(1961) "Stochastic M" ds Music-East and West. Report on 1961 Tokyo East-West M Encounter Conference, Tokyo, Executive Committee for 1961 Tokyo East-West M Encounter, 1961, pp. 134-140

MUSIC - EAST AND WEST

Report on 1961 Tokyo East-West Music Encounter Conference

Edited and Published
by
Executive Committee for 1961 Tokyo East-West Music Encounter

STOCHASTIC MUSIC

by Ianis Xenakis (Greece)

The basic aim of music is often forgotten in the welter of avantgrade styles, whether they be contemporary, preparing for a future development or frankly "ahead of their time." Some critics, composers and technicians, lost in the false notions which abound in contemporary music, mistake technique for art, a piece of stone for a piece of sculpture. Esthetics, in so far as it is a science of "Beauty", has been passed down to us so confused that what is left is often only meaningless clap-trap. One has only to read the papers which were produced during the course of the last Esthetics Congress in Athens to becomes convinced of its emptiness.

Art, and above all music, has as its fundamental function that of a catalyst. Its aim is to bring about an uplifting of emotion in which the individual is able to lose himself and become one with a rare, immediate, and perfect truth. This immense truth is not composed of things, of feelings or of sensations; it rises above them, in the same way as Beethoven's 7th symphony rises above music, as such. In this way, art brings us to realms which are nowadays usually reached only by a few people, through religion.

How everyday artistic activity becomes Art is still a puzzle. Its adepts reach it without realizing exactly how they do so. Many merely struggle along in the ideological or technological undertow of their particular period. By keeping our eyes on this supreme meta-artistic end, we shall endeavour to define the paths which may lead to it, but first we must consider the mass of contradictions which stand for music today.

One must first rid oneself of inherited and conventional ways of thinking, by investigating how thought takes place and how it is converted into action. Those who have not done this, have unfortunately had to remain satisfied with the mechanics of tonality and modality, or by those of serial music, their direct heir. Such people have lost the meta-musical vision, and the problems to which they devote themselves are little more than faul mensuration.

Just what does a piece of music suggest to us, on the level of form? It presents a collection of supposedly causal progressions. More simply, if a major scale implies a hierarchy of tonal functions (tonic—dominant—sub-dominant) around which all the notes gravitate, it creates on the one hand linear progressions (melodies) and, on the other, simultaneous or depth progressions (chords in a strictly deterministic way). The Viennese School replaced this causal musical organization by another system which was more rigorous and abstract. This was their greatest contribution. Messiaen generalized on this discovery and went a step further when he systematised as abstractions all the variables of instrumental music. Paradoxically, he did this a modal spirit. Messiaen created a multi-modal music which immediately found many imitators, among serial composers. Messiaen's generalization was justified by multi-serial music. All the post-war neo-serialist composers have drawn their inspiration from him. Ever since, they

have been walking ahead blindly, following Messiaen and the Viennese and borrowing occasionally from Stravinsky or Debussy and proclaiming their "truth". There have been other developments of a stronger sort, such as the systematic investigation of sonority, of bizarre instrumentation, of noise. Varese is the pionner in this field, and electromagnetic music the beneficiary. (Electronic music is really only a sub-division of instrumental music). On the other hand, problems of form and composition have not been gone into conscientiously. At the heart of the fundamental problem problem of music one still finds multi-serial music—a blend of the multi-modality of Messiaen and the serialist in Vienna.

This situation was already well under way in 1954, when the completely deterministic complexity of music composition and the works which resulted from it were creating an aural and ideological nonsense. I commented on this an article which appeared in the first number of the *Gravesaner Blaetter*, 1955, entitled "The Crisis of Serial Music." "Linear polyphony," I wrote at that time, "is destroying itself by its complexity. In reality. In reality, all that one hears is a collection of notes in various registers. The music's enormous complexity makes it impossible for any listener to follow the different lines, and as a result one has the impression of a completely arbitary and unreasonable dispersion of tones ranging over the entire gamut of the sound spectrum. In consequence, there is a contradiction between the linear polyphonic system and the result which is nothing but surface or mass.

This contradiction inherent in liner polyphony will disappear as soon as the sounds can be made completely independent. When linear combinations and the polyphonic superposition of these combinations cease to work, the important thing will be the satistical means by which all of these isolated elements are combined at a given moment. The overall effect can therefore be controlled by the mean of the movements of objects chosen by us. A nation of probability results from this and in this case implies the calculating of combinations. Here, in a word, is a possibility for advancing beyond the "linear" concept that has hitherto governed musical thought. At the time, this passage just cited made me a figure of ridicule to some of the foremost neo-serialists, who openly called me an imbecile. Today, however, they too are using chance in musical composition, and so it would seem that my imbecility had at least proceeded theirs.

We now come to the introduction of mathematical calculations into music. For if, owing to its complexity, the strict causality—the determinism, in a word—of the neo—serialists was abandoned, it had to be replaced by a generalized causality, by a logic of probalities which would contain as a subdivision a generalized causality. And have we arrived at "Stochastics." Stochastics is the study of the laws governing socalled large numbers as well as these governing rare events, random processes, etc.... In this way, music built on chance began to develop in 1954 out of the dead-end which serial music had reached—music which I was to call Stochastic Music two years later. The laws governing the calculation of probalities in music came to form an integral part of composition.

Stochastic music can also be reached from other directions. Natural sounds—these

auditory "events" are in reality made up of thouands of separate sounds. The overall "event" takes place in a given time and form which also follow Stochastic rules. For example, if one wishes to create a work made up of separate sounds, such as string pizzicati, one must understand the mathematical laws which are, in fact, nothing more than the expression of a long chain of reasoning. Everyone has had the experience of hearing a vast river of people shouting a slogan in rhythm. If another alogan is fed to them, it will travel through the crowd and replace the first, like a wave, from the front to the back. The shouting fills the city. In this ferocity, this is an extremely powerful and even beautiful thing. Then the crowd finds the enemy it seek. The perfect rhythm of its shouting is broken up into a chaos of screaming which, in its turn, mores as a wave. If one can further imagine it, let us have the noise of dozens of machine-guns and the whistling of shells added to the overall sounds. Then the crowd disperses and the aural inferno gives way to the calm of depair, death and dust. The statistical laws govering these things, when emptied of moral or political content are the same as those which govern the locusts or the rain. They are the laws which describe the passage from order to disorder in either a continuous or a sudden way: they are what are called "Stochastic" laws.

We now come to one of the problems which have haunted philosophers since antiquity: the problem of whether change is continuous or dis-continuous. The sophisms of movement (Achilles and the Tortoise) and definition (baldness) are—in particular the latter—solved by means of mathematics, that is, in a "Stochastic" way. However, one can have continuity with continuous elements or with dis-continuous elements. A group of short string glissandi gives an impression of continuity as completely as a group of string pizzicati. The transition from continuity to dis-continuity is controlled by means of the "Stochastic" theory. Long ago, I made these experiments in instrumental music. However, as far as most musicians were concerned, the mathematical approach frightened them and made works as well as their understanding—particularly difficult. Recently, however, a break-through has been made toward the appreciation of such music. It takes time for new ideas to gain acceptance.

Rhythmic variation is another path which leads to "stochastics". This path also owes much to the work of Messiaen. Here, the problem has been to discover the limits of total assymmetry and, consequently, complete breaks in causality between different durations. An example is the sound made by a Geiger counter as it approaches a radioactive source, stochastics have provided a law to fit this phenomenon. I would like to make a short detour before bringing to a close this brief resume of these new and enriching discoveries which were until recently accessible only to the initiate. If glissandi are long and properly connected, continuously evolving areas of sound are produced. Among these possibilities there is that of creating many of the surfaces that are capable of being generated by straight lines moving in space (the glissandi are represented, of course, by straght lines). Such an experiment was incorporated in my orchestral work entitled *Metastasis*, first performed at Donaueschingen in 1955. Several years later, while I was working as assistant to the architect Le Corbusier, he asked me to propose

a design for the Philips Pavillion at the Brussels World Fair. I found that the experiment of *Metastasis* now influenced my work and that, in this instance music and architecture were intimately related.

I should at this point like to indicate some of the Stochastic formulas which I have been using over the past years in my compositions. *Pithoprakta*, a work composed in 1955 for string orchestra and first performed in Munich in 1957, under the direction of of Hermann Scherchen, yields the following examples:

The Poisson formula: $P_k=\frac{m^k}{K!}e^{-m}$ for the density of sound particles.

The Maxwell-Boltzmann-Gauss law $f(v)=\frac{2}{a}e^{-v^2/a^2}$

for the speeds of glissandi

A law of continuous probabilities: $P_x=ae^{-ax}dx$ for durations.

A second law of continuous probabilities:

$P(j)dj=\frac{2}{a}\left(1\frac{j}{a}\right)dj$ for interval and intensity.

The above laws, which have recently appeared in various spheres, are veritable gems of contemporary thinking. They are laws governing the appearance, of being and of becoming. One must realize, however, that they are by no means an end in themselves, but only tools for creation, the railing, as it were, for the bridge of knowledge—a knowledge more general than the binary knowledge of Aristotle.

However, this brings us to another problem, a problem which is created by the Stochastic method itself: "What is the minimum of logical control necessary for the the fabrication of a given musical progression?"

The following answer applies to instrumental music, and can be extended to cover all types of sound production:

1) In a given place there are men;
2) Contact betweeu the men and the instruments makes possible the emission of instrumental sounds:

from these two propqsitions, and with the aid of stochastics, a musical work can be composed with no further restrictions whatsoever. Hermann Scherchen created sucn a work in my Achoripsis for 21 instruments, which was first performed in Buenos Aires in 1958.

If the first steps are summed up in the formula Vision: Rules: Works, the question of the minimum of control reverses the order to Rules: Vision. Stochastics make possible a fundamentally philosophical vision, a vision which first to all allows for plastic elaboration of a certain idea and then leads to knowledge, as shown in the last example.

Before further generalization as to the essence of musical composition, one must speak about improvisation, the principles of which are making such a stir among neo-serialist and which they believe have given them the right to speak with authority about chance or uncertainty in music. The neo-serialists compose scores in which certain combinations of sounds are freely chosen by the interpreter. It must be evident that the composers consider the differences between these groups of sounds as being of equal

value. However, there are two weak points in their argument which could prevent them from speaking about chance.

a) the performer being merely a strongly pre-conditioned being, one cannot therefore speak about him as one would about a game of roulette. The suicides at Monte Carlo should be sufficiently convincing on this score, so we shall not go into them here.

b) the composer begs the question as soon as he admits more than one possible or equal "circuit". Freedom of choice is betrayed in the cover-all plan of the comosition. In any case, there is no trace of uncertainty in the composer's thinking, nor in the result which he puts down on paper—unless he arrive at a combination of notes by throwing dice—an idea which is childish as well as uninteresting.

An extreme example of this attitude is the drawing of signs on paper which are read by the performer as he improvises the composition. The drawbacks mentioned above are greatly magnified in this case. One question comes to mind: suppose that this sheet of paper is put before an excellent pianist who happens to be a specialist in Chopin. Isn't it possible that the result would be influenced by the style of Chopin in the same way that concerto cadenzas and influenced by the style of the composer? And would not such a performance be therefore uninteresting? Two conclusions can be drawn: serial music has already become so commonplace that it can be improvised and, secondly, the composor has completely given up his role as musician, a role which might just as well be taken over by painters, or the makers of hieroglyphics.

There is one in which this seemingly senseless position might be tenable: be destroying the conscious and allowing the psycho to take over, one may arrive at something, interesting, but it would needs to be completed by yoga or other forms of controlled reflexes, It has been attempted by such composers as John Cage, Earl Brown and David Tudor, in a way similar to that employed by certain painters and schools of poetry. It may turn out to be very valuable in the future especially, if it should open up the discovery of an integration of conscious and subconscious thinking in one harmonious whole.

To complete this discusion of the composer as a roulette-board, I should like to add the following remark: chance is something very rare, like a trap, and it can be constructed only with great difficulty and only up to a certain point. With the aid of complex logic and mathematical formulae, chance can be constructed, but it can never be imitated. Emile Borel, the great mathematician, was a specialist in the calculation of probabilities, and he demonstrated that it was impossible to imitate chance. As soon as one gets away from the lowest level of chance happenings (which is not interesting to musicians), the calculation of probabilities (stochastics) defines those paths which one must not follow and furnishes a system of logic for the enrichment of sonnd processes.

Michel Philippot, a Parisian composer has assayed to analyse the act of composition in the form of Orgarigrames for Imaginary Machinc. This is a basic analysis of Stochastic choice and of voluntary choice which results in a chain of unpredictable or deterministic "events", illustrated through a work for double orchestra. The term "Imaginary Machine" means that, taking as his example the electronic computer, the

composer is able to define the elements of his craft in a rigorous manner.

These opinions are at present the basis of agreement among the members of the MYAM, a newly-formed Parisian group consisting of four people: Michel Philippot (see above), Andre Moles, who is a specialist in the Theory of Informations, Alain de Chambure, an electronic acoutics expert, and myself.

Now to make some rapid generalizations about the technical study of composition, with the help of Stochastics. First, Stochastics are valuable not only it instrumental music, but also in electromagnetic music. I have shown this myself in a number of compositions. Secondly, Stochastics, leads to the creation of new sound material and new forms. In order to do this, one must first adopt a hypothesis regarding the nature of sound. For example, that sound is by nature quantie and granular. All sound is made up of galaxies of elementary particles which may be individually defined as a pure frequency, a given intensity and a weak duration, and which appear and disappear instantaneously. This hypothesis is corroborated by Garbor's theory of the elementary acoustic signal, which he introduced in the Theory of Information. He supposes that the acoustical signal defined in a trihedron of time, frequency and level, has an envelope in the form of a Gaussian bell-curve. At a given instant, if one takes a section parallel to the plane of frequency and level, the image of the sound at that precise point is an assemblage of many particles. Any sound can be transcribed in this way, with the help of a group of previously defined sections, which are called screens. An assembly of screens describes the life of a particular sound, even of a piece of music. The geographical distribution of these assemblages of sound-particles and the local superficial densities characterize the sound at any given instant. The theory of "ensembles" introduces logical relations. Order in relation to disorder creates as a measure entropy, for zones distribution on a microscopic scale is Stochastic. The liaison between the planes of frequency, intensity and density is worked out by means of the matrices of transition probabilities. These matrices, in their turn, define a chain of Stochastic process which may follow all kinds of laws. One of the more simple is that in which each state of being depends in some way on the one which preceded it, and is called the Markov process. Others are more determined in nature, or more open to chance, and serve to make this particular theory of composition extremely fruitful. Some essays have already been made toward composing music with this theory, but the main routes of its usage are still open to exploration.

In conclusion, I should like to present some additional observations about musical stochastics.

Man-made or machine-made music belongs to a general class which we can call "Antonomous music." Generally, it must be admitted that the nature of the technical oppositions (instrumental and directional), or even those which grow out of the aesthetic logic behind musical communications, is an innate part of the written work -at least up to now. Tension is a part of the musical score, even when one uses Stochastic procedures which are more or less defined.

It would be interesting and might be fruitful to conceive another class of musical

discourse which would intraduce the notion of external conflict between, for example, two orchestras, or two instrumentalists in opposition to each other. These units would influence each other reciprocally. The conversation in sound would then be identified with a rigorous succession—at times Stochastic—of opposed sound—actions resulting both from the wills of the two conductors (or several conductors) and from the intents of the composer, all of which would take place within a higher dialectical harmony.

External conflict (heteremony) may take in all types of form, but can always be summed up by a Matrix of Accounting which will conform to the Mathematical Theory of Games which demonstrates also that in general there is a minimum of gain and a maximum of loss guaranted where there are two players and if they play intelligently. The figure of maximum and minimum are always identical. This figure is generally called the "Game Value."

This musical heteremony can also be spoken of as "sound strategy."

I have sketched out a general framework for an artistic attitude which uses mathematics in three different ways:

1) in a philosophical résumé of Being and the evolution of Being: the Poisson Law.
2) in the qualitative support and mechanism of the Logos: the Theory of Ensemble, the Chain-Process theory, the Theory of Games.
3) as an instrument for measurement which will aid investigation, realization and perception, such as the calculation of entropy and matrix calculation.