Code–notes–music: an epistemological investigation of algorithmic music

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This paper deals with the role of the composer in algorithmic music. This role departs from traditional models because of the way computers are used in the compositional process, particularly when signal processing techniques are being integrated with sophisticated formal models to generate musical compositions. We shall examine several types of 'musical formalism' in order to bring out the active role of the composer in the compositional process.

1. INTRODUCTION

Composing algorithmically – using a computing process to devise a composition – has been considered in the past. We could trace the history of such practice from Vaucanson's flute player automaton to the compositional potential that Ada Lovelace saw in Babbage's analytic engine. We could argue that the advent of modern electronic computers simply permits implementation of similar automation in real time, with a level of complexity and thoroughness which does not in any new way change the compositional process. In contrast, if the involvement of computers in composition is seen as significantly different from the simple programming of an automaton, it raises the question of dehumanisation of the process of composition and casts doubt on the idea of creation, the production of the new.

Algorithmic music can be defined as a music which is 'automatically' composed by formal mathematical algorithms that operate deterministically or stochastically on sound attributes and/or musical structures. This compositional process may be used in 'real time' or in 'deferred time'. Early examples of algorithmic music include Xenakis' formal music (Xenakis 1971), Pierre Barbaud's algorithmic music (1966) and Hiller's *Illiac Suite* (1959). More contemporary uses of this technique include the fractal experiments of Voss and Clark (1978) and Holtzman's experiments in generative grammar (Holtzman 1981). Algorithmic music, in effect, uses formal models, defined by a choice of representation and a finite set of axioms and rules (Hofstadter 1979) to help control the sounds which constitute music or the language which structures musical forms. Various approaches to algorithmic music can thus be compared in terms of the use and integration of these two components – sound and language – and alternatively in terms of the type of formalism (formal model) they use. An evaluation of several types of formal model in terms of structure and the philosophy of knowledge implied will help to situate the composing subject in the process of algorithmic music.

2. SOUND/LANGUAGE

First introduced in the early 1950s, computerised algorithmic music formalisations were primarily concerned with the structure of a composition, its language, and were for the most part written for traditional musical instruments which provided the sound. A newly articulated information theory (Shannon 1948) seemed to reasonably model linguistic as well as musical expectations (Meyer 1967) and inspired this privileged interest in structure. Structural methodology used by many linguists and musicologists (Ruwet 1972) was also a factor in this research of musical structure.

At that time, the large computational requirements of signal processing, a science still in its infancy, prohibited any real-time processing of sound. However, several technical and aesthetic changes prompted a focus on sound analysis and its possible processing by computer. Iannis Xenakis in reaction to total serialism, which he argued could not possibly correlate the row writing of the score with the perceptual effect of the sound, proposed to systematically compose 'clouds of sounds'. Inspired by the evolution of the sciences toward a probabilistic framework, he suggested literally computing sounds from stochastic combinations of elementary textural components such as string pizziccati or glissandi. Xenaxis effectively demonstrated this technique in *Metastasis* (1954) and *Pithoprakta* (1956). From another perspective, Jean-Claude Risset pursued the timbral analysis which Pierre Schaeffer (1952) had initiated. After dismissing Helmholtz's theory of musical acoustics as unsatisfactory, Risset (1969) dissected the micro-variations of the spectra of trumpets or violin tones and succeeded in resynthesising them by

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generating credible sound samples from the short-time Fourier transforms of their dynamically varying spectra. At the same time, Max Mathews (1969) laid the first foundation of the first patchwork software, *Music V*, to automate the computations similar to those suggested by Risset. *Music V* was a programming language capable of describing the computation required for the generation of series of complex sounds, with varying spectral and envelope characteristics. To this day, *Music V* has remained a model of musical software organisation. Today the integration of real-time signal processing and structural language control is possible thanks to the speed and capability of modern computers. Entire pieces of music can be algorithmically processed in real time, as the Chant/Formes system demonstrates. Indeed, technology is so advanced that a composer can realise 'spectral' compositions which intimately relate the micro- and the macrostructure of the composition by making the structure of the musical language directly dependent on the characteristics of the sounds used in the composition (Born 1995).

3. A MENAGERIE OF MODELS

The range of formal processes used in algorithmic music differs significantly when it comes to processing sounds and processing form. Although the formal models used in the synthesis of sonic material usually provide significant control, these models have always remained close to acoustics and the procedures of signal processing. In contrast the formal models of structural musical language have been influenced by a number of models related to music. Formalist models of music based on statistical and linguistic theories were developed, but other formalist models only loosely related to the musical process were also tried. For example, mathematical models derived from information theory, in particular Markov chains, were used by Xenakis, Hiller and Isaacson. Moreover, Barbeau and Xenakis also used more formal mathematical models such as set theory and game theory as organising principles for their compositions. Since music and language are formally and informally described within generative and semiotic paradigms in a structural description (e.g. Schenker 1954, Lerdahl and Jackendoff 1983, Cope 1991) or temporal implication description (e.g. Meyer 1973, Narmour 1977, 1990, 1992), formal models more specific to music were also used. In these generative and semiotic models 'language' was represented by a finite set of production rules. The generative approach (Chomsky 1975, Schank 1972) derived its rules from *a priori* formalisms, while the semiotic approach derived its rules from experience through the recursive application of arbitrary transformations.

Algorithmic music has also structured composition through generative models simply thought to be 'more representative' of the musical process on a strictly philosophical ground. Fractal models and chaotic models are prime examples of this type of formalism because processes with fractal dimension are thought to be 'between order and chaos', where music is also assumed to be. In the same way Thom's application of catastrophe theory to morphology exhibits a formal structure which describes the macrostructure as a direct isomorphism of the microstructure. This formal property of Thom's morphological model gives the composer a way to formulate the relationships between sound structure and the language structure framing the compositional process as one of organic growth. In general, choosing a structuring formalism often becomes the expression of a deep belief of what music is and how it relates to the world. As a consequence the composer can arbitrarily choose formalisms on the basis of aesthetic preference or mysticism. Cage's use of the 'I Ching' for the composition of *Music of Changes* (1952) or Xenakis' explicit relationship between music and architecture in *Metastasis* (1954) or the relationship of music to visual traces in *Mycenae-Alpha* (1978) are emblematic of this approach.

4. TEXTUALITY

Reliance on what appear to be arbitrary models or at best models informed by the composer's 'spontaneous philosophy' may put into question the very scientific justification of algorithmic music. But, more profoundly, the process of algorithmic composition which 'textualises' music to the extreme by crystallising its very 'being' into a code and, possibly, into a complex of hardware and software, raises an epistemological question. Artistic creations using formal systems ought to be critically considered as they appear to suggest the possibility of the completeness of textual representation while the principle of their genesis defines a fragmented and fundamentally incomplete domain of expression of knowledge (Hofstadter 1979). In other words, is formal musical knowledge a knowledge *of* music or a knowledge *about* music? This question, in effect, raises the very possibility of creation, the production of the new.

To establish key relationships between music and knowledge, critical in unravelling the epistemological status of algorithmic music, we must first evaluate various modes of thinking which will necessarily frame the analysis. On the one hand, the formalist position is strongly supported by a Western philosophical tradition exemplified by Plato, Descartes, Hegel and Husserl, that systematically describes the 'world' in logocentric terms and that postulates an authority, a judge (URteil) at its origin. As Husserl

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states in his *Formal and Transcendental Logic*, 'We must place ourselves above this whole life and its cultural tradition' (Husserl 1969: 5) to partake in the project of apprehension of the real. This movement of dominance and control is the mark of the modern project which believes 'in the possibility of an advance of humanity toward perfection' (Bury 1932: 164–5). The German prefix UR (Super-) of the judge (URteil) signifies this position by establishing a transcendence best approximated by formalisms. This UR is the governing principle of the 'UR-text' of the Russian formalist, Freud's 'UR-Sein' and Schenker's 'UR-Satz'. Science is privileged to fully explicate the single truth of the real. Knowledge is the result of this apprehension ultimately expressed in an all-encompassing univalent textual description.

However, other currents of thought, present in the philosophy of Heraclitus, Nietzsche, Foucault and Deleuze, keep the issue of knowledge an open one. Instead of organising 'complete systems', these philosophers rest on the UNdefined, proceed through the UNdecidable and profess the 'UNheimlich', the UNfamiliar. This position is one grounded in history which focuses on daily practices. In this view, truth is a product of the historical complex of power/knowledge. This approach, metonymically marked by the German prefix UN, is one of openness which does not engage in a work of purification of the real but allows all realms of possibilities at the crux of UNdecidable propositions. Knowledge participates in a dynamic which 'untangle[s] the lines of the recent past and those of the near future' following the interrelated movements of 'power, knowledge and subjectivity which constitute social apparatuses' (Deleuze 1992: 163).

The UR discourse is modelled on the objective rationality of the sciences: Descarte's dream. This discourse follows the Hegelian logic which in its conclusion leaves no room for the arts. The UN discourse explodes in Dyonisian excess witnessing UNmediated expressions of the field of experience. One discourse is tediously chained to the many steps of a logical construction, erecting, over time, the development of a timeless structure; the other appears, at once, in the dance of Zarathustra participating in the historical reality of a mosaic of instantaneous moments.

Knowledge of music has been traditionally transmitted through apprenticeship. In western culture this relationship of quasi-ritual initiation existed until the middle of the eighteenth century when musical notation was codified along with the tempered scale to formalise communication. This textualisation of music is almost contemporaneous with the encyclopedic period which predates and prepares the scientific revolution. Since this period of 'enlightenment' the rationalisation of music has expanded through the development of theories which, by means of ever complicated notations, have acted in many different roles. Milton Babbitt (1972) identifies four prevalent functions of theory which appeared, almost chronologically, as symbolic description, as structured formulation of statements of relations among observed phenomena, as collections of rules for the representation of observables, and as an interpreted model of a formal system. This progression in the status of theory is marked by an ever increasing domain of operation coupled with a higher level of formalisation. Today, with the help of computers, formalisation of music has heightened in complexity and speed. However, the epistemological question stated earlier remains: Is this knowledge a knowledge *of* music or a knowledge *about* music? Will the formalisation and computerisation of musical composition turn the activity of music writing and music playing into a new branch of engineering? In response to these questions I propose looking at the formalisation of music along two axes of reflection. The first axis characterises how various modes of formalisation are constructed and seeks to understand how the formalisations explicate knowledge. The second axis of reflection provides a critical reading of the relationship of 'scientific' formalisations in music with respect to time and to the composing subject.

5. MODEL STRUCTURE

Formalisation of music comprises the development of representational attributes which describe musical objects and rules which logically relate these objects' attributes with each other. The purpose of formalisation is to understand and explain a phenomenon. The core device of such a formalisation is the well-known IF . . . THEN logical pair which computer scientists, knowledge engineers and automation engineers use to make knowledge explicit.

Three main types of formulations exist in music, each addressing different aspects of musical knowledge and each having slightly different purposes. They are, following Kant's typology: (i) pure musical knowledge, (ii) practical/procedural musical knowledge, and (iii) judgemental musical knowledge.

The most 'complete' knowledge representation of music, pure knowledge, is certainly present in Iannis Xenakis' compositions where the compositional structure is literally formulated by *a priori* formal concepts such as the groups of transformation used in *Nomos/Alpha* (1971). The musical analysis of such a piece is almost irrelevant as it is derived entirely from a stated formal structure, the consequences of which are already present. Fractal music, Markovian music, cellular automata, chaos and catastrophy theories fall under that same category of musical formalisation which assumes a universal isomorphy

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between all natural phenomena. These models consider phenomena strictly as they appear under the conditions of space and time. In this 'we find nothing that resembles freedom: phenomena are strictly subject to the law of a natural causality' (Deleuze 1983: 29–30). These approaches indeed provide rules which are predictable and repeatable at least as much as the phenomena from which they are copied; however, they rest on the reductionist belief that what is formally equivalent should have the same effect. Therefore a 'beautiful geometrical fractal' should translate into an equivalently 'beautiful fractal musical' composition as if the experience of beauty was a matter of equivalent formulations between disjoint sets of parameters mapped onto one another through an arbitrary equivalence relation.

The second form, practical/procedural knowledge, results in a music formalisation which uses production rules and recognises that an absolute knowledge of composition is not strictly attainable with mathematical and physical representations of the musical phenomena. But, following a structuralist approach, this form posits that by studying the corpus of written musical texts one can unveil the fundamental rules which have been used in writing a set of compositions. As an example, Noam Chomsky's approach to linguistics which resulted in the theory of generative grammar, was applied to tonal music by Lerdahl and Jackendoff and resulted in a set of 'well-formedness' rules and 'preferences rules' which are used for the analysis or composition of music. Similarly, Baroni and Jacoboni (1978) through an analysis of Bach's chorales derived a set of rules which explicated the writing of soprano voices in Bach's Chorales in general. In the same vein, Cope (1991) formalised a meta-theory of style by statistically characterising a stratified corpus of compositions. However, these approaches are either very limited in their scope or somewhat open in their implications. The formal rules leave visible cracks in the system. In particular, contrary to Chomsky's theory of linguistics whose pivots are the transformational rules which aim at universal explanation, the theory developed by Jackendoff and Lerdahl revolves around the concept of preference rules which, by definition, allows diversity and choice. Following the Kantian approach, this practical reason 'legislates in the faculty of desire that is to say in its practical interest'. The knowledge of the practical reason is a procedural knowledge made up of chosen *ad hoc* laws which operates on the 'things in themselves thought as noumena, in so far as they form a suprasensible nature' (Deleuze 1983: 31).

The third type of music formalisation does not even attempt to explain the structure of compositions *per se*. Its only rationale for the development of rules is to understand some invariance in musical perception. Rather than relying on mathematics or physics or on the determination of creation of an utterance, its core principle focuses on perception and on developing implication rules based on gestalt. The purpose of these rules is limited to the field of musical analysis; they are used to explain systematic structures encountered in musical composition but do not claim to explicate all possible music. This rule system is literally a system of local heuristics used as an analytical tool. Although the basis of this system of rules is somewhat general in its formulation, it never claims universality because it does not seek provability and can be replaced on the spot by other working hypotheses. The rule system, thus provided, only sets a context for the composer. The implication/realization theory developed by Narmour (1977, 1990, 1992) is a prime example of this approach. Narmour proposes certain operating rules for analysis but always allows the specificity of the piece to speak with or against the formal backdrop framed by the theorist. Paralleling Kantian typology the theorist who practices judgemental musical knowledge 'know[s] that there are two types of legislations, thus two domains corresponding to nature and freedom, to sensible nature and suprasensible nature. But there is only one terrain, that of experience' (Deleuze 1983: 40). This third category of formalisation is the only one to focus on the subject of perception in the actuality of his/her experience, and in that, significantly differs from the other two. This final category inherently recognises and respects the difference between the arbitrary *de jure* provided by the rules and the reality of the *de facto* perceived in the particular realisation of a particular space.

6. THE SUBJECT OF THE MODELS

The image that comes to mind when one speaks of sciences is a domain of well-defined concepts, unambiguous definitions and clear procedures. This somewhat caricatural view shows every phenomenon destined to be reduced to its minimal explicative nucleus. What remains, the difference, must be squeezed out, discarded as an error later to be reduced to zero. We recognise in this model the certainty of Newtonian physics as seen through nineteenth century ideology: one formula to explain the world where everything works on the same universal, uniform principle. To be sure, the scientific method has been very successful within the confines of what our society has decided to call successful, but dissenting voices can be heard. In particular, Freud's discovery of the unconscious established that experience embedded in history cannot be reduced to this proverbial formula. In line with this reflection on the unconscious, the formal models of semiology or structuralism can be criticised as lacking reference to

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that unconscious. It can thus be argued that the reality of language resides in the speaking subject which is fundamentally heterogeneous. Musically speaking, this reference to the unconscious subverts a traditional 'scientific spirit' by letting the subject in his/her temporal reality take the forefront of the scientific scene, and by letting the composing subject cut through the formalities and allow expression of pleasure and desire.

Pure formal systems provide an explanation of the world that is posited as universal and independent of time and space. Formal models of music do not escape this objective: they attempt to find an explanation for every structure that can be encountered. However, there is a paradox when theories of music deny or completely control time, the very principle of music's existence, and when, in the same move, these all-encompassing formalisms deny or repress the subject of music: the composer, the interpreter or the listener. Indeed, the parametric time of physics or even the time coded in musical symbols (Chronos) is not the same as the psychological time of musical durations and musical experience (Aion). These formalisations could, in fact, border on an extreme caricature of the tradition of our technological society. By solely representing the pure expression of a symbolic lingo, music formalisation leads to the logic of madness described by Foucault (1973).

But there are alternatives to such a univocal totalitarian world. Barthes suggests that we let multiple meanings wink at each other 'as if the words' meanings were in that wink, so that one and the same word, in one and the same sentence, means at once and the same time different things' (Barthes 1977: 72). Music formalisation can take advantage of such an alternative when used as a metaphor, a tool for the explanation of something bigger than whatever it spans, while acknowledging the composing subject. The freedom of interpretation is at the core of this practice. It is the practice of specific intellectuals who do not 'admit to the universality of the founding subject . . . but also do not admit of univeral catastrophes in which reason becomes alienated and collapses once and for all' (Deleuze 1992: 182).

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