Composing with Numbers: Iannis Xenakis and His Stochastic Music

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Iannis Xenakis

- Born in Braila, Romania, 1922, the eldest son of a Greek businessman.
- In 1932 began studying at a boarding school in Greece on the Aegean island of Spetsai.
- Graduates from boarding school in 1938 and heads to Athens to study at the National Technical University of Athens to study architecture and engineering. Also studies music – harmony and counterpoint.
- Passes entrance exams but studies interrupted in 1940 when Italy invades Greece.
- Member of the Greek resistance during WWII, joining the communist National Liberation Front (EAM) to fight the occupation by Germany and Italy.

Iannis Xenakis (cont.)

- Later joined the Greek People's Liberation Army (ELAS).
- In December 1944, during the Greek Civil War and Britain's involvement, he was severely injured in street fighting with British tanks, losing eyesight in his left eye.
- Eventually graduates from the Technical University in 1947.
- Forced to flee from Greece to Paris in late 1947 when new non-communist government came to power.
- Sentenced to death (in absentia) by the right-wing administration. Death sentence finally lifted in 1974.

Xenakis on fleeing Greece

For years I was tormented by guilt at having left the country for which I'd fought. I left my friends — some were in prison, others were dead, some managed to escape. I felt I was in debt to them and that I had to repay that debt. And I felt I had a mission. I had to do something important to regain the right to live. It wasn't just a question of music — it was something much more significant.

Xenakis: Start in Paris

- Begins work as an engineering assistant in the architectural studio of Le Corbusier. Starts small but quickly given lead role as design engineer.
- Tries to study music in Paris with Boulanger, Honegger and Milhaud but is rejected — a rebel with little training.
- Encouraged by Olivier Messiaen to incorporate his training in engineering and mathematics into his music.

  "[Y]ou have the good fortune of being Greek, of being an architect and having studied special mathematics. Take advantage of these things. Do them in your music."

- Leaves Le Corbusier's studio in 1959, able to make a living as a composer and teacher.

Xenakis: Later Life

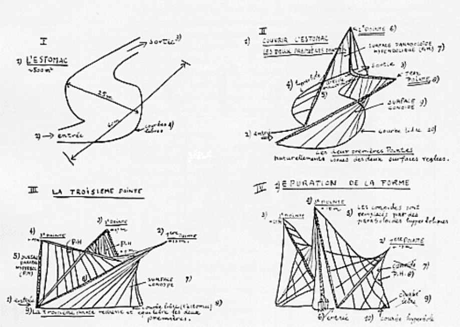
- Helps establish the school *Equipe de Mathématique et Automatique Musicales* (EMAMu) in 1966 for study of computer-assisted composition.
- Teaches at Indiana University from 1967-72 and at the Sorbonne from 1973-89.
- Writes several articles and essays on stochastic processes, game-theory and computer programming in music. Eventually translated and expanded into the well-known text *Formalized Music: Thought and Mathematics in Composition*.
- Wins the Swedish Polar Music Prize in 1999 along with Stevie Wonder.
- Stops working in 1997 and after several years of serious illness, passes away in February of 2001.

The Philips Pavilion

Figure: Image source: Nicolas Janberg's *Structurae*

Collaborates with Le Corbusier on the Philips Pavilion at the 1958 Brussels World Fair. Building later demolished.

The Philips Pavilion (cont.)



Design uses conoids and hyperbolic paraboloids (saddles such as $z = x^2 - y^2$). Architectural ideas had already been used in his piece Metastasis ("transformations"), composed in 1953-54.

Metastasis, 1953-54

- Piece written for 61 orchestral players (46 strings), with each playing a different part.
- Uses multiple glissandi (straight lines) in the music for string and horn parts. These indicate for the player to begin at a certain pitch and slide through all the frequencies on the way to a different pitch (could be higher or lower).
- Xenakis realizes that drawing the glissandi in the score can create a special surface of straight lines, called a ruled surface. This was the inspiration for his design of the Philips Pavilion.
- He thought of the glissandi as graphs of straight lines (time on the horizontal axis, pitch on the vertical), where different slopes correspond to different "sound spaces."

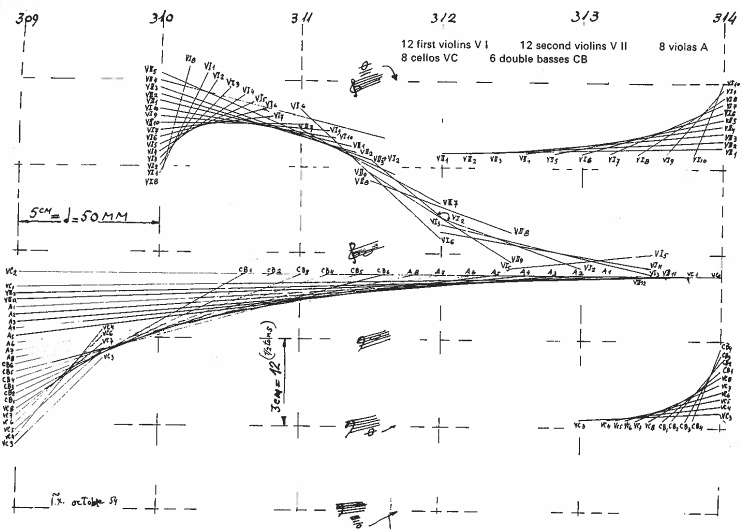


Fig. I–2. String Glissandi, Bars 309–14 of *Metastasis*

Fig. I–1. Score of *Metastasis*, 1953/54, Bars 309–17

Metastasis (cont.)

- Focus of piece is on mass of sound and timbre, rather than individual pitches. Xenakis strove to portray

  "sound events made out of a large number of individual sounds [which] are not separately perceptible, ... [to] reunite them again ... [so that] a new sound is formed which may be perceived in its entirety."

- Used pitches based on 12-note rows and assigned durations using the Fibonacci sequence and the golden section, a concept already utilized by earlier composers such as Debussy and Bartók, and one which Xenakis also employed in some of his architectural designs.

- Fairly clear that Xenakis' experiences with warfare influence this and some later pieces.

Xenakis, *The Crisis of Serial Music*, 1955

Linear polyphony destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers. The enormous complexity prevents the audience from following the intertwining of the lines and has as its macroscopic effect an irrational and fortuitous dispersion of sounds over the whole extent of the sonic spectrum. There is consequently a contradiction between the polyphonic linear system and the heard result, which is a surface or mass. This contradiction inherent in polyphony will disappear when the independence of sounds is total. In fact, when linear combinations and their polyphonic superpositions no longer operate, what will count will be the statistical mean of isolated states and of transformations of sonic components at a given moment. The macroscopic effect can then be controlled by the mean of the movements of elements which we select. The result is the introduction of the notion of probability, which implies, in this particular case, combinatory calculus. Here, in a few words, is the possible escape route from the "linear category" in musical thought.

Xenakis' Stochastic music

- A stochastic process is random and non-deterministic. The next state of the environment is not fully determined by the previous one.
- Xenakis used probability theory to determine what should happen next. The length, pitch, timbre and dynamics are all determined by a probability density function (pdf).
- To Xenakis, this was like hearing "the sound of science." What do the laws of nature and physics actually sound like?
- Example: Pithoprakta ("Actions through probabilities"), 1955-56. Drew inspiration from Maxwell-Boltzmann's kinetic theory of gases.
- The individual notes or timbres are "unpredictable" and less relevant. The overall block of sound is the focus, and may be discernible.

Pithoprakta, 1955-56

- Piece dedicated to Hermann Scherchen who conducted its premiere in March 1957 in Munich.
- Instrumentation: 46 strings (remarkably all playing different parts), 2 trombones, 1 xylophone and 1 wood block.
- Work explores the conflict between continuity and discontinuity.
- Continuous sounds: glissandi in the strings and trombones, short bow strokes.
- Discontinuous sounds: pizzicati plucking in the strings, tapping the wood of the strings with the opposite side of the bow, and use of the wood block.

“Speed” Equals Slope

A continuous glissando is graphed as a line with the change in pitch associated to a particular “speed” (slope of the line).

$$\text{positive slope} \implies \text{pitch is increasing}$$
$$\text{negative slope} \implies \text{pitch is decreasing}$$

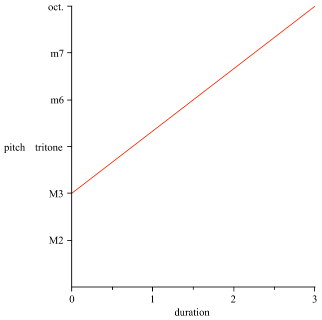


Figure: A glissando traveling from a M3 to an octave in three time units.

Determining Speed

Goal: Distribute speeds among all players so that:

1. Density of speeds is constant, i.e., two regions of the same length along the pitch axis average the same number of glissandi.
2. Distribution of speeds is uniform – uses a bell curve, a Gaussian (normal) distribution. Likelihood of speed being in a given interval equals the area under the curve over that interval.
3. “Isotropy” achieved by having an equal number of sounds ascending and descending.
4. Pitches are freely distributed (no one pitch is favored over any other.) Note how this generalizes Schoenberg’s 12-tone method.

Fig. I–6. Bars 52–57 of *Pithoprakta*

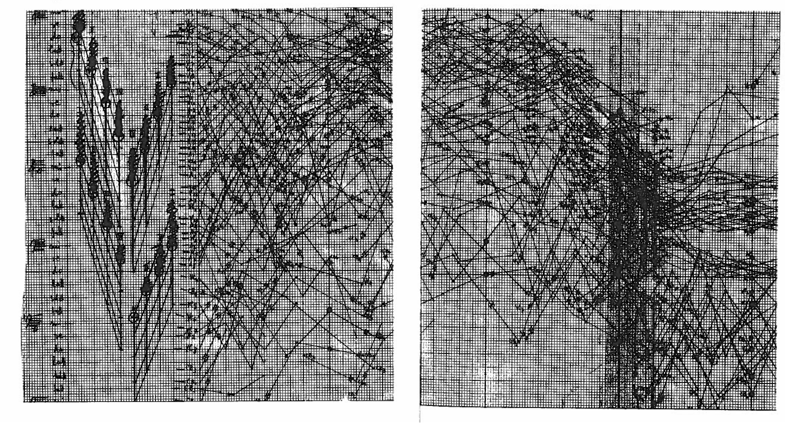


Figure: Graphs of Bars 52-57 in *Pithoprakta* showing the numerous “speeds” of each instrument. 1 cm on the vertical axis is equivalent to a major third.

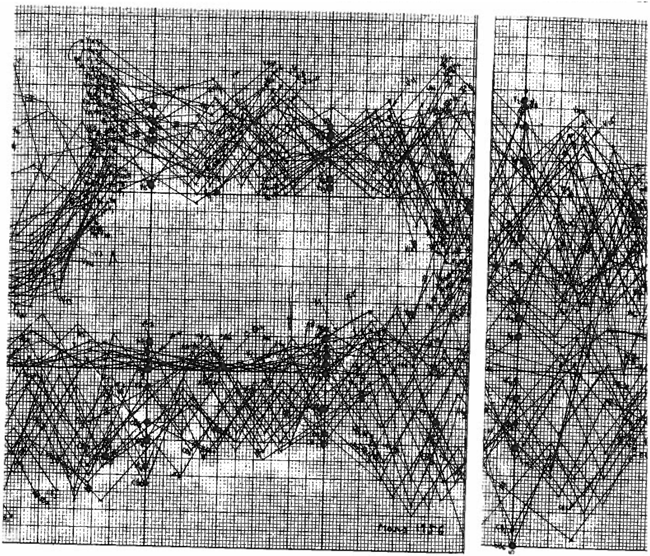


Figure: Graphs of Bars 52-57 in *Pithoprakta* (cont.)