Images of Sound in Xenakis's *Mycenae-Alpha*

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Abstract: *Mycenae-Alpha* (1978), composed by iannis Xenakis on the UPIC system, presents an example of the relationship between graphic image and sonic structure in electroacoustic music. The graphic score of Mycenae-Alpha provides a basis for an analysis of the work's form and a guide to its characteristic sonic features.

1. Introduction

Mycenae-Alpha is an electroacoustic work that Xenakis composed in 1978 as part of an installation of lights, movement and music that took place at Mycenae Acropolis in Greece. *Mycenae-Alpha* is also the first work to be composed entirely on the UPIC system. The UPIC is a tool for the graphic composition of electroacoustic music which was first developed in the late 1970s by Xenakis and his staff at the Center for Studies in Mathematical and Automated Music in Paris. The UPIC has undergone several modifications and improvements since that time. My presentation today is organized around two main topics related to *Mycenae-Alpha*. The first topic concerns the relationship between the striking images that make up the work's graphic score, which is included in your handout, and the equally striking sounds that these images represent. The second topic concerns the large-scale structure that is generated by the relations among the various sections of which the work is composed.

2. The UPIC system

The UPIC is a system of computers and peripheral devices that allows the user to generate all aspects of an electroacoustic composition graphically. These aspects may be divided into two levels of composition: microcomposition and macrocomposition. Microcomposition refers to the generation of timbres by the creation of waveforms. These waveforms vary in kind from standard types, such as the sine, triangular, and square waves that are basic to electronic sound synthesis, to complex, quasi-random waves that may be designed graphically by the user. The relative simplicity or complexity of the waveform has a direct impact on the quality of the sounds produced. Generally, simple waveforms produce sounds that are "cold" and lacking in harmonic color, while complex waveforms tend to produce rough, grainy sounds. Those of you who are familiar with Xenakis's music will not be surprised that he prefers sounds in the rough, grainy category. Macrocomposition refers to the organization of sounds in pitch and time. This organization takes place independently of the choice of waveforms and results in the perceptible structure of the music, which is generated by the composition of a graphic score. Microcomposition must occur prior to macrocomposition, for if no waveforms are selected, the events represented in the graphic score will be unable to produce any sounds.

Figure 1 shows a schematic of a version of the UPIC that dates from the mid 1980s. In this and in earlier versions, waveforms and graphic scores were designed on a graphics tablet equipped with an electromagnetic pen. Input from the graphics tablet was processed through a digital-to-analog converter before being recorded on tape and broadcast through loudspeakers. In more recent versions of the UPIC the graphics tablet and electromagnetic pen have been replaced by a PC and a mouse, with special software that has been designed to operate in a Windows environment. Real-time technology has also been incorporated, which allows the user to hear the sounds as they are being produced rather than having to wait until after the completion of a section of music before playback can occur. *Mycenae-Alpha*, of course, was composed on the original UPIC, which featured the graphics tablet and electromagnetic pen and did not include a real-time playback system.

Information concerning the microcompositional aspects of *Mycenae-Alpha* is not readily available, but its macrostructure is represented by its graphic score, which will provide a focus for my analytical comments. In order to interpret the microstructural aspects of the music we will have to rely on our ears, which we will have an opportunity to do shortly, since this presentation includes several recorded examples. [The reader may wish to obtain a recording Mycenae-Alpha, which is available on Harmonia Mundi CD/Neuma Records 450-74.] For now, however, please turn to Figure 2, which shows the graphic score to *Mycenae-Alpha* with annotations.

The two dimensions of the graphic score resemble those of a conventional music score. The vertical axis represents pitch. At the far left of the first system, the pitch space is calibrated in octaves, and A 440 is given as a specific reference point. These points of orientation function analogously to the staff lines and clefs of standard musical notation. The horizontal axis represents time, which is measured in minutes and seconds. Individual sounds are represented by lines, which Xenakis calls "arcs." The arcs in the score appear in two basic orientations: horizontal and oblique. Horizontal arcs produce sounds whose pitch is steady, or relatively steady, depending upon the evenness or crookedness of the arcs. Slight variations in the pitch of the horizontal arcs are an inevitable result of the compositional process, in which the arcs are drawn freehand. Oblique arcs produce sounds whose pitch varies in extremely small increments over time. The audible result resembles the sound produced by a glissando on a string instrument, or by a siren.

The arcs cohere into larger structural units, which are known in UPIC terminology as "pages." The notion of the page derives from the method of UPIC composition, in which collections of arcs are designed separately and are then sequenced in order to produce a complete composition. The graphic score of *Mycenae-Alpha* represents one possible sequence of the pages produced during its composition. The boundaries of the pages are indicated by marks along the temporal axis, and are labeled with the times at which they occur. As you can see, from two to four pages fit within each system of the score. You can also see that the pages vary in duration. Unlike an instrumental or vocal score, in which instructions for the players or singers are encoded for each performance, the graphic score of a UPIC work is required only for its initial realization, for the sounds represented by the arcs are transferred by the system directly onto a recording medium which thereafter represents the definitinve version of the work. After the initial realization of a UPIC work, the graphic score may then function as a fully realized compositional sketch—realized, that is, in the dimensions of pitch and time—and as an aid to the study of the work's macrostructure. Xenakis seems to have attached special importance to the graphic score of this particular work, for its has been published by Editions Salabert, has been reproduced in *Perspectives of New Music* and in the booklet accompanying the commercial recording on compact disk, and photographic slides are available on rental from Salabert for projection during public performances of the work. The numbering of the pages in Figure 2 represents my own annotation to the composer's graphic score.

3. Analysis

For analytical purposes, I prefer to call the temporal units of the work "segments" and the collections of arcs that occur within the segments "configurations." The segments in *Mycenae-Alpha* have been labeled above each system with integers from 1 to 13. Some segments, like numbers 2 and 3, for example, contain a single configuration, while others, like numbers 1 and 4, contain multiple configurations dispersed through the pitch space. The configuration or configurations within a segment tend to be made up either of horizontal or oblique arcs. The arcs in the configurations in segment 1, for example, are mainly, though imperfectly, horizontal. The configuration in segment 2, on the other hand, is made up entirely of oblique arcs. There is a definite difference in sonic quality between configurations made up of horizontal versus oblique arcs. As a result of this difference, the configurations may be divided into two categories: sustained (i.e., those made up of horizontal arcs), and glissando, (i.e., those made up of oblique arcs). In order that you may hear the difference between these two types of configurations, please listen to the first minute of *Mycenae-Alpha*, which comprises all of segments 1 and 2 and the beginning of segment 3.

[Recorded example #1: first minute of *Mycenae-Alpha*]

If the categorization of configurations into sustained and glissando types is continued throughout the entire work, the result is that 9 out of the 13 segments may be classified as "sustained" and the remaining 4 segments as "glissando." This categorization is illustrated in Figure 3. The figure shows a table in which each segment is represented by the number with which it is labeled in the score and the segment's duration, in seconds, is given to the right of the number. The total duration in each category is also shown. The results are summarized at the bottom of the table, where it is demonstrated that the glissando configurations account for 0.37 of the work's total duration, and the sustained configurations account for 0.63 of its duration. The relationship between the categories approximates the simple proportion 2:3. Remember this proportion, for as we will see shortly, it is replicated elsewhere in the work.

I turn now from the general classification of the configurations to an examination of more specific relations among them. Let us begin by focusing on the configurations in segments 1 through 6 alone. These configurations have been extracted from the score and reordered in Figure 4, so as to facilitate comparisons among them. As shown in the figure, the six segments are grouped into three types. The configurations in segments 1 and 4 are members of the same type—which I arbitrarily call Type A—because they all consist of densely packed, mainly horizontal arcs. Despite their differences in duration and morphology—that is, general shape or contour—the configurations in both segments appear to be representations of the same basic type of material. Moreover, they are similar in sound, which may be demonstrated by playing the two segments in direct succession.

[Recorded example #2: segments 1 and 4]

The configurations in segments 2 and 5 are paired together as members of Type B on account of their morphological similarities. Specifically, both configurations begin within a narrow band of pitch space and then expand outward. The configuration in segment 5, however, begins with a single line, unlike that in segment 2, and its expansion is much wider. Perhaps because of the greater width of its expansion, the texture in number 5 is notably less dense than that in number 2 and, unlike the configuration in number 2, the one in number 5 returns to a narrow band of pitch space as it nears its conclusion. Both configurations are made up primarily of oblique arcs. They should now be heard in direct succession.

[Recorded example #3: segments 2 and 5]

Perhaps because of the differences in density, these two configurations are not as similar aurally as their graphic representations might suggest. Nonetheless, they are noticeably more similar to one another than to any of the surrounding configurations.

The configurations in segments 3 and 6 are paired together as members of Type C. The resemblance between these two configurations is closer than either of the resemblances that have been described previously. Both configurations begin in the same way and are nearly identical in duration, with number 3 having a duration of 58 seconds and number 6, 60. The only appreciable difference occurs at the end of the configurations, for number 6 features a cumulative ascent through pitch space that does not occur in number 3. This ascent has ramifications for the large-scale structure of *Mycenae-Alpha*, which I will discuss later. For now, however, listen to segments 3 and 6 in direct succession. Note that, due to the sensitivity of the UPIC instrument, even the very slight differences in morphology at the beginning of each of the configurations—due, no doubt, to the freehand method of composition—have a perceptible effect on their sound. These segments also show differences in intensity, i.e. segment 6 begins significantly more softly than segment 3.

[Recorded example #4: segments 3 and 6]

A similar, but more loosely constructed system of correspondences operates in segments 7 through 13. (See again Figure 2.) The configurations in segments 7 and 13 are visually identical, but different in duration. The duration of segment 7 is 24 seconds and of segment 13, 61 seconds. The precise visual correspondence between them suggests that Xenakis replicated the graph of segment 7 in segment 13, changing only the duration specified for the playback function. Duration is a factor that can affect the perception of pitch and timbre and therefore, despite the exact graphic resemblance between these two segments, the pitch of the arcs is more easily perceptible in segment 13 than it is in segment 7. Incidentally, these are the only two segments in which sounds are not produced continuously. In addition to the silences that separate them, Xenakis further distinguishes between some of the configurations in these segments by adjusting the volume of the channels through which they are heard, thereby creating the illusion of spatial displacement. Segments 7 and 13 should now be heard in direct succession.

[Recorded excerpt #5: segments 7 and 13]

Another pair of configurations that bear a close resemblance to one another are those found in segments 11 and 12. The morphology of both is similar, but number 12 is less dense than number 11. Further, 11 contains a mixture of horizontal and oblique arcs, whereas 12 contains only horizontal arcs. Because it includes a fair number of oblique arcs, number 11 was classified as "glissando" in Figure 3. On closer examination, however, it must be considered a hybrid type of configuration. The analysis of other works by Xenakis demonstrates that hybrid configurations sometimes appear in contexts that are otherwise dominated by strictly polarized configuration types. The existence of these hybrid types, which generally appear at or near the end of a work, implies a process of dialectical synthesis in the presentation of materials as a composition unfolds in time. Processes of this kind may contribute additional variety and interest to the structure of a work. Please listen now to segments 11 and 12.

[Recorded excerpt #6: segments 11 and 12]

Morphological resemblances among the configurations in segments 8, 9 and 10 are less immediately apparent, though all of them have a duration of 60 seconds or close to it—segment 8 has a duration of 59 seconds—and all of them occupy virtually the entire available pitch space. Upon closer examination, however, partial correspondences with configurations in other segments are apparent, giving a sense of overall coherence to the group of segments 7 through 13. For example, the vertical density of the horizontal arcs in number 9 appears very close to that in number 12. Likewise, the density of number 10 resembles that of both numbers 7 and 13. Finally, numbers 8 and 11 contain the most complex configurations in the group. The images in these two configurations are notable for their possible biological associations, from the branchings in number 8 that suggest some sort of plant life or possibly a microscopic organism—whether terrestrial or otherworldly—to the area at the lower right of number 11, which resembles a plucked chicken or a baby bird. One last detail in this group is worth noting. Joining numbers 9 and 10, both of which were classified as sustained configurations in Figure 3, is a fairly long glissando. The duration of this glissando is about 6 seconds, which makes the global proportion of glissando to sustained material approximate 2:3 a bit more closely.

The networks of associations among the configurations in segments 1 through 6 and 7 through 13 suggest a large-scale structural division of the work into two parts. It will come perhaps as no surprise, given the careful attention paid to the division of the work's total duration into glissando and sustained configuration types, that the structural division between segments 6 and 7 not only approximates, but precisely corresponds to, the proportion 2:3. The calculations that support this statement are shown in Figure 5 (located directly below Figure 3). Figure 5 also shows that, within the parts, the proportion between the durations assigned to glissando versus sustained configurations corresponds to or approximates the proportion 2:3. The correspondence is exact in part 1, but only approximate in part 2. If the 6 seconds of glissando at the end of number 9 are added to the total duration of glissando material and subtracted from the total duration of sustained material, the approximation to the proportion 2:3 is a little closer, in fact almost the same as it is in the work as a whole, which is given in Figure 3.

There is an important difference between the proportions that refer to the division of the work into parts and those that refer to the total durations of glissando and sustained material within the parts and in the work as a whole. The former refer to the temporal structure of the music as it unfolds in time and the latter are independent of the order in which the segments are presented. Xenakis has a theory that accounts for this difference. According to this theory, divisions that occur in the music as it unfolds in time are expressions of its inside-time structure. But musical materials may also be organized independently of their temporal succession and location within a work. This more abstract organization constitutes the outside-time structure of the music [Xenakis 1992]. In *Mycenae-Alpha* the inside-time and outside-time structures are related through the use of a common proportion, 2:3, which appears in the division of the work into parts and in the classification of configuration types, both in the work as a whole and within the parts.

In addition to the various appearances of the proportion 2:3, there is a second system of proportions operative in the inside-time structure of the work. I mentioned previously that the cumulative ascent through pitch space that takes place at the end of number 6 plays a special role in the large-scale structure. The ascent begins at 3'40", or 220", which is not marked in the annotated score because it does not constitute the start of a new segment. As shown in Figure 5, the point at which the ascent begins divides the work in such a way that the music up to that point exists in a proportion of 0.618 with respect to the music from that point to the end. The music from that point to the end likewise exists in a proportion of 0.618 with respect to the whole work. This proportion is none other than the famous golden section. The golden section appears in other works by Xenakis as well, either as the principal proportion or as a secondary proportion marked by some notable structural feature in addition to the principal proportion, as it is here.

4. Conclusion

One issue that I have not yet addressed is the relation of a graphically-generated work such as *Mycenae-Alpha* to the mathematically-generated structures for which Xenakis is better known. Of course, mathematics are involved in the proportional organization of the inside-time and outside-time structure of the music, and this is consistent with the way in which many of Xenakis's instrumental works are organized. But in a work like *Mycenae-Alpha*, any reliance on mathematical devices for the organization of the music's details—such those described in Xenakis's treatise *Formalized Music*—has been stripped away, leaving the composer alone in front of the UPIC graphics tablet (or PC), equipped only with his visual and aural imagination and his electromagnetic pen (or mouse). Rather than speculate further on the relationship between mathematical and graphic compositional methods in Xenakis's work, it is perhaps better to leave the final word to the composer himself, whom I quote:

> What is obtained by calculation always has limits. It lacks inner life, unless very complicated techniques are used. Mathematics gives structures that are too regular and that are inferior to the demands of the ear and the intelligence. The great idea is to be able to introduce randomness in order to break up the periodicity of mathematical functions, but we're only at the beginning.
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> The hand, itself, stands between randomness and calculation. It is both an instrument of the mind—so close to the head—and an imperfect tool.
>
> The products of the intelligence are so complex that it is impossible to purify them in order to submit them totally to mathematical laws. Industrialization is a forced purification. But you can always recognize what has been made industrially and what has been made by hand. Industrial means are clean, functional, poor. The hand adds inner richness and charm [Xenakis 1987].

References

[Lohner 1986] Henning Lohner, "The UPIC System: A User's Report." *Computer Music Journal* 10/4 (1986): 42-9.
[Marino et al. 1993] Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski, "The UPIC System: Origins and Innovations." *Perspectives of New Music* 31/1 (1993): 258-69.
[Serra 1993] Marie-Hélène Serra, "Stochastic Composition and Stochastic Timbre: *Gendy3* by Iannis Xenakis. *Perspectives of New Music* 31/1 (1993): 236-57.
[Xenakis 1978] Iannis Xenakis, *Mycenae-Alpha*. Paris: Editions Salabert, 1978. Score reprinted in *Perspectives of New Music* 25/1 (1987): 12-5.
[Xenakis 1987] Iannis Xenakis, "Xenakis on Xenakis." *Perspectives of New Music* 25/1 (1987): 16-49.
[Xenakis 1992] Iannis Xenakis, *Formalized Music*, rev. ed. Stuyvesant, NY: Pendragon Press, 1992.

Recordings of electroacoustic works by Xenakis on CD

Gendy3 (1991). Neuma CD 450-86.
La légende d'Eer (1977-8). Montaigne (Auvidis) MO 782058.
Mycenae-Alpha (1978). *Perspectives of New Music* 25 (1987) (cassette); Neuma CD 450-74.
Taurhiphanie (1987). Neuma CD 450-86.
Voyage absolu des Unari vers Andromède (1989). *Perspectives of New Music* 28 (1990).

For further information on UPIC:

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Figure 3

Categories of Sonic Configurations

sustained		glissando	
segment	duration (sec)	segment	duration(sec)
1	17	2	38
3	58	5	55
4	5	8	59
6	60	11	59
7	24	total	211
9	60		
10	60		
12	20		
13	61		
total	365		

Total duration of *Mycenae-Alpha* = 576”

glissando/total = 211”/576” = .37
sustained/total = 365”/576” = .63
glissando/sustained ≈ 2:3

Figure 5

part 1 (segments 1-6): 233”
part 2 (segments 7-13): 343”

part 1/whole = 233”/576” = .4
part 2/whole = 343”/576” = .6
part 1/part 2 = 2:3

within part 1:

glissando/part 1 = 93”/233” = .4
sustained/part 1 = 140”/233” = .6
glissando/sustained = 2:3

within part 2:

glissando/part 2 = 118”/343” = .34
sustained/part 2 = 225”/343” = .66
or
glissando + 6”/part 2 = 124”/343” = .36
sustained - 6”/part 2 = 219”/343” = .64
glissando/sustained ≈ 2:3

secondary division:

in segment 6, ascent through pitch space begins at 220”

ascent/whole = 220”/576” = .382 (1 - GS)
ascent/remainder = 220”/356” = .618 (GS)
remainder/whole = 356”/576” = .618 (GS)