**Research > COMPOSING WITH PROCESS: PERSPECTIVES ON GENERATIVE AND SYSTEMS MUSIC**

**Generative music is a term used to describe music which has been composed using a set of rules or system. This series of six episodes explores generative approaches (including algorithmic, systems-based, formalised and procedural) to composition and performance primarily in the context of experimental technologies and music practices of the latter part of the 20th Century and examines the use of determinacy and indeterminacy in music and how these relate to issues around control, automation and artistic intention.**

**Each episode in the series is accompanied by an additional programme featuring exclusive or unpublished sound pieces by leading sound artists and composers working in the field.**

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**Written and edited by Mark Fell and Joe Gilmore. Narrated by Connie Treanor.**

**Mark Fell is a Sheffield (UK) based artist and musician. He has performed and exhibited extensively at major international festivals and institutions. In 2000 he was awarded an honorary mention at the prestigious ARS Electronica, and in 2004 was nominated for the Quartz award for research in digital music. He recently completed a major new commission for Thyssen-Bornemisza Art Contemporary, Vienna which premiered at Youniverse, International Biennal of Contemporary Arts, Sevilla. He is currently working on a research project at the University of York UK funded by the Arts and Humanities Research Council looking at independent practices in radical computer musics. www.markfell.com**

**Joe Gilmore is an artist and graphic designer based in Leeds (UK). His work has been exhibited at various digital art festivals and galleries. His recorded works have been published internationally on several record labels including: 12k/Line (New York), Entr'acte (London), Cut (Zürich), Fällt (Belfast) and Leonardo Music Journal (San Francisco). Joe is currently a part-time lecturer in the department of Graphic Design at Leeds College of Art & Design. He is also a founder of rand()%, an Internet radio station which streamed generative music. http://joe.qubik.com**

# COMPOSING WITH PROCESS: PERSPECTIVES ON GENERATIVE AND SYSTEMS MUSIC #3.1
**Determinacy and indeterminacy**

The third episode in the series examines the use of determinacy and indeterminacy in music. It looks at how chance has been used in a variety of ways in the composition and performance of musical works – from works derived from the tossing of coins, to more rigorous explorations of the laws governing probability. The programme also looks at the use of chance in the visual arts and literature, and changing approaches to science during the twentieth century, describing the impact of these disciplines upon music making. It investigates concepts and ideas behind these works with reference to works drawn from different traditions.

## 01. Transcript

**Iannis Xenakis 'Mikka S' (*Chamber Music 1955-1990*, Montaigne, 2000)**

Welcome to the third episode of COMPOSING WITH PROCESS. The piece we have just heard is 'Mikka S', composed for solo violin in 1976 by Iannis Xenakis. The score was made using an IBM computer to pre-determine pitches and durations using Brownian motion – a mathematical model used to describe the random movements of particles suspended in a medium such as water or air.

This process of composing music clearly differs from more traditional forms, where the composer precisely determines aspects of a composition, usually through a score. The score defines which instruments are to be used, which notes to play, when and how to play them, and for how long. In indeterminate music an element of chance is involved in some aspect of the music's composition, performance – or both.

In indeterminate composition, pitches, durations, their occurrence in time and even instrumentation can be determined using dice, random numbers or any other process in which the outcome is unpredictable. An example of indeterminate composition is Earle Brown's 'Indices'. Brown used a book of 10,000 random numbers, called *Random Sampling Tables*, to determine each sound event in the composition. In this piece the method used to compose the score is indeterminate. The result of this procedure is determinate – that is, the music will sound the same each time it is performed.

In indeterminate performance, some elements are left to the performer's discretion. For example, the performer can decide the order in which to play parts of a score. An example of this is Karlheinz Stockhausen's 'Klavierstück XI', which consists of 19 parts spread over a single sheet. The performer is instructed to play these in any order, until a section has been played three times, at which point the performance ends. Here, the score is determined by the composer, but the structure of the finished work is indeterminate… that is, it will sound different each time it is performed.

Many composers in the mid twentieth century incorporated indeterminate processes in their works. In 1951 John Cage developed a method of notating music using the I Ching, an ancient Chinese system of divination. Several works for piano were composed using this process, including: 'Music of Changes', 'Two Pastorales' and 'Seven Haiku'.

The text of the I Ching is a set of statements, each represented by 64 sets of six lines, called Hexagrams. The process of consulting the I Ching involves determining a hexagram, by a random method such as tossing a coin.

Using a system of tables consisting of 64 cells, Cage developed a process for translating the random results of the I Ching into music. Charts were created for sounds and silences; pitch values; durations; and dynamics. The I Ching was consulted to generate values for each of these parameters and then a score was conventionally notated.

The following piece is 'Seven Haiku', which was composed using this method.

**John Cage 'Seven Haiku' (*The Complete John Cage Edition, Volume 29*, Mode, 1952)**

Throughout the twentieth century composers exploring indeterminate music were part of a general intellectual zeitgeist, which was influenced by Eastern thought and scientific theories such as Special Relativity and Quantum Mechanics. In the Harvard Dictionary of Music, the author Willi Appel suggests that these ideas tended to 'express the world in terms of possibility rather than necessity.'

The general acceptance of these new scientific theories prompted a shift from the determinism of Newtonian physics to the uncertainty and probabilities described by quantum mechanics.

However the idea that chance could play a part in creativity was, in fact, nothing new. Ancient Chinese Cha-No-Yu potters embraced the unpredictable patterns which emerged in the glazings of their ceramics. This random process was accepted because it was understood to be in harmony with the workings of the Universe.

It is also well known that Mozart used chance to compose musical games in the eighteenth century. These games were designed so that an unlimited number of waltzes could be generated using dice. Similarly, in the visual arts, chance had been incorporated into the paintings and collages of the Surrealists in the twenties.

And, in the fifties, Brion Gysin and William S. Burroughs applied indeterminate processes to the written word. Gysin introduced the so-called 'cut-ups' to Burroughs, who used the process extensively in several of his novels including *The Naked Lunch* and *The Ticket that Exploded*. The cut-up technique involved cutting vertically through various texts and then re-arranging them to form random narratives and meanings. These techniques were subsequently applied to both sound and film. The album *Breakthrough in Grey Room* released in 1986 contains numerous examples of the audio cut-up. The following tape piece, 'Silver Smoke of Dreams', was edited in the early sixties by William Burroughs and Ian Sommerville.

**William S. Burroughs 'Silver Smoke of Dreams' (*Break Through in Grey Room*, Sub Rosa, 1986)**

In the fifties several composers and engineers began to use computers to generate music. One of the first pieces of music written with the aid of a computer was Lejaren Hiller and Leonard Issacson's string quartet 'The Illiac Suite' in 1956. Hiller, a chemist at the University of Illinois, was investigating chemical probability processes. He realised that these processes could be applied to music and began experimenting with Issacson on the University's Iliac 1 computer. In the fourth movement of 'Illiac Suite', Hiller and Isaacson used probabilities in the form of Markov chains to control the distribution of melodic intervals. The rhythm in this section was determined by the composers and the computer decided which pitches to assign to the notes.

A Markov chain describes how to get from one state to another. For example, if you have 3 states, A, B and C, the chain defines the probability of what the next state will be. For example, if the current state is A, then the likelihood that the next state will be B can be defined as 60%, and C, 40%.

**Lejaren Hiller 'Quartet No. 4' ('The Illiac Suite') (*Computer Music Retrospective*, Wergo, 1986)**

Around the same time that 'Illiac Suite' was composed, Iannis Xenakis was also composing music using computers and probability. He wrote programs in the

[Lejaren Hiller in the Experimental Music Studios]

Fortran language to generate probabilities which he then transcribed into scores for traditional instruments. Xenakis called this process 'Stochastic Music'. 'Stochastic' means 'random' – from the Greek word for 'aim' or 'guess'. A stochastic process is one whose behaviour is non-deterministic.

Xenakis had been composing with principles relating to indeterminacy since the fifties, although as we shall see, his theories and methods were radically different to those of his contemporaries. Xenakis used Probability Theory in his first two compositions, 'Metastasis' (1953) and 'Pithoprakta' (1955). In 'Pithoprakta' which means 'actions through probability' Xenakis used the Kinetic Theory of Gases. This theory describes a gas as a large number of individual particles in random Brownian motion. Xenakis used this model to determine the behaviour of masses of individual orchestral sounds.

Inspired by natural phenomena such as 'the collision of hail or rain with hard surfaces', Xenakis' interest lay in articulating the stochastic laws and principles underlying these events.

The following is a short excerpt from 'Pithoprakta':

**Iannis Xenakis 'Pithoprakta' (*Metastasis / Pithoprakta / Eonta*, Le Chant du Monde, 1988)**

Far from relinquishing compositional control, Xenakis used indeterminacy to represent natural, complex phenomena which defy accurate measurement.

For Cage, the reasons for using chance to compose music were deeply connected to ideas he borrowed from Eastern thought, particularly Taoism and Zen Buddhism. In his music, Cage sought to remove intention, in line with the Taoist concept of non-action, in order to foreground sound itself. He stated that he used chance instead of operating according to his likes and dislikes.

Xenakis attacked the methods of Cage and his contemporaries. He described the process of 'playing with sounds like dice' as 'simplistic'. He also rejected the idea of indeterminacy in performance, pointing out that the performer is a highly conditioned being. Asking the interpreter of a score to make choices is ultimately a shift in responsibility – not an indeterminate process.

Initially Xenakis began composing with probabilities by hand, calculating and plotting the results on graph paper. In the sixties he automated this process using an IBM-7090 computer. But it was not until 1967 that Xenakis was able to use a computer for stochastic sound synthesis. The results of this new method of non-standard synthesis were used in 'Polytope de Cluny' and 'La Légende d'Eer' in the seventies.

In the eighties Xenakis continued his research into stochastic synthesis, extending the earlier algorithm and implementing what he termed 'Dynamic Stochastic Synthesis'. He outlined the methods behind this technique in his paper 'New Proposals in Microsound Structure'.

In Dynamic Stochastic Synthesis, digital waveforms are synthesised using probabilities. In this process, envelope breakpoints in the waveform are determined using random walks. A random walk differs from other methods of generating randomness – such as throwing a dice – in that each successive number is a step from the preceding number. Random walks are applied to both time and amplitude of each cycle of the waveform. The behaviour of the random walks can vary wildly depending on the probability distribution used.

Several pieces were composed entirely by computer using this method including 'Gendy 3' which was composed in 1991.

**Iannis Xenakis 'Gendy 3' (*Aïs - Gendy3 - Taurhiphanie - Thallein*, Neuma Records, 1994)**

In recent years, the German artist Florian Hecker has composed several pieces which utilise Xenakis' method of Dynamic Stochastic Synthesis. The first of these – 'Pandämonium 9 Playlist' and 'Stocha Acid Vlook' – were released on Compact

[Farmers Manual performing at Schirn Kunsthalle, Frankfurt am Main, Germany, in February 2002]

Disc by the Vienna Secession in 2001. Both these pieces utilise an implementation of Xenakis' Gendy algorithm programmed in SuperCollider 2 by Alberto de Campo. In the following track, 'Stocha Acid Vlook' the algorithm's random walks are clearly demonstrated.

**Hecker 'Stocha Acid Vlook' (from the CD accompanying the catalogue of the exhibition *Ausgeträumt...*, Secession, Vienna, 2001)**

The Japanese media artist Yasunao Tone has been using indeterminacy in his work since the sixties.

In his 'Wounded CD' or 'Man-yo' pieces, Tone applies scotch tape to the surface of CDs. Although this is a determined action, the process is rather different from scratching piece of vinyl in that the results are often less predictable. It is this undermining of intentional action that Tone is drawn to.

Tone states he is not satisfied with recorded media 'because it presupposes to repeat the same sound over and over.' Through interrupting the CD player's information decoding process, Tone's music is indeterminate.

The following is an excerpt from *Solo for Wounded CD*:

**Yasunao Tone 'Solo For Wounded CD Part 1' (*Solo For Wounded CD*, Tzadik, 1997), excerpt**

Another work which utilises CD player technology to achieve indeterminate results is *Explorers_We* by the Austrian group Farmers Manual. The CD is indexed with 60 second track marks and is designed to be played in shuffle mode. Group member Oswald Berthold describes the piece as a 'pool of soundfiles' and letting a program run across it.

We leave you with a recording from the CD *Explorers_We* as it shuffles between tracks.

**Farmers Manual 'Final Lap' (*Explorers_We*, Or, 1998)**
**Farmers Manual 'Poptastic' (*Explorers_We*, Or, 1998)**
**Farmers Manual 'Sci Fi Lo Fi' (*Explorers_We*, Or, 1998)**
**Farmers Manual 'Galactic Bar' (*Explorers_We*, Or, 1998)**
**Farmers Manual 'Space Race' (*Explorers_We*, Or, 1998)**

## 02. Acknowledgements

## 03. Copyright note