Music, Number and Architecture:

Xenakis' Polytopes

1. Iannis Xenakis

Early Life -

Xenakis was born in Braïla, Romania in May 1922 and was the eldest of three boys. He was exposed to music from a young age, as his mother was a keen pianist, and gave him a flute when he was a little boy. Xenakis' mother sadly died when he was five, leaving the three boys to be educated by nannies. In 1932 at age ten, Xenakis moved to Greece to study, learning a love for Maths, and further learning about music. In 1938, Xenakis moved to Athens and began taking private lessons in composing with Aristote Koundourov where he also studied musical analysis, harmony and counterpoint. Here he also prepared for entrance exams to study architecture and engineering at the National Technical University of Athens. Although he was accepted in 1940 his time studying here was intermittent due to the war, not least the Italian invasion into Greece in October 1940.

Xenakis' war years -

Over the next few years Xenakis was heavily involved in various parties and war effort, being a part of The National Liberation Front, participation in mass protests and demonstrations which led to Xenakis joining the armed resistance. It was at this time, defending a building when a British shell blew up, many assumed he was dead and he was left there. His father found him, and Xenakis under went many operations and was left badly scarred and lost his left eye. After the war Xenakis graduated in 1947 with a degree in Civil Engineering. However the upheaval of the war was not over for Xenakis, around this time the new Greek government were looking for former resistance members and sending them to concentration camps, fearing for his life he went into hiding and fled Greece and arrived in Paris in November 1947.

A new life in Paris -

This new start saw Xenakis' career in architecture and music really take off. He started working as an engineering assistant with the architect Le Corbusier where they eventually collaborated in many projects such as Sainte Marie de la Tourette. Le Corbusier also helped Xenakis on his famous Phillips Pavillion, for the Expo 58. During this time with Le Corbusier, Xenakis was trying to further his compositional skills, approaching the well known teacher Nadia Boulanger, who rejected him. He tried to study with many other teachers at this time, none of which were particularly enthusiastic with his music. Eventually he approached Olivier Messaien, who saw something in Xenakis the other teachers had not. He took classes with Messaien in the early 1950's. His compositional career went from strength to strength throughout the 50's. In 1954 he was excepted in to Groupe de Recherches de Musique Concrète, the organisation by Pierre Schaeffer and Pierre Henry. In 1957 he received a composition award from the European cultural foundation, in 1958 he also received his first commission from radio France and later to do a soundtrack for a documentary film.

Xenakis left Le Corbusier's studio in 1959 and had become a widely known composer by this time. He spent most of his time teaching , composing and in research. He founded the Equipe de Mathématique et Automatique Musicales and gave talks and lectures all over the world. As well as this Xenakis authored many books, articles and essays about the techniques he discovered and used. Towards the end of his life in 1999 he was awarded the Polar Music Prize.

Personal life -

In 1950, Xenakis married Francoise Xenakis (Gargouil), and their daughter Mâkhi was born in 1953. At the end of his life Xenakis suffered with Alzhiemers and worked for as long as he was able to, but died at the age of 78 in his Paris home in February 2001.

2. Metastaseis

was composed by Iannis Xenakis in 1953-54, which was one of his most important pieces. The name comes from Greek, which Meta means after or beyond, and staseis means immobility. The combination of those two words brings the meaning of "Dialectical transformation".

Metastaseis is an orchestral piece that involved 61 musicians and all players play an independent part. This piece is dominated by string instruments, which are played in unison at the beginning of the piece before they are split into 46 different parts. It also requires piccolo, flute, two oboes, bass clarinet, three horns, two trumpets, two tenor trombones, timpani and percussion.

3. Free Stochastic Music

In probability theory, a purely stochastic system means that the state is non-deterministic so that the state is based on probabilities. In music, mathematical process based on probability (P(x)) can generate stochastic elements. Stochastic elements are used in the composition of music or can be produced within a performance. Stochastic music was pioneered by Iannis Xenakis, who coined the term stochastic music.

In Xenakis' piece 'Metastasis', he used stochastic music to determine the note lengths within the piece, the intervals of intensity and pitch within the mass of sound and the speeds of the glissandi in the different instrumentation.

Elements of the music	**Stochastic Laws and Incarnations**
Durations/Note lengths	P(x) = $\partial e^{-\partial x}$dx where $\partial = linear\ density\ of\ points$ and x = the length of any segment.
Intervals of intensity and pitch	$\theta(y)dy = \frac{2}{a}\left(1-\frac{y}{a}\right)dy$ This gives probability that a segment (interval of intensity and pitch) within a segment of length (a) will have a length within y, for $0 \leq y \leq a$
Speeds of glissandi	Based on the three hypotheses: **1.** Two regions of equal extent on the pitch range contain the same average number of glissandi. **2.** The absolute value of speeds of glissandi is spread uniformly. **3.** There is no privileged direction for the movement of glissandi sounds in any register. There is an equal number of sounds ascending and sounds descending. • f(v) = the relative frequency of occurrence of v, where v = absolute speed. • n = number of glissandi per unit of the pitch range. • r = portion taken from the range. • From hypotheses 2, the number of glissandi with speeds of value v is a function which depends on v^2 (as equal amount ascending as descending), so this function is g(v^2). $nr\frac{1}{2}f(v)dv = nrg(v^2)dv$ when simplified, the equation amounts to: $f(v) = \frac{2}{v\sqrt{\pi}}e^{-v^2}$
Pitch and time	Uses a graph on graphic score to show the pitch and time :