After tasting the oranges the peasant had offered to him, the King expressed his approval with a compliment. Happy and proud of his produce, the peasant answered: "Your Majesty! You haven't seen anything yet! With these we feed the pigs." (from a poem my grandfather often used to tell; also in O. Bernardini, "The cost' una larga figlia", p.77 Ed.Romiti Rome 1980)

Introduction

A recent document from INOAK begins with the following statement: "The problem that Musical Research must solve today are not so much technological as cognitive" (INOA - Recherche Musicale 05/06 p.1). We feel that this statement summarizes most insightfully a situation that at first glance looks very confused. Despite the great technological leaps of the recent past and of the present, computer music - and, for that matter, music in general - still seems to be, aesthetically speaking, at a very critical point. Indeed, there are many ideas circulating, but few of them seem relevant to compositional activity.

The aim of this paper is to penetrate the twists and turns of composition in the Western world today (including the USA), and, in the space at our disposal to try to point out at least some of its relevant instruments - both physical and theoretical. Coming from a composer music computer, this paper might be considered a compositional proposal (though not in the generative/procedural sense), although it must be clear that: 1) it is not intended to be an absolute in any way; 2) rather, it is a reflection that stems from the compositional activity in the field of computer music; 3) it is not, by any means, an analysis of the author's own composition. We would hope that what a composer thinks about composition is quite different from the compositions themselves.

Since the paper will delve into many different fields, prior works will be mentioned only as they help to clarify specific elements in the discourse. Moreover, we will try to convey their meaning and purpose in spite of the necessarily short quotations. Of course, the responsibility for any inaccuracy rests entirely with the author, who wishes to encourage all remarks, observations and criticisms that may arise.

Some reflections on the computer's environment

To understand how a compositional model works in its related environment it is first necessary to analyze the reality in which this model exists: that is, postmodern society, in our case. Culture in postmodern society has been abundantly studied (cf., for ex., Harris 1971; Lyotard 1979; Lyotard 1984; Vattimo 1985); we are therefore relieved of the responsibility of doing it ourselves.

So, let us underline what we consider to be its most important characteristics. In postmodern societies "narrative function" shatters into clusters of narrative, but also descriptive, prescriptive, descriptive, etc. linguistic elements, each carrying within itself some sui generis pragmatic valency. (....) Thus, the derivating society is less dependent on a Newtonian anthropology... than on the pragmatism of linguistic particle" (Lyotard 1979, p.6).

Lyotard's thesis is that, in this way, this society produces a "crime du réel", a crisis of the narrative device that, up to now, has allowed the legitimisation of
of knowledge (cf. Lyotard 1979). All that remains of language as it disappears is an infinite chain of separate phrases. The uniformity and homogenization of this condition can be broken up only in that "instant of language in which something that must be expressed in phrases cannot be expressed yet" (cf. Lyotard 1984). This "lag" is the "different" which indicates a verbal surplus in respect to human will and which casts doubt on the concept of "a language naturally at peace with itself, "communication", and agitation solely by reason will question and intention" (cf. Lyotard 1984). Of course, this involves many sociological and political implications which, although important, are beyond the scope of this paper.

Paraadoxically, this new nihilism, this "passion deboe" (cf. Watino et al., 1983) produces a "subjectivity without a subject" (cf. Mochot 1953) which incorporates in itself its own contradiction: a "strong" element of hope and survival. In fact, it is not surprising that hermetic philosophers are now claiming a "return of the subject" (cf. the 7th issue of Language, Paris March 1985), by reevaluating thinkers like Renanistes and Durkee and their fight against the subtext of a transcendentalism without a subject (cf. Huron 1983) operated by structuralism.

The status of sounds

In the society described above, sound is trying to establish a new identity after the irreversible transformation undergone due to the development of sound reproduction techniques. This transformation has been double or analysed from the sociological point of view (cf., for ex., Adorno 1964; Benjamin 1974; Adorno & Enard 1955). The output of these studies has produced many considerations which are indeed valuable for the electronic and tape music composer (cf. Stolnaya 1958). The loss of the traditional "no et non", the "aura" (cf. Benjamin 1974) of the reproduced work of art, which becomes "more and more the reproduction of a work of art designed to be reproduced" (cf. Benjamin 1974) is something with which most of us deal daily on a day to day basis. On another level, "the influence of the various manifestations of media industry (...) have induced (...) a deep change in the 'music' institutions as it has been handed down to us through history and of the functions and structures of both old and new music" (Bayer 1985, p.119). Willingly or not, we musicians are part of this change and it would be foolish to ignore it.

Still, we find that something in these sociological studies has been neglected, that is, sound itself, along with today's human perception of musical structures is the era of their reproducibility. However, other authors from not specifically musical fields have provided approximate insight into these matters. McLuhan, for one, by analyzing the transformations introduced by typographic technologies (cf. McLuhan 1962), has given us good clues as to what happens during and after media revolutions.

Music notation and music reproduction

Referring to the transformations introduced by the phonetic alphabet, McLuhan wrote that "a new kind of processing of problem, one thing at a time..., must succeed to the older dialogue. For the scholastic method was a simultaneous opacity, a dealing with many aspects and levels of meaning in crisp simultaneity. This method will no longer serve in the new [alphabetical and typographical] linear era" (McLuhan 1962, p.29). This "linearity" of processing, transposed to the introduction of music printing shortly after typography, has contributed to the essential development of tonality (a phenomenon that McLuhan himself noticed - cf. McLuhan 1962, p.61). Here too, some self-evident facts hide a deeper transformation, the influence of which is still being felt (cf. below). The proliferation of the marimba, of the French polyphonism "Chansons" and of late tablatures are evidence to the expanding market directed towards the new bourgeois classes and the urban aristocracy, a market enhanced beyond imagination by the new-born music publishing business. But we are allowed to think that, if music printing changed the target of compositional activity from a religious to a more lay (though not yet entirely bourgeois) one, it then set the basis for a music in perpetual linear development. That is, a development based on sequential transgression of the rules set forth in precedence. The tempered tonal system served as an excellent starting point because of its strong grammar, and has lasted more that 300 years (a long time considering how weakening such transgression has been). This is the model of music composition evolution we have in-
It is reasonable to consider that the simultaneity between the shattering of the ontoic system (and subsequently, of its development model) and the birth of sound reproduction was a mere coincidence. Nevertheless, this simultaneity heralded the crisis music has been suffering in this century exceedingly profound. Considering digital developments, we may not agree with Sollman’s prediction that “our world shifts from a visual to an auditory orienta- tion in its electric technology” (Sollman 1962, p.20). Here music composers knew too well how hard life is in the “civilisation of the Big Eye.” Still, many of these reflections proved to be useful. “The new electric structuring and con- structing of life more and more encuent in the old visual and fragmentary procedures and tools of analysis of the mechanical age” (Kochan 1964, p.26). On one hand, the oscillation ... from visual to auditory space took human consciousness back to a sensual one... and on the other, this return was not structured as a simple return to a pre-alphabet past” (Hochhein 1986, p.71). This means that the mind is now able to maintain its linear epistemological habits in a multi-dimensional perceptual world, which brings us back to the post-modern situation we envisaged at the beginning of this paper. And as we suspect that sound reproduction involves far deeper transformations than music printing did, we are bound to think that, instead of synthesizers, digital technology, etc., sound reproduction, as a medi- ier of our own, perceptual structures, is really the instrument of a new kind of composition, which must not be confused with a new kind of composition.

The musical sign’s status today

Goodman (cf.Boose 1986, p.99; also cit. in Eo 1975, p.241) makes an im- portant distinction between “aesthetic” and “allegroic” arts: “the former cannot be natural and do not contemplate per- formance, while the latter can be trans- lated into conventional notation, and the result is ‘score’ not be performed, with a certain freedom of variation (i.e., mu- sic)” (in Eo 1975, footnote in p.241). Who then specifies that this distinction is derived from the opposition between ‘dense vs. discrete’ signals. A ‘dense’ or ‘continuous’ signal is out for which it is difficult to determine generating rules making any kind of replica impossible (i.e. paintings) (cf.Boose 1960; Bos 1970), This is not without consequences, because, in language theories, dense signals have been considered to constitute sy- bolic monoplane systems. That is, they are not interpreted; rather they tend to be interpretable (cf. Hjelmslev 1914). And even what someone like Eo tries to estab- lish a system for these signals, he is obliged to limit himself to very vague terms like “textual galaxies,” “open signals,” “propositional structures” and so on (cf.Bos 1975, par.1.6.6). This is because of the non-segmented nature of these signs, which will not allow precise and definite articulation. Since music has always been “reproduced” by means of conventional notation it is usually con- sidered to be constituted by “discrete” signals. We want to point out that this conception of the musical sign is only partially correct, since it works only because of notation. It would seem, then, that musical signs behave like verbal ones, constituting some sort of dichotomy like that proposed by Sollman (the dichoto- my komen/parole) of, Muszma 1922, chap. (III) or that suggested by Pikes (the subdivision a-rhythm / rhythm of Pikes 1947, chap. II). Many musicologists and linguists have adopted those schemes to represent music in terms of languages (cf.Springer 1956; Ayusus 1967; Wright 1943; Andtl 1971; Guenewant 1971; Chartier 1975). Sollman (Sollman 1975, pp.74 and ff.) has fore- seen in the adaptation of music to the language/paroles dichotomy some of its limi- tations, and has tried to demonstrate that this dichotomy automatically generated a typology in the following way (Sollman 1975, p.22):

**Languages**

<table>
<thead>
<tr>
<th>Parole</th>
<th>Notated Comp.</th>
<th>Particular Interpretation</th>
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<tr>
<td>Language</td>
<td>Compositional</td>
<td>Noted Comp.</td>
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However, since “the tonic system [among other reference systems] exists only for harmonic traits [manufacturers, etc] and mon- grammatical rules are in fact stylistic rules” (Nattiez 1975, p.64), our author answers, “between the single composition and the tonic system ... as infinity of stylistic levels” (Nattiez 1975, p.36). But this does not eliminate the affinity between verbal language and musical lan- guage since Nattiez himself writes a little
later that "it is extremely interesting to establish that it is impossible, in the musical field, to depend on a single pertinence level, much in the same way as linguistics have been forced to re-
recognize the distinction [language/semiology]" (Stalleur 1975, p.66). Evidently the problem is elsewhere.
The fact is that, from the "notation-as-meaning-of-reproduction" point of view, rather than a discrete signal sound be-
haves like a so-called "dense" signal. Following the definition given by H. of such signals, given a perceptual model as a 'dense' representation of a certain experience, assigning to the perceived object x the properties y, z, \ldots, x, as soon as the cultural experience is carried out the perceptual model originating a semantic model that keeps only a (x properties of the 'dense' representation) [italics ours] (Sco 1975, p.112).
Which is exactly what happens with music notation.
We believe that the mistake of considering sound a "discrete" more than a "dense" signal is due to the fact that we think of music in an old-fashioned way, while experiencing it through the contemporary world of reproduction and media. This mistake has given rise to many inconsistencies in the study of musical signs. Think that the difficulties encountered in establishing pertinence levels by means of the classical organization of music (cf.Roelof 1967), among others, has led many musicologists to think of music as a monopla-
nar language (cf., for ex., Leiby 1975, p.90; Jakobson 1973, p.14; Delalante 1955, p.53) as do the proponents of the tradi-
tional formalist theory (cf.Hall 1957; Stravinsky 1947; Jansen 1951; etc.). This, in turn, has led the theorists who believe in a musical language not purely syn-
tactical but provided with a semantic depth, to think of the semantic connota-
tions of music in terms of referential connotations exclusively (cf. the extreme example of Cooke 1962; but also; Sayer 1956; Osmond-Smith 1972; Leiby 1975; and to a certain extent; Lauma 1976; Stefani 1976). It is worth noting, however, that the problem of a semantic le-
vel of music has been debated for more than a century now, and it is still very confused.

Once again, sound reproduction comes in very handy, because of its ability to to subdivide the sound continuum into seg-
ments as small as desired. It is clear, then, that sound reproduction is an in-
novation comparable to that of the pho-
netic alphabet and of movable type, while the representation of sound and music given by musical notation is, at best, com-
parable to the representation a good pho-

tograph can give of a work of art. The lack of a means of segmentation in music has orients its perception in the past towards a purely denotative system of signs (ex-
cept in the case of programmatic music in which, although the references were coded quite artificially, some semantic capabili-
ty of music was thus demonstrated).
Sound reproduction (and its corollaries, such as music diffusion etc.) has allowed our perception to grasp new connotational levels that were simply inconceivable be-
fore. Of course, it is the appearance of digital technology that clarifies beyond doubt the potential of segmentation, falsi-
ification, and of connotation production inherent to sound reproduction. Other problems raised by musicologists during the time of analog sound reproduction, such as the problem of a scientific anal-
ysis of musical interpretation (cf.

Ruet 1975, p.34) (just to make an example of a problem clearly dictated by the new status of musical sign), can now be solved with digital means (cf.Cytron 1964). In this frame of ideas, it is not surprising that the computer music community has spent a lot time trying to establish unam-
blish if a certain technique or a certain machine is able to reproduce natural sounds, insisting on the fact that this is not done for a musical reason but for an experimental one. There are very good musical reasons to do it, and computer music composers are starting to become aware of them (cf.Marriere 1984, p.182).

Possible models of compositional develop-
ment
It is evident now that our tradi-
tional linear compositional nodes need to be revised under this new light. The amb-
iguity and depth of this new process message in music will not be described by linear development of, for ex., a new musical variable to be serialized or some new more or less designed stochastic pro-

cess (cf.Thompson 1983). It should be clear that, after all, by John Cage there can no longer be any linear "transgression of rules" in music (sufficently enough,
Cage begins his book Silence with the following sentences (cf. Cage 1973, p. xii):

nothing is accomplished by writing a
"    " hearing "
"    " playing "

place of music

"    " in excellent
"    " condition

Further, the poetic spark of music might be created, today, by the compositional ambiguity of the present time multi-dimensional musical language. That is, music is getting closer and closer to the mechanisms of poetry, which means, in short, that musically has finally acquired the possibility of becoming its own meta-language. This possibility was foreseen by a few perceptive investigators (cf. Lev). Strauss 1964; Court 1971; Eco 1975) and composers (among others, Kajser, Berio, Ives, Nancarrow, Berio, Stravinsky). But, due to technological and theoretical limitations, the full potential of this model is far from being realised. The authors we have just mentioned do not push themselves much farther than sophisticated quotiblet and quotation techniques.

A general model for semantic representation which works quite well in music is the NH model elaborated by Eco (cf. Eco 1975, par. 2.11 - NH stands for Semantically Reformulated Notation) and adapted to specific musical examples by Stefani (cf. Stefani 1976, pp. 200 and ff.). Up to now, however, it has served to demonstrate specific referential connotation capabilities of functional music. It is particularly meaningful that in Stefani's study, the examples used are jingles for advertisement, a genre closely dependent on sound reproduction. The model is represented in Fig. 1.

The (parola sintattica) represent the syntactical marks that allow the significare to be combined with other significati to produce well formed and grammatically acceptable phrases even though they are anomalous ... and therefore to define as unacceptable other phrases that would instead make sense from a semantical point of view" (Eco 1975, p. 111);

"the g's and the g's are denominations and connotations ... [and] denotative ... marks ... constitute ... the cultural unit to which the significare is primarily related and on which successive connotations are based ... connotative ... marks ... contribute to one or more cultural units expressed by the sign function previously constituted" (Eco 1975, p. 223).

"(a) signare are contextual selections, which give instructions of the type 'finding (conta) use the following g's and g's when the element is contextually associated with an g's seneshe';

(circ) are circumstantial selections, which give instructions of the type 'finding (circ) use the following g's when the significare that corresponds to the seneshe is accompanied situationally by the event or object [g], which must be intended as a significare pertaining to another semiotic system'" (Eco 1975, p. 151).

"The contextual selections file other elements ... usually associated with the represented seneshe; circumstantial selections file other significati ... which belong to different semiotic systems, or events and events gathered as extensive signs, usually occurring with the corresponding significare of the represented seneshe" (Eco 1975, ibid.).

This model is a good starting point to understand music as it is perceived in our era. Even by using an approach limited to strongly programmatic music (jingles), Stefani can demonstrate that the NH model allows the integration in an

![Diagram](after Eco, U. 1975 Trattato di Sensazione Generale, Bompiani, Milano)
homogeneous manner on one single level, of sign occurrence; but are usually con-
considered ‘special’, if not anomalous, by
musicologists, as in the mode of quotation.
As a matter of fact, quotation is confined to the MMR as a mark like any other, simply denoted on the basis of a given selection (Stefani 1976, p. 210).
We add to this that the MMR can also de-
scribe connotations that do not have exter-
ternal referents. Rough examples of verbally expressed connotations could be: ‘pointillistic’ or ‘sounds like Debussy’ or ‘pianistic articulation’ etc. - expres-
sions which serve to show how much rougher verbal language is when speaking of music than are the connotations them-
selves. Another important feature of the grid is that it can explain why the same composition can be ‘heard’ in many different, even opposite ways, by differ-
ent people. It depends on the differ-
ent amount of selections that each listener can perform (for a similar ap-
proach, cf. Nattie 1975, p. 71). This means that the MMR model is able to ex-
plain different cultural approaches (cf. Stefani 1976, ibid.), however, the MMR model is not perfect. Eco himself under-
lines its deficiencies, noting that ‘every mark constitutes ... inside a semantic module the space of sense that generates its own unrolling and so on ad infinitum, ... how it is possible to re-
present the infinite of possible marks, especi-
ally when it is exactly the semantic universe in which human beings live’ (Eco 1975, p. 74). This problem is par-
ticularly felt in music, where syntactic marks and semantic marks of signifiers of different nature (i.e. pitch, rhythm, ac-
chronic and diachronic form, timbre, in-
strument, techniques, spatial relation-
ships, etc.) are often tightly interrela-
gled together to give very specific and meaning marks (this has also been noticed by Stefani cf. Stefani 1976, p. 209). For example, it is as if, on top of enumerating other elements and connotations, we tried to specify all the para-linguistic activity (i.e. facial ex-
pressions, intonation, gestures, etc.) that occurs when someone speaks (a mani-
pulation of these parameters, as a matter of fact, has already taken place in some musical pieces, such as Stravinsky’s The Rake’s Progress Mobile or note-edge com-
positions). As a possible solution to this problem, Eco mentions the 0 model, named after its creator J. Ross Quillian (cf. Quillian 1968). The 0 model is a mo-
del of semantic memory that allows a cer-
tain degree of analysis of semantic pro-
decesses of understanding. Unlike the MMR model, in which the structure is base-
upon a number of different elements and all elements are in the same dimension, the principal characteristic of the 0 model resides in its two basic elements and seven linking categories in which elements are in a dimensions (or planes), n being the number of elements that the model includes. It is a model essentia-
ially based on defining linking types as op-
posed to the earlier one based on defi-
ning element types however, some rough similarities between the two models can be found - as we will see further on.
“The memory model consists basically of a mass of nodes interconnected by differ-
ent kinds of associative links. Each node may be thought of as named by an English word, but by far the most im-
portant feature of the model is that a node may be related to the meaning (con-
cept) of its name word in one of two ways. The first relates directly: i.e., its assosiative links may lead directly into a configuration of other nodes that represent the meaning of its name word. A node that does this is called a type node. In contrast, the second kind of node in the memory refers indirectly to a word concept by having one special kind of associative link that points to that concept’s type node. Such a node is re-
terred to as a token node, or simply taken” (Quillian 1964, p. 234). The similarity between type node and designation and token node and composition is noticeable, “in the memory model, ingredients used to build up a concept are represented by the token nodes naming other concepts, while the configurational meaning of the con-
cept is represented by the particular structure of interlinkages connecting these token nodes to each other. It will be useful to think of the configuration of interconnected token nodes that repres-
ents a single concept as comprising one plane in the memory. Each and every token node in the single memory lies in some such plane and has both its special asso-
ciative links pointing within the plane to other token nodes comprising the configura-
tion. In short, token nodes make it possible for a word’s meaning to be built up from other words meaning as ingredients and at the same time modify and recombine these ingredients.
Fig. 2 (after Quillian, M.R. 1968 "Semantic Memory", in Semantic Information Processing, Minsky M. ed., MIT Press, p.236)
into a new configuration" (Quillian 1966, ibid.). Fig. 2 is an example concerning the representation of the three meanings of 'plant' as they are described in a dictionary. "The three circled words, 'plant', 'plant' and 'plant', placed at the heads (upper left-hand corner) of the three planes, represent type nodes; every other word shown in the Fig. 2 planes represents a token node. These non-terminating arrows from tokens indicate that each has its special pointer leading out of its plane to its type definition, i.e., to a type node standing at the head of its own plane somewhere else in the memory. Each of these planes, in turn, is itself entirely made up of tokens, except for the words that make it. (...) Therefore, the overall structure of the complete memory forms an enormous aggregation of planes, each consisting entirely of token nodes except for its head node, which is always a type node" (Quillian 1966, p. 24 and ff.). "As to the nature of the nodes themselves, it will be assumed that they correspond not in fact to words, to sentences, or to visual pictures, but instead to what we ordinarily call 'properties'... Representing a property requires the name of something that is a variable, an attribute, plus some value or range of values of that attribute. This feature is achieved in the memory model by the fact that every token is considered to have appended to it a specification of the appropriate amount or intensity in the particular concept being defined... These values allow encoding restrictions to a fineness of nine graduation, i.e., permit nine degrees of 'absolute discrimination' to be represented" (Quillian 1966, p. 242). This means that the model's range reading on tags [appendend to each token node] together with its ability to form distinguishable sets of multiple nodes provides with a ready facility for representing information having a great deal of vagueness. This in essential. It is the very vagueness of the meaning of most language terms that makes them useful" (italics ours) (Quillian 1968, p. 243).

This fairly detailed description of the 6 model is necessary in order to clarify potentialities and problems concerning the use of this model in music. The 6 model proves to be a good analysis method because, not being a generative but a semantic model, it provides the following features: 1) it embodies, as we have seen, meaning ambiguity and vagueness; 2) it is possible for the system to make inferences (described as "plane-hopping"; cf. Quillian 1966, p. 29); 3) the system can operate structure modi- fications by itself; 4) finally, it is n-dimensional, allowing the different semantic planes of music (or of any other language) to be linked together. Actually, the possibility of adaptation of this model to music seems to be dependent mainly on the possibility of expressing links in terms of musical objects, an operation that, at first, sounds quite remote, however, speaking of visual memory, Quillian states that "it seems at least as reasonable to suppose that a single store of information underlies both 'semantic' memory and 'spatio-visual' memory; their difference being not in the structure of the information store, but rather in the way that the static information of that store is used" (Quillian 1966, p. 239). Once again, segmentation of a continuum (in this case, the visual one) is the conclusive condition for semantic proliferation; this condition is now possible in music by means of sound reproduction.

There were a few problems in the 1968 version of the 6 model, some of which were more of a technical nature and may well have been solved by now (cf. Quillian 1969, par. 4.5). But one of a more structural nature underlined many of its possibilities: it was, basically, a deterministic node, the idea of memory as a huge dictionary, derived from the Katz-Pastin model (cf. Katz & Pastin 1964) (a node) that Quillian himself criticized (cf. Quillian 1969, p. 265), im- plies the model into marvelous aggregations of planes" (Quillian 1968, p. 237) which seems to have little rela- tion to a normal human memory (as Minsky wrote in the introduction of the same book: "I have never heard of any instance that seriously suggests that a person can hold many millions of independent facts"; cf. Minsky 1968, p. 29). In his book, Eco asserts that the competences of a subject is more similar to an encyclopedia than to a dictionary (cf. Eco 1975, par. 2.120.2) and that "the fact that..., the encyclopedia looks more like a Speculum Mundi than an Encyclopedia Britannica, suggests the idea that the natural language universe is far from..."
from the universe of formal languages and has instead a lot in common with a `primitive universe' (Rosch 1975, p.162). A model that we believe comes even closer to the target is the memory model of a mental 

*image* which is an infinite number of *images* and *symbols* that are connected by a kind of *network* (at least in our case). The content is a *nested* with contents where a memory search is needed and the mind "makes a walk in the edifice" to find what it was looking for (Levine 1966).

At any rate, a possible way to solve this problem is to model it as well as the model itself. It resides in the range that is appended to each model. These steps determine the preferential and secondary meaning paths that might explain both the functioning of human memory and that of ambiguity in signification.

The token nodes and their tags constitute what is known as a Fuzzy set, that is a class of objects with a continuum of grades of membership (Zadeh 1965, p.139; cf. also Zadeh 1973 a, 1973 b, 1968; Zadeh, Sun Fu, Takaki & Satsuma 1973). Reedan 1961, 1962; Schmude 1961; Wang 1968; Pat 1961; Saka, Termini & Brillan 1984; Kaufmann 1973). The formal definition of it is a fuzzy set (class A) is a \[ A \] is characterized by a membership (characteristic) function \[ f_A(x) \] with the value \[ f_A(x) \] to unity, the higher the grade of membership of \( x \) to \( A \). (Zadeh 1965, p.139). In intuitively, a fuzzy set is a class with unsharp boundaries, that is, a class in which the transition from membership to non-membership may be gradual rather than abrupt (Zadeh 1968, footnote p.161). \( f_A(x) \) can be defined in a variety of ways; in particular, (a) by a formula, (b) by an algorithm, (c) by an algorithm (reconstructively), and (d) in terms of other membership functions (as in a dictionary) (Zadeh 1968, p.160). Due to the lack of space, it will suffice here to indicate that fuzzy sets can, as other kind of sets, undergo a number of operations such as identity, complementation, containment, union, intersection, algebraic product and sum, absolute difference, (fuzzy) re-

Another, and can be convex, nonconvex, bounded or unbounded (cf. Zadeh 1965).

The union, intersection and complementation operations follow De Morgan's laws as well as distributive laws; union and intersection operations can be represented by networks of sieves (analogous to the switch networks of ordinary logic) (cf. Zadeh 1965, pp.146 and 151). It is evident that the wealth of operation on these sets allows for qualitative formalization of such things as meaning (a fuzzy subset of a universe of discourse) (cf. Zadeh 1965, pp.164 and 151) and language (a fuzzy binary relation from a set of terms to a universe of discourse) (cf. Zadeh 1965, pp.169 and 170), though completely nonstatistical in nature (Zadeh 1965, p.160) fuzzy sets provide the necessary tools for extremely complex or ill-defined problems (Zadeh 1969, p.469). The implementation of a time-dependent fuzzy set theory (cf. Levine 1972, p.367) could suit some deterministic aspect of music particularly well. In general, fuzzy set theory can complement the Q model to provide planning schemes often needed in music composition.

Music theory references of these models

Semiotics of music would seem the appropriate field in which to develop these concepts. A semiotic musicological discipline began developing in the sixties and became quite popular in the seventies, together with all other semiotic studies. Given the wide disregard among musicologists which followed, we will avoid a detailed descrip-

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designated by musicologists and, of course, work in a musical context; they are only marginally useful to composers (except during their apprenticeship). This does not mean that musical meanings or musicology per se is useless: on the contrary, the role of musicologists is to develop the discourse about music, a thing that could never be accomplished by composers (with a few notable exceptions). Nevertheless, when we attempt to use the type of knowledge found in semantic musicology in the context of our compositional goals, we run into problems. Let us rapidly analyze a few of them.

The first one is that some musicologists and sinologists believe that music cannot be its own meta-language, and tend to designate verbal language as the appropriate meta-language for music (cf., for ex., Nettles 1975, p.45; Stefani 1976, p.13; Nettles 1976, p.11 Jakobson 1961, p.11). Others, it is true, do not trust the verbal language as meta-language, but nonetheless use it—not finding anything better suited to the purpose (cf., for ex., Saroni 1964, p.35; Imberty 1978, p.94; Oye manuscript 1978, p. 3). A third group assumes that the verbal language is absolutely incapable of conveying musical meanings, thus denying the possibility of existence of musicology itself (cf. Weingartner 1972; Bartles 1972; Rouzet 1979; Lüli-Strawn 1971). But nobody thinks that music will ever become a meta-language (some sort of an exception is constituted by Barthes, who believes that the speaking and singing voice can be used in the meta-musical sense; cf. Barthes 1972).

The second problem is the absolute faith these scholars have towards musical graphic linear notation, conventional and not (cf., for ex., Nettles 1975; Holm 1975) which we know too well how problematic such an aspect is today (cf., for ex., a kind of writing by relying on notation, it is clear that analyses, even the most precise and detailed ones (cf. for ex., the distributional analyses proposed by Rouzet 1976; Nettles 1975; etc.) are bound to be limited to some particular aspects (i.e., formal aspects, melody contours and redundancy, subdivided rhythm and meter, etc.) while ignoring others (i.e., the ontological aspects and, in general, all meta-musical aspects) which are often noticed instead by much speculatively and "non-scientific" music critics (cf., for ex., Ives 1955). A different approach to the subject has been given by Ogan, who has made spectrograms of entire compositions and of specific passages (cf. Ogan 1964). This approach works in the opposite way: it does not reduce information in the notation process, so that the reader can freely select which aspect to look at for any given time: the reduction of parameters, necessary for controlling the process, is subjective, much as it is in listening to a piece of music.

The third problem is "scientistic legitimacy": true, in the past it is often seemed as if "anything goes" had become the motto of musical analysis and criticism; as a reaction to this, an all too understandable tendency to stricter formalization occurred (cf. Stefani 1976; Nettles 1975). But, with all these problems we have listed it should be clear that a "scientistic" approach in musical analysis can be desired only by people who do not have a very precise idea of what "science" is, having themselves open to strong criticisms from authoritative figures in the field (cf., for ex., Huet 1975; Brückeck 1972). Therefore, it is questionable whether "scientistic legitimacy" is useful at all.

Actually, these problems do not exist in musical composition. As in composition music is its own meta-language, using semiotic principles and methods can only enhance the insight and control of musical processes by the composer. Just to make an example of how different this approach is, it is possible to show that something like the "double articulation" of languages as expressed by Martinet (that is, the subdivision of language in a first level of natural segmentation and a second level of cultural segmentation the "semiotic units"; cf. Martinet 1960), a theory very much criticized by musicologists, could be very useful in establishing the actual meta-linguistic capabilities of music precisely.

Many uses of the computer as a musical instrument. It is evident from what we have said so far that the typical instrument to allow the development of music in the era of its reproduction is the computer. The ultimate segmentation abilities of a digital system can operate on the sound continua need further demonstration. Particu-
more these abilities can provide such a control on musical constructive selections that it is possible to anticipate the definite stabilization of a perceptual model based on a sophisticated double articulation system (cf. above and Martinet 1960), the multiplicity of musical language parameters constituting the first level while the second level is built upon the articulation of the constructions established by the particles. This preference towards the computer does not mean that other, traditional instruments cannot be used as well, simply that some of these will adapt to this model better than others (i.e., voice, percussion, string orchestra vs. piano, organ, saxophone, etc.). As we mentioned in the beginning, digital signal processing technologies and all computer-related issues are fairly advanced as far as music is concerned. Still, a lot of progress can be made, but the basics (i.e., synthesis techniques, hardware, etc.) are quite well under way. The main problem in the use of computers in music resides with the conceptions most composers have of what to do with them.

In general, our tendency is to take the concept of analog electronic music, and expand it to digital technology; in other words, a certain unlimited "faith-in-the-machine" tempered only by the difficulty, for a musician, to enter the digital world. A description referring to digital techniques such as: the electronic material, the synthesised sound give - in the field of the possibility of creating a decisively new universe, liberated from the limits imposed before" (Boulez 1975, p.58) appears surprisingly similar to another one which twenty years earlier was related to analog technology "we are on the lookout for an unheard world of sounds, rich of possibilities and practically unexplored" (Boulez 1954, p.34). While enthusiastic comments about the possibilities of the computer are not uncommon, it is interesting to notice that many results in computer music are often explained in terms of clearly analog operations: "we have (fear not) analogs that use the computer ignore general theories, especially mathematical, physical and acoustical theories [why not language theories]? Their talent, when they have it, is not capable of penetrating the virgin spaces where only abstraction can guide their experience..."

b) scientists who have access to computer technology feel a sort of inferiority complex in the face of musical aesthetics... They lack experience in an aesthetic field and do not know which direction to take at all... Direction which Xenakis then proceeds to outline, stating that a fusion between micro-composition and micro-composition is based on particular structural and mathematical properties (cf. Xenakis 1961, p.58 and cf.). These have strict nothing to do with musical semantics, which indicates a certain concept of the composer for the empirical data of now is his composition going to sound. It must be clear that we are not criticizing Xenakis' music, which can be intriguing and beautiful, but the use of mathematics in music (of which we just gave an example of above "Fuzzy sets"). All we are trying to say is that the semantical aspects of that music are either based on the very empirical "ways of the composer" (referred to as 'talent' by Xenakis) in selecting the output of his algorithms, or completely coincidental (which is fine as far as music is concerned). In the same vein, it is easy to show that an integral serialism, more than "a... method for pitch [Rhythym, Dynamics, attack, timbre, etc.]" structuring" (Boulez 1966, p.151; cf. also Boulez 1966, p.152), semiotically speaking represents the absolute suprasity of timbre over all other semantic systems that act in music (which is explained by the obvious lack of any material structures - timbres - with even the weak second-level articulation, have ever abstract, second articulation structures that do not possess first articulation foundations - the serialized parameters)(cf. on this subject the enlightening, provocative and much criticized Overture in "Devis et-Bravies 1964, pp.70-78; cf. also Martine 1960). These are just two very rough examples of the linear romantic ideal of music development that composers have inherited from strong non-fragmented languages, along with the ideas of "talent", "genius", etc. We think these conceptions are cute outdated, just as we believe that Bach was required by his contemporaries (found about the time of the beginning of music printing) as we now might consider an excellent film music composer more than a genius in the romantic sense.
These same conceptions have led to a questionable speculation operated by some composers with respect to psychoacoustics. These composers have considered psychoacoustics as the new "art of orchestration". We would like to invert this statement; there is very little theory today, by psychoacoustics that cannot be found in explicit musical terms in good old orchestration manuals. Of course, the immense effort of explaining orchestration (among other things) in terms of psychophysical sciences need not be underestimated, but it is clear to psychoacousticians themselves that this theory lies in an incoherent native field, very close to natural phenomena (that means, is rough terms: that psychoacoustic research stops a few inches inside the "ural system"). Just to quote the most obvious example, the fact that the very limited timbral semantic segmentation provided by certain models (cf. Sabin 1960) has been sufficient for some composers to base compositional procedures on it gives testimony of our still strongly traditional way of thinking (that is, to old linear schemes of composition evolution, such as looking for algorithmically created timbres as some "new" compositional tool to be exploited). What we want to stress here is that psychoacoustical knowledge will be extremely useful (i.e. to clarify structural marks and physical properties of "musical space") once we have found the way to link it to the musical sensibility. As far as we know, this has not been attempted yet.

Considering the situation exposed in this paragraph, it is not surprising that results in computer music are generally rather meager. Another good excuse for this - a strange one, at that - is that the whole field of contemporary music is at a critical stage. While this is not absolutely true, what is unrefutable in that computer music has a very strong general computation already. That is, we can easily define a computer music space, an unapronnable fact when we think that composers are instruments with possibly potentially unlimited capabilities in sound synthesis and reproduction.

The computer as a new musical instrument for new musical thought

Considering the change of perspective proposed in this paper, we will briefly proceed to outline a few immediate possible development directions. The first and most important one is the study of the computer music instrument under the profile of what we could call "transparency" or "neutrality". Transparency is a non-quality; it is the lack of linguistic and cultural connotations of an expressive medium (the "absence of "noise"; cf. Shanon 1949). The piano is a clear example of non-transparent instrument ("opaque"). Any sound from a piano keyboard will not fail to recall to us at least one of the different "universes of language" represented by piano literature. Therefore, we can see that total "transparency" is practically impossible to attain. Transparency means, in this sense, that the source composer has to the manipulation of the microstructures of the synthesized sounds (i.e. single samples or groups of samples) in terms of how many parameters he/she must define for them. For example, hardware-defined machines are not transparent. They will force the composer to use the same synthesis technique over and over, a great problem considering that synthesis techniques themselves are, as we will see, "opaque". Thus, micro-programmable machines (cf., for ex., Di Stuugo & Kott 1981; Sabin 1960) have constituted a real breakthrough. One problem with them is that, even when they are extremely powerful, they are still not powerful enough (i.e., they perform only fixed-point arithmetics, etc.) and they are quite difficult to control ("transparency", indeed, for most composers). However, the great technological leaps operated by WAT technology (cf., for ex., the TEM 1220 chip, the WADLIGH technology, the 5016 general purpose chip, the dedicated semi-customs, etc.) will presumably solve these problems in the not too distant future. Nevertheless, we do not think that it will be possible to solve the transparency problem completely. As "efficient" techniques will always tend to be compromised because of the data reduction schemes ("opaque" in its result), while a "flexible" one will never be easy to handle because of the number of parameters involved ("opaque" in its control). This cannot be avoided, but an attempt to "measure the transparency" should be made in order to select and realize more "magnificently powerful" synthesis techniques. A proposal in this di-
section could be the analysis of the various synthesis techniques we already possess (cf. Risset 1969; Zarlino & Gold 1974; Crocker & Zarlino 1981) to establish a quantitative "transparency" factor based on some kind of a "sample flexibility/number of control parameters" ratio (in relation, maybe, to lognormal linear approximation method or non-linear approximations like spline functions, etc.). This could be particularly useful in the evaluation of synthesis-by-note techniques or synthesis technique aggregations. Artificial intelligence could be used to provide "intelligent" automated parameter controls to improve "transparency" on non-efficient techniques.

Following the general trend of convergence of methods between synthesis and composition tool structuring (cf. for ex., the CHAIN/POUMIX project in Mexico, Potsd & Barrère 1984; Rost & Santos 1984) some new methods for quantitative music analysis could be devised, in the path of the theories of information shaped more than two decades ago (cf. Shannon & Weaver 1963; Neyra 1970; Boone & Frankenbichl 1986; Rössle 1960), other problems that should be solved concern loudspeaker "oppositions", which play an important role in all loudspeaker-designed music (and, of course, all reproduced music as well). These problems are basically divided into two categories, which we could call "sound localization" and "instrument vs. loudspeaker irradiation". To our knowledge, these two categories of problems are presently being studied separately (the first one, of Kendall & March 1964a, 1964b; Benetet, Harker & Eliak 1969; Britz 1965; the second one, of Bemaze 1965). In our opinion it is very important, in the perspective indicated in this paper, that these two fields be brought together in order to provide a general theory on loudspeaker "transparency" (a theory we realize has a long way to go yet).

Conclusion

There are many topics that could still be discussed widely under the point of view proposed here. The return of subjectivity, now concept of "un Modal" and "atonality" in the sound reproduction era, the generative approach to analysis and composition, artificial intelligence, non-deterministic systems, cross-synthesis techniques, the notion of structural coherence and that of "materials" in this perspective, etc.; these and other arguments will not find a space in this paper. In any case, it is important to re-assert now what has already been pointed out in the beginning. We hope this paper has presented a new way of thinking about music, and some (by no means all) of its most important aspects and strategies. Once again, we wish to make it clear that it is not the usefulness of systems and theories that we are questioning (in composition, anything is useful) but how they are used.

Though we believe in our model very firmly, we need feedback as in the case for our compositions. Way it will be forthcoming from all interested in discussing the views and the research proposals presented here.

BIBLIOGRAPHY

Adorno, T.W. 1963 Der geistreiche Korrektor. Frankfurt/Main
Adorno, T.W. & Eulzer, H. 1977 Komposition für den Film. Leipzig
LYE, Computer Science Press Rockville MD
Shannon, C. & Weaver, W. 1963 The mathematical theory of communication, University of Illinois Press
Stefani, G. 1976 Introduzione alla Semiotica della Musica, Sellerio Palermo
Strange, S. 1975 Poetics of Music, Harvard Paperback
Vattimo, G. 1989 La fine della modernità, Garzanti Milano
Wang, C.K. 1973 Fuzzy points and local properties of fuzzy topology, University of Illinois at Urbana-Champaign
Zadeh, L.A. 1965 "Fuzzy Sets", in Information and Control 8 pp.338–353