic included, and compositional models embodying a possible TSE - for the notion of emergence is of central relevance also for theories of cognition and concept formation [Edelman, 1989].

In such the same way as subsymbolic paradigms of cognition try to capture how mental data are mentally pre-processed to constitute a symbol, and then how symbols are treated as components of higher forms of organization, a holistic approach to composition - understood as a theory of nontraditional emergence - may find it appropriate to describe its models of sonic design in terms of subsymbolic processes yielding the musical structure we experience by listening.

4. Summaries

In the first part of this paper, I have discussed the relation of forms is material, of sound to structure within the dualistic paradigm of music composition - which, in the composer's age, reflects into the distinct experiences of algorithmic composition and timbre composition.

As shown in the second part, computer music composition can go beyond the boundaries of that paradigm, by blurring the separation between models of sound material and models of musical design, one can approach composition from a holistic perspective, questioning the very opposition (once reputed ontological) of form versus material, of structure to sound.

In the third part, I have attempted a clarification of what kind of theory of composition may be put forth within the holistic paradigm just described. The definition of Theory of Subcompositional Emergence has been prompted, together with a short discussion of the constraints and the prerequisites for instance models of such theory.

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