ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF ARTS AND SOCIAL SCIENCES

SPATIALIZATION THROUGH GEOMETRICAL SOUND MOVEMENTS IN PERSEPHASSA BY IANNIS XENAKIS

MASTERS THESIS

Sabina KHUJAEVA

Institute of Social Sciences

Masters Programme in Music

JUNE 2019

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IANNIS XENAKIS'İN PERSEPHASSA ESERİNDE GEOMETRİK SES HAREKETLERİ ARACILIĞIYLA MEKANSALLAŞTIRMA

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Sabina KHUJAEVA, an M.A.student of İTU Graduate School of Arts and Social Sciences, 40915116, successfully defended the thesis entitled "SPATIALIZATION THROUGH GEOMETRICAL SOUND MOVEMENTS IN PERSEPHASSA BY IANNIS XENAKIS", which she prepared after fulfilling the requirements specified in the associated legislations before the jury whose signatures are below.

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To my mother,

FOREWORD

This project has been developed out of ideas that emerged in courses and case studies I attended during my master studies at MIAM for the past three years. It would not have had the spirit without the invaluable influence, active contribution, support and psychological help of very unique people to whom I would like to express my deep feelings of gratitude.

I would especially like to thank Amy Salsgiver for her mastery in percussion instruments, which raised in me the massive enthusiasm to love the world of percussion music. My gratitude goes to my mentors in the period of my master studies: Reuben de Latour and Pieter Snapper. I greatly benefited from learning and exploring compositional techniques of the music literature of the 21st century through the analysis of new musical aesthetics and tendencies. Comprehension of complex ideas, terms, terminologies and flexibilities in investigations of new fields have provided me to observe new music through various approaches and perspectives. Also, without Jeremy Woodruff, it would not have been possible for me to discover some of the methodologies that I have referred to in the thesis. I would also like to thank Manolis Ekmektsouglou for his help in translating some literature from Greek to English and for having a crucial influence on my understanding of Xenakis`s music.

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May 2019

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Musician

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SPATIALIZATION THROUGH GEOMETRICAL SOUND MOVEMENTS IN PERSEPHASSA BY IANNIS XENAKIS

SUMMARY

Prominent musicologists, composers, psychoacoustic scientists, and many other researchers have made numerous investigations on the subject “space”. In the flux of various directions and tendencies of the musical styles the enthusiasm for spatialized music grew steadily among composers as well. It became one of the central notions of musical literature of the 20th century. Undoubtedly, after vast research by scholars on music cognition, the perceptual efficiency of the listeners became a significant phenomenon in music. Composers such as Charles Ives, John Cage, Karlheinz Stockhausen and Henry Brant started to consider those factors in creating their compositions. Among them, Xenakis gave “space” an influential role in his music. Due to his dual career as composer and architect, he occupied himself with space more intensively than most of the other composers. As a result, he achieved new kinds of spatial integrations in his compositions.

In the piece “Persephassa”, Xenakis reaches an advanced level of creativity in percussion music literature. A hexagon shape surrounding the performers provides the special physical embodiment and special listening perception of the sounds. Notwithstanding the stationary positions of the performers, the composer simulates visualized geometrical sound shapes, their rotation, and motion through geometrical sound figures. It is achieved by the transformation and manipulation of the rhythms, pulse and meters. The synchronization and desynchronization of the piece gain another significance. Ultimately, Xenakis reaches the multidimensional quality of sound through the density and depths of the music sounding and by means of merely acoustic percussion instruments without any digital amplification. Because each listener may occupy an individual localization for each performance and hear the unrepeatable sounding of space in various concert venues, the piece Persephassa grants multi-interpretative form. All those facts raised in me the deep enthusiasm to investigate this topic. Iannis Xenakis has a holistic and integrated approach to science

and musical art. He enriched the picture of modern music and established a new musical phenomenon in art. Various sound images and compositional techniques which he used are holistically interesting if one conducts research on the perspectives of the music listener. These compositional tools are especially important for music creation and contribute to an adequate perception of the music of the 20th and 21st centuries.

IANNIS XENAKIS'İN PERSEPHASSA ESERİNDE GEOMETRİK SES HAREKETLERİ ARACILIĞIYLA MEKANSALLAŞTIRMA

ÖZET

Önde gelen müzikologlar, besteciler, psikoakustik konusunda çalışan bilim insanları ve çok sayıda araştırmacı, müzik literatüründe çok çeşitli açılardan ele alınabilecek bir konu olarak "mekân" üstüne çok sayıda araştırmalar yaptılar ve yaklaşımlar geliştirdiler. Müzik tarzlarının çeşitli yön ve eğilimlerinin akışında, mekansallaştırılmış müzik 20. yüzyıl modern müziğinin temel kavramlarından biri olmuştur ve bu müziğe merak giderek büyümektedir. Müzik algısı üzerine yapılan çok sayıda araştırmanın ardından, dinleyicilerin algısal etkinliği de müzikte kuşkusuz önemli bir fenomen haline geldi. Besteciler kompozisyonlarını oluştururken bu faktörleri de dikkate almaya başladılar. Mekansallaştırma Charles Ives, John Cage, Karlheinz Stockhausen, Henry Brant ve çok sayıda diğer bestecinin çeşitli eserlerinde ortaya konmuştur. Bunlar arasında, diğer besteciler ile kıyaslandığında Xenakis'in müziğinde mekansal eserler önemli yer tutar. Xenakis müziğini notalar ile değil, sesler ve tonlar ile inşa etmiş ve mimar olmasından dolayı diğer bestecilere göre müziğinde mekan faktörü çok daha belirgin bir rol oynamıştır. Bunun sonucunda Xenakis'in eserlerinde yeni mekansal entegrasyon tarzları ortaya çıkmıştır.

Xenakis'in *Persephassa* adlı eserindeki vurmalı çalgılar yazısında sergilediği yaratıcılık, müzik literatüründe ileri bir seviyenin örneğini oluşturur. Perküsyon icracılarının oluşturduğu altıgen, eseri oluşturan seslerin fiziksel olarak şekillenmesini ve dinlenme algısını sağlar. İcracıların sabit pozisyonda bulunmalarına rağmen, besteci, eseri oluşturan seslerde bir rotasyon etkisi elde etmeyi başarmıştır. Eser farklı geometrik şekiller yoluyla ritm, vuruş, ölçü ve seslerin akışkanlıklarını kullanarak konumlaştırma algısında çeşitli dönüşümler sağlar. Parçada senkronize olan ve olmayan kısımlar böylece ayrı bir önem kazanır. Sonuçta, Xenakis, müziğin yoğunluğu ve derinliği boyunca ve herhangi bir dijital amplifikasyon olmadan sadece akustik vurmalı çalgılarla çok boyutlu bir ses ortamı yaratmayı başarır. Her dinleyicinin eserin her performansında o ana özel bir konum işgal etmesi ve eser çeşitli konser salonlarında seslendirildiğinde de mekanın sadece kendisine özel ve başka

mekanlarda tekrarlanamayan akustik ortamı, Persephassa her yorumlandığında farklı deneyim sunan bir eser formu meydana getirir.

Bütünsel anlamda hem bilimsel hem sanatsal bir yaklaşıma sahip olan Iannis Xenakis, modern müziğin panoramasını zenginleştirdi ve yeni bir müzik fenomeni oluşturdu. Kullandığı ses imgeleri ve besteleme yöntemleri bütünsel olarak dinleyicinin algısını inceleyen araştırmacılar için önem taşır. Bu konudaki bilgiler özellikle müzik yaratımına ve 20. ve 21. yüzyıl müziğinin doğru şekilde algılanmasına katkıda bulunacaktır.

1. INTRODUCTION

1.1 Purpose of the Thesis

In many respects, spatialization is a fundamentally different phenomenon from existing musical parameters and it is difficult to define or measure. Its notions have a heterogeneous network of concepts among creators and are influenced by a considerable number of different interrelated factors. Initially, the overall musical aesthetic of writing spatial music is instinctual. Moreover, in some cases, the artistic validity of various works in spatial music is appreciated in terms of perceptual efficiency rather than artistic validity. Henry Brant, a composer who is tightly connected with spatial music, explains that some of the principles of spatial music are direction and tone quality which should act together to identify certain kinds of music; otherwise, space does not express anything and creates chaos (1992). Accordingly, the choice of musical materials demands the intelligent construction of the initial idea into the larger structure. Those conceptions generally require specific compositional means.

The concept of "spatialization" has become an important academic research topic in fields like musicology, music theory and composition. Consequently, "space" is an influential term in other various disciplines as well such as science, philosophy, neuroscience, psychology, and others (Bates, 2009). Hence, the spatiousness is a significant phenomenon in the musical culture of the 20th century composers. It creates numerous compositional ideas and concepts for the realization of the visualized sound images.

Xenakis was one of the influential musical figures of the 20th century. His music was radically different from his contemporaries because he came from an intense engagement of modern architecture and higher mathematics. His remarkable scientific knowledge created an unconventional musical language. As an architect, Xenakis was a sound sculptor. Furthermore, he was interested in the geometry of sound images and their spatial movements. Even his scores visually represent geometrical figures. The

intersection between music and architecture led to spatiousness and geometric sound images, which is an indispensable part of his works (Kermit-Canfield, 2013). The thought of multidimensional quality exists in various compositions by Xenakis. Multi-dimensional music translates the music listening experience into physical movement, where sound sources are placed behind, above, and below the listener. For example, Xenakis placed the listener inside an orchestra in his piece Terretektorh, realizing complex spatialized sounds (Solomons, 2013, p. 60).

The piece "Persephassa" is a special example where the composer utilizes innovative percussive applications, which provide spatial exploration through cross-rhythmic pulsations, timbres and time management. The morphology of percussion music is innately contradictory in terms of specificity of attacks, note values of rhythmic complexity and intellectual accuracy. It also has relationships with the physical language of rituals and ancient traditions (Schick, 2006). By placing the performers around the audience area, the composer reaches a more conjoint experience of listening by the auditor. Due to the extensive manipulation of the sound, Xenakis creates the rotation of sound gestures and draws the picture of representative geometrical shapes, which might be visualized by the listener`s ears. He creates space in music and space inside space by means of building complex rhythmical and timbral textures and by including abrupt silences. His music possesses density, richness, and depths, which simulate multi-dimensional sound quality through acoustic percussion instruments.

The thesis generally refers to the concept of spatialization in music through various sound qualities and sound images. It examines the multi-directional and multidimensional attributes of sounds and their modifications in the texture of Persephassa. The purpose is to identify the role of the geometry of sounds and revise the adaptation and demonstration of specific compositional techniques in the context of Xenakis`s music creativity. It also explores the simulation of spatiousness, sound movements, various horizontal, vertical sound directions and dimensions, fusions, and rotations in percussion music. However, the thesis can cover only some aspects of a much larger picture.

1.2 Motivation

In the last century, the importance of human perception became one of the main notions of art. Hence, the listener became an active consumer of musical artwork. The

new approaches arose from psychological and physical attention to the sound itself. Respectively, each sound became an important event of the musical material. Noises and silences found their meaning in conception and perception of the music. New sound qualities and spatializations of music provide the listener with a deeper immersion of the sonic world of a particularly spatialized piece instead of listening to it from a distance.

Primarily, any artwork actually and potentially has the purpose to impress the psyche of the consumer. In Koenig`s opinion, aesthetics deals with the perception of the listener rather than the composer (Koenig, 1968, pp. 1-3). An artist always seeks to realize this impact within tools and implementations that are appropriate to one or another type of art. By considering every aspect of these creative tools, the author tends to use them in tandem with one another in order to truly represent the compositional idea. Here the word "tandem" is the keyword which reveals that an artistic device cannot express an imaginary idea by itself. Therefore, in music, each element and detail in the organization of sound may considerably change the overall compositional design. In fact, this phenomenon provides numerous choices of techniques and creates a complex concept that does not repeat itself. Different approaches raise the interest to investigate new artworks in order to identify the type of methods and executions for the realization of unique ideas.

Space in music also has multiple implementations and it intertwines with various musical devices, which elicit numerous perspectives. It is an effective artistic tool in constructing an imaginary sound design. For instance, experiencing music from different locations and perceiving them as one unified organism of sounds have an impressive effect on the listener. The auditor can not only conceive the multidimensional fictitious music from multiple directions but also live inside the specifically created sound world. It also provides hearing the spatialized composition from an exclusive point, which will not result in an identical perception of every listener. This kind of phenomenon opens the doors to an interpretation of other perspectives and challenges composers to realize new conceptions in musical art. It also raises other questions and thoughts about human perception and musical cognition.

The motivation to conduct this research is related to the interests in the investigation of spatialized music for percussion instruments which are stationary but produce mobile sounds in various dimensions.

1.3 Methodology

Spatialized music is a complex network of ideas, rather than a single line of development. The traditional method of analysis in terms of melody, rhythm, and harmony is not an appropriate way to examine the pieces from spatial perspectives. The methodology of research is a complex and exceptional novelty that requires detailed and creative processes of analysis by considering all aspects of the music. The research questions require new and unconventional approaches to investigate the topic.

Firstly, the thesis is based on various literature and investigations concerning spatialized music and already existing musical examples. There are highlighted musical layers, rotations, juxtapositions in the texture and illustration of the geometrical sound figures, which represent the angles of sound movements in *Persephassa*.

There are various approaches for analysis and yet, methodologies provide a more informative and comprehensible picture of mobile sound. However, it is virtually impossible to make a full review of all aspects of spatialization and Xenakis`s approaches in the piece. The ideas in the thesis are based on the existing fundamental arguments, statements and analyses by research in the field of spatial music; in addition, there are references to Xenakis`s own ideas about space in music. The thesis does not deeply examine the mathematical logic within its formulas, architecture disciplines, acoustic properties, or sound cognition in the perception of spatial music. The focus of attention is the direct compositional techniques in the realization of spatiousness in music and its implementation in the score.

1.4 A Short Literature Review

In Chapter 1 the thesis mainly discusses the general aspects of spatialization in music, motivations, and methodology of the thesis.

Chapter 2 provides a definition of the term “space” and makes an overview of the historical evolution in spatial music. It mentions the influence of the antiphony of

music, off-stage strategies, and the notion of electroacoustic music which impacted the spatialized music of the last century.

In Chapter 3, different methods, classifications, and utilization of spatialized techniques are examined. This chapter makes a review of the biological and psychological perception of the sound, considers the technical aspects of performance, and discusses the theoretical proposals of Bregman (1990).

Chapter 4 examines the process of idiosyncratic spatial effects in the piece *Persephassa* by Iannis, which is taken as the main example for the profound and conceptual analysis. Particularly, attention is given to the usage and effectiveness of various spatialization articulations, strategies, and technical implementations.

Lastly, Chapter 5 is the conclusion where the thesis compiles all ideas and compositional applications of spatial music and its perspectives in the future of the music.

The literature of the subject is comprehensive and it has a long evolution in the history of music. The references frequently relate to Ph.D. dissertations by Enda Bates, titled as “The Composition and Performance of Spatial Music” (2009). Bates outlines the conceptions and implementations of spatialized music in various musical genres. He discusses and summarizes the various statements about electroacoustic music and instrumental music by significant composers and theoricians.

Another work is “Space and Spatialization in Contemporary Music” (1994) by Maria Anna Harley. She explored the philosophy, notion of spatialization, and psychoacoustic impacts. Authors of these dissertations provide a full review of all aspects of spatialized music. In addition, the thesis refers to the ideas of Xenakis himself. Iannis Xenakis was an inventor of unique ideas, and he approved his conceptions, his understanding of music and his philosophy in his books, articles, and interviews. His work “Formalized Music Thought and Mathematics in Composition” (1992) is another supportive material in explaining his process of sound development.

2. HISTORICAL EVOLUTION AND METAMORPHOSIS OF SPATIALIZED MUSIC

The thesis partially examines European musical traditions and aesthetics concerning this subject. This section will outline the historical background of spatialized music from different composers.

2.1 The Notion of Space in Music

According to Fedina, each epoch has created symptomatic “new types of art” and their new means, corresponding to the spatial image of the world, principles, and methods of cognition. The Middle Ages relate to Gothic architecture, polyphony, and spatial and intellectual aspirations. The Romantic Period is an illusion of life drama by means of illusive expression in all types of arts. Modern Era relates to photography and cinema with a new aesthetics of abstract colors, lines, and shapes in visual art forms. In music, it is sound synthesis, electronic and computer music art. All of them are based on human psychology and perception. Artists keenly felt the value and beauty of new images and aesthetics. They even created the aesthetics of "super-realistic" illusions, renewing and expanding the artistic imagination of the spatial world (2012).

Harley discussed various theories of space to discuss absolute, vector, cosmic, natural space-consciousness, living space and human experiences with space. This terminological expression exists in philosophical, psychological, physical, and mathematical domains. Different authors seek other terms and give different names to the space phenomenon. Some of the terms like extrinsic music, acoustic music, perceptual music, auditory music or sound space denote the notion of spatialization in music (1994).

In a literal sense, the music essentially and naturally is spatial in terms of all musical criteria (Harley, 1994, p.3); moreover, the listener cannot perceive it in a separate way. Schmele also explains that space has indisputably been an intrinsic component of music with its own meaning (2011, p.10). The sense of spatial music is to encompass every aspect of sound and elaborate the significance of sound itself. Spatialization provides a sense of immersion and involvement in a reverberant sound field, which fully surrounds the auditor (Rumsey, 2001, p.10).

The term "spatialized music" designates the sounding with various dimensions, where the listener could be immersed inside of the sound produced. Distribution of sound signals into different areas and their motions in the performance area are the primary criteria in spatialized works. Furthermore, the music might be treated as spatialized if the performance venue is modified for the musical event or if it has a reverb effect. In these cases, these factors function as a particular musical parameter and aesthetic of a particular composition.

According to Raskevicius et al., in the perception of space, there are six vectors that are defined in three-dimensionality: back and forth, up and down, right-left. The vertical line differentiates layers according to the register and frequency positions. The horizontal line defines the time and deploys musical events and all other details of the texture. It is applicable to supplement a diagonal dimension, which brings other creativities to the music. Depth is a bundle of functional heterogeneous plans (2016, p. 8).

All these factors allow creating methods and logic for the placement of sound materials. Presumably, spatial music demands the unity of geometry by considering all dimensions and components of musical tissue. The complexity of the vertical and horizontal musical lines and relationships of musical elements may create depths of sounds and various dimensions in music. In this way, space also coordinates various musical combinatorics into a single system. The problem of differentiation and measurability in its quantitative and qualitative aspects require a detailed study of the ratio and different scale levels of perception.

Spatialization can provide illusions of movements of sound gestures through the utilization of electro-acoustic system. It is possible to achieve spatialization by moving musicians with instruments as well as using the effects of a static well-planned settlement. For example, the spatialization could occur through dialogues among several groups which are based on antiphony principles of music. In addition, the texture of music may simulate spatiousness in music.

The phenomenon of space in music has its own long history and evolution; however, as a new musical definition, it was introduced in early 1928 in Germany (Beyer, Robert, 1928), in the period when many musical and aesthetic conceptions were changed and modernity had already put the traditional musical conceptions into question. For example, harmony and thematic construction had reached a dead point and new musical parameters were rediscovered. The pure sound and its manipulation

became the main material to music-making among composers who were interested in the spatialization of music. A new understanding of music was transmitted to the big impetus of innovated musical concepts in the music literature. In addition, the human perception of sound was one of the major topics of scholars. It drastically changed viewpoints and musical aesthetics of many composers. Traditional concert halls with a fixed position in a stage-audience model fell short in ensuring the interests of spatialized music composers.

"Music is not a language. Every musical piece is like a complex rock formed with ridges and designs engraved within and without, that can be interpreted in a thousand different ways without a single one being the best or the trust. By virtue of these multiple exegeses, music inspires all sorts of fantastic imaginings like a crystal catalyst. I, myself, wanted to deal with the abysses that surround us and among which we live. The most formidable are those of our own destiny, of life and death, of visible and invisible universes. The signs that convey these abysses to us are made up of lights and sounds that provoke our two predominate senses. This is why I have conceived the Diatope as a place for the condensation of these signs and signals from our various worlds. Rational knowledge blends with intuitive knowledge, or revelation. It is impossible to dissociate them. These abysses are unknowable; that is to say, knowledge of them is an eternal and desperate search, composed of milestones or hypotheses that have marked our various epochs." (Xenakis, 2008, op. cit, p. 261).

Harley mentions another means referring to the notion of extension that co-exists simultaneously at the same temporal instant. Obviously, Charles Ivens, Hanry Brant, and Karlheinz Stockhausen used those techniques in their compositions. Most of them used different unrelated independent musical layers in various registers at different tempo and meters. Those potentially dissonant musical materials or separated musicians reinforce internal polyphony and emphasize spatial effects in a whole piece or a particular moment of the piece (1994, p.19).

The form of thinking in the spatial sound-making significantly differs from writing conventional music. A vast range of factors must be comprehended in order to incorporate it into the overall compositional framework. On the other hand, the composer should remember that not all specific compositional strategies and tools may be perceived and comprehended by the listener.

2.2 The Influence of Electroacoustic Music

History shows that spatial music was rediscovered as part of musical structure and performance from the 1950s on, separating the arts from the art of the past. There is a strong association that the history of electroacoustic music of the 20th century brought colossal changes of that time and it is a powerful device in the simulation of the space. Literally, electronic music has an impact on many musical parameters. Spatialization is an indispensable aspect of electronic music which provides physicality and dynamism by enhancing the listening experience (Bates, 2009, pp.159-166).

Bates indicates that electroacoustic music has several strategies to produce a spatialized sound. The most widely used approach is to play an electronic track which was recorded and prepared. However, there is a significant difference between a laptop musician and performer playing the instrument. Undoubtedly, electroacoustic music also has superiority to instrumental music in terms of the degree of sound control (2009). Unquestionably, the naturalistic illusion of sound images might be better controlled by means of electroacoustic music compared to instrumental music. However, by the end of the 1980s, the technological progress of digital computing allowed processing of the sound in real-time by using instruments. For example, the programming language Max/MSP is a widely used and practical tool in electroacoustic performances.

One of the earliest electroacoustic pieces is the *Kontakte* by Stockhausen which is written in 1958. It combines live instrumental performers and spatialized electronic sounds. The composer reaches the spatialization through the successful integration of instrumental music with synthesized electronic parts through crescendos from one source with respective responses from other sources. By passing the sound through crescendos and decrescendos, the composer enriches a smooth transfer from one instrumental group to another. By this method, he deletes the border of the static sound.

Répons by Pierre Boulez is the piece for orchestra, solo instruments such as harp, glockenspiel, vibraphone, cimbalom and two pianos, six loudspeakers, and IRCAM's real-time digital signal processing system. Boulez positioned the orchestra in the center of the stage; however, the audience is surrounded by the six soloists and the loudspeaker in circle form. *Répons* has not been performed frequently enough because

the piece requires a vast venue for the distribution of musicians and loudspeakers and other technical issues (Bates, 2009).

2.3 The Influence of Polychorality and Antiphony

Apart from electroacoustic music, the tendency of space usage can be found in the distant past of many cultures and musical traditions of purely acoustic instrumental music. Since the 16th century, there has been a long path of evolution of spatialized music. By doing analytical researches in the field of spatialization, a strong connection could be found between space and ancient music making.

The earliest type of spatial music might be related to the tribal dances of different cultures. Actions of performers while singing and dancing create mobile sound models. These examples imply that the movement of sounds was not only a metaphor in spatialized music history. Moreover, in many countries of the world, people send messages through different instruments such as horns, drums, or bells in open air spaces. There were calls for different types of religious and spiritual rituals, traditions, events or even the time indications of the day. In ancient times, some music produced in caves had its own natural spatiousness (Kermit-Canfield, 2013).

The most notable technique of different cultures was the call-and-response model. Fundamentally, the call-and-response pattern was effectuated in the polyphonic choral music of the 16th century, when there was wide use of antiphonal singing in the medieval church music. The musical materials of antiphonal music are based on continuous divergent phrases with an interchange between the group of choirs. In 1550, a Flemish composer, Adrian Willaert, composed a piece for two choir groups which are isolated from each other, creating dialogues between them. The piece is one of the earliest examples of music that the spatialization features are inherited directly (Bates, 2009).

The conventional school of choir singing was elaborated by the early seventeenth-century composers of the Venetian school beyond two choirs into an increased number of choir and instrumental groups. Followers of Wilbert such as Andrea and Giovanni Gabrieli composed numerous large-scale works for these extended groups. They were the earliest composers to include dynamic markings and specific instrumentation in the scores. According to Bryant, the larger group was placed at ground level as they

had other ceremony functions throughout the mass (1981). Other smaller Cappella, who did not have a role in the rituals, proposed taking an unobtrusive position in haylofts. It appears that two additional conductors operated with the main conductor located at ground level with the principal choir for the synchronization of distributed groups. Presumably, the multi-directionality of sounds had not been afore something extraneous for that epoch of music (Bates, 2009). These types of localization conduce the depth in sounding. In addition, it is possible to assume that multi-directionality of sounds might simulate the multidimensional spatial contours.

Another level of usage of antiphony texture could be found in *St.Matthew Passion*, which was written in 1729 by J. S. Bach. In addition, in the piece *Serenade in D* by Mozart, written for four Orchestras with divided groups, the motive is transferred from one group to another (Bates, 2009, p. 116). Evidently, spatial music establishes a general sense of relationship and association with genres according to sound quality.

2.4 Other approaches to spatialized music

Practically, music making in the frame of church traditions was one of the spiritual and secular rituals of that period. Therefore, it is doubtful to say that only the architectural peculiarities of performance place affected the sound making by composers. Bagenal, for instance, claimed that the reverberation time of a performance space was a crucial factor in the evolution of polyphony (1930). Therefore, there is a strong correlation between architecture, traditions of making music and textural style of compositions. However, there is no fundamental and single theory about the notion of space in early music.

Hence, polychoral music is noted as the origin of reflection in spatialized composition. The advantage of distance between the groups became one of the main compositional tools for many composers. Nevertheless, musical history shows that the authentication of space as a musical effect has been admitted since the 1920s (Harley, 1994, p.118).

The period of romanticism brought other approaches for spatialization in music by composers. Kermit-Canfield discussed that sometimes, spatialized effects were used in order to demonstrate the contrast of the timbral palette more significantly by replacing the stationary instruments to the far distance as the off-stage instruments. Significant composers of the epoch used this strategy sufficiently. In 1837, Berlioz's

Requiem for singers, woodwind instruments, horns, strings, and percussion was premiered, including four brass ensembles located at four different positions (2013). Another composer, Gustav Mahler, additionally used the off-stage instruments in his pieces. In his *Symphony No. 2* written in 1894, he used brass and percussions as the off-stage instruments (Kermit-Cankfield, 2009, p.16).

It is noticeable from the history of music that the American composer Charles Ives usually incorporated a functional tonal system with contrast and independent sound layers, juxtaposing different meters and rhythms. In the piece "*Unanswered Question"* (Kermit-Cankfield, 2009, p.16)*,* the composer manifests three discrete layers which operate independently at their own tempo and which are positioned at a distance to one another. The stage position has woodwinds; the off-stage position has strings; finally, solo trumpet is located at a distant position: in a balcony. Each group represents its own function and meaning according to the notion of the piece. The strings circle the audience and constantly perform the gradual moving of harmonized sounds. In the opinion of the composer, it represents the natural world. The question and answer dialogues are distributed on the trumpet and woodwinds. The dialogues occur on the trumpet which is punctuated by short clear phrases as a question. The woodwinds answer with multiple, overlapping and unrelated phrases. Ives`s music has a dense texture where the synchronization of musical materials transmits into a rich unity of sounds. The idea of "layering technique" came from Ives's live experience of hearing two instrumental bands passing each other on the march, each playing a different piece (Morgan, 1974, pp. 145-158). While marching and performing music, the dynamic dimensions gradually change as well according to the changing conditions.

There are off-stage instruments such as 4 trumpets, 4 horns, triangle, cymbal, and bass drum that appear in the development (m. 343-379) of Finale in Symphony No.2 (1893-1894) and in the section preceding the Resurrection chorus (mm. 448-471). During the first appearance of the off-stage band, its military fanfares are superimposed on a layer of music in the strings. At first, the band sounds in the furthest distance (m. 343); during its subsequent entries (m. 355, 376), the fanfares become gradually louder. According to a draft program of this symphony, being the image of distant approaching, brasses have a specific and apocalyptic significance. By implementing a superimposed plan of texture, Mahler varies and exaggerates the depths and directions of sounding.

Interestingly, the similarly musical phenomena that Mahler took as models for polyphony inspired Iannis Xenakis's "stochastic music," which is a massive form of sound and where the individual elements are barely distinguished. Thus, Mahler's use of spatial sound has more common conceptions with Charles Ives compared to Xenakis's notions. One of the main intentions to establish audible and comprehendible musical material between opposed layers and timbres is by distributing groups and instruments at a distance (Harley, 1994).

Another one of the most prominent, influential and avant-garde composer of the 20th century is Karlheinz Stockhausen (1928-2007). During his career, he composed various spatial and electronic music and published papers about them. He claimed that the 20th-century history of spatialized music began with the juxtaposition of simultaneously developing "streams" of sound material in the works of Mahler and Ives (Harley, 1994, p.123). Even though the two composers came from different musical traditions, in expositions of their musical materials, both of them used similar strategies.

One of Stockhausen's works is *Gruppen*, where three orchestras are located to the left, in the front and to the right of the audience in order to present clear correlations among different textural layers. The crescendos and decrescendos are clearly reminiscent of stereophonic panning techniques. Stockhausen describes that spatial division of the groups originally resulted from the superimposition of various layers which have different musical expressions and which are complicated to realize for a massive orchestra (Moritz, 2002, p. 1).

Composer John Adams had his own creative thinking about space. He proposed that sound and environments have strong relationships in his music, from being about a place to become the place (Davis, 2014, pp. 175-181). However, defining the relationship between the visible actions and the audible result is quite difficult. In addition, the familiarity of sound has a strong influence on the perception of space.

Henry Brant is another composer who is influenced by Ives's conception of spatial music. Brant wrote numerous works and has become one of the most famous composers of orchestral spatial music. *Antiphony I* contains many of the essential ideas which the composer continued using throughout his career (Kermit-Canfiled, 2013, p. 16). In addition, he summarized the main observations about space and music.

According to Brant`s own theories and hypotheses, the spatial division in combination with timbre may give the appearance of interesting effects such as a wall of sound. The simulation is placed vertically through the wall of the hall by means of string groups and by planning the pitch organization from the lowest to the highest according to the placement. Another method is to cover all performance areas in a round shape and to play the musical element from one player to another with gradual changes of volume. In all the mentioned circumstances, musical sounds occupy segments of physical space and their temporal character may be either static or dynamic (Brant, 1967).

Ultimately, it is evident that the spatialization has various roles in arrangements of music by different composers. The section highlights only several examples from eminent figures among spatial music composers.

3. SONIC MAPPING OF SOUND

3.1. Human Auditory System and Spatial Perception

As it is known, humans possess an ability to hear binaurally, which is a crucial factor in the human auditory system. Researches explain that any first arrived source which is closest to the ear diffracts around the head. It shades the signal and transfers it to the other ear. This process brings an amplitude deviation between the two ear signals. The differentiation between the signals in the two ears is called interaural. It should be noted that the perception is also based on the source signal`s frequency. It is affirmed that 700-800Hz becomes unreliable and incapable above 1.6 kHz. In fact, the interaural level difference may detect a signal source with a high frequency more easily than one with low frequency (Blauert, 1983, pp. 37-50).

The equal perception of both ears is named monaural. Localization mechanisms are often detected in interaural and monaural form, defining the interaural level difference. However, there are still puzzling and unanswered questions by scientists about brain behavior while detecting sound signal placements. It is suggested that making a slight movement of the head allows for determining the position of the sound.

Various studies have shown that parameters such as pitch with its division of a semitone, rhythm, and timbre might be perceived and temporally segregated with a relatively high degree of accuracy. Consequently, the size of the wavelength of a signal is a decisive factor in diffraction (Bates, 2009, p. 16). The delay time of the arriving signal provides the detection of the source localization. The interaural time delay which determines the source is the main principle of the human listening mechanism. The analyses reveal that the spectral content, attacks, signal envelopes, and the spectrum of the source might be driven by interaural time delay (Blauert, 1983, pp. 37-

50). If there is a continuous signal, identification of the sound source might be more accurate (Bates, 2009).

First of all, the nature of our hearing should be considered in order to comprehend all spatialization aspects. The heterogeneity of levels in hearing deals with three methods of listening: casual, semantic, and reduced.

Casual listening is the most common and natural type of hearing when humans gather any information about the source of a signal and make generalizations by dividing them into a human, mechanical, or animal type of sounds. Moreover, it is a type of sound where humans may hear various categorized sounds simultaneously. For example, in cinematography, it is accepted through gestures and visions, which makes us believe in the sound image. In addition, the verbal sounds are captured and take the attention of humans much faster than any other sound. After identifying the source of speech and its meaning, a human may seize the rest of the sounds (Chion, 1994, pp. 22-24).

When it comes to semantic listening, Chion refers to code or language as a form of a message (1994, p. 6). Stumpf and Hornbostel attributed spatial elements to the field of analogies, symbolism, and metaphors. For example, the musical interval in different registers corresponds to different timbre altitude, which expresses the distances of sounds. Stumpf also outlined a physiological explanation of some spatial sound qualities. For instance, the sensation of “width” is related to low tones with a greater length of sound waves. Overall, the harmonious integration of the horizontal and vertical dimensions of music plays a considerable role in making spatial music. Those lines are extracted from the temporal development of music and pitch frequencies. Riemann stated that temporal and spatial components are natural and necessary in every art. Lastly, the third type of listening mode is reduced listening. Schaeffer gives a definition to reduced listening as listening by focusing on the sound itself without analyzing its cause and meaning. Reduced listening changes the habit of passive listening to instructive modes such as identifying the pitch, tone, and interval (Chion, 1994, pp.25-26).

3.2 Sonic Geography

For many centuries, listening to music in the standard concert halls with stage and auditorium was considered to be a socio-cultural activity. However, creating spatialized music radically differs from that model of listening to music. It creates a special and unique listening experience for each listener. Hence, attending a concert hall and listening to music with configured multi-dimensional loudspeakers or a different type of instrumental groups which are placed extraordinary to various locations conducts a unique experience which cannot be reached elsewhere (Bates, 2009).

Firstly, a musical-spatial design is not purely geometrical. It occurs through the spatial attributes of sound matter. Secondly, the consideration of the human auditory system is an indispensable component of spatial arrangements. Apparently, the first-arriving wave dominates and there are relatively shorter and diffused forms of waves that arrive from walls and ground (Bates, 2009, p. 89). The proper distribution of performers among listeners is perceptually more important than their accurate balance of timbre and volume. By considering the performance and perception of spatialized music, certain acoustic environments and conditions serve as part of a composition. Consequently, there are concerns as to why sound sources should be positioned at certain locations. As an answer, it could be said that there are several factors that need to be considered such as the human auditory system, type of sound waves coming from sources, and acoustic properties of the performing place.

There are several principles of spatial design by Harley, which should be mentioned and defined (1994).

The type of acoustic environments:

1. *Enclosed space* of the concert hall may include different types and sizes of concert halls, churches or any type of closed space such as vestibules, corridors, museums, etc.

Obviously, concert halls possess desirable acoustic features in order to increase the quality of sound reflections directed to the seating areas.

2. *Open air* areas

Mostly used in sound installations, but it does not exclude the occurrence of the other type of making music. Mostly, it is wide areas such as parks and squares and it permits different acoustic backgrounds such as natural and unnatural noises.

As an example, there is John Luthern Adam`s piece *Inuksuit* (2009), where the composer determines the music of landscape for the large percussion group that is designed to be played outdoors. The piece embraces a large spectrum of sound-colors realized from miscellaneous types of percussion instruments. In addition, the acoustic environment allows manifestation of those varieties of timbres in absolute, extreme volumes and musical dimensions. As it is known, many percussion instruments require a space in a musical texture to execute sounding in a sense of noise values or timbre shades. Outdoor musical performances can take place in unusual spaces, as in Brant's *Brand a de Amstel*, a site-specific composition for four boatloads of flutes floating through the canals of Amsterdam and encountering multiple ensembles dispersed throughout the city (1984).

3. *Variable space, static performers with mobile auditors* relates to the sound works where musicians and audiences can change their positions during execution time.

The piece *Inuksuit* may serve as an example for the performance scheme where players may hold an inactive role while the audience is allowed to move. In this piece, musicians interact with one another from different angles of the auditorium and play their own individual musical parts. The large ensemble fills up the acoustic environment totally and creates special sonic zones for listeners. Each listener may discover his/her own sound area by moving from one place to another, which guides them to give their own decision whether to focus on timbre or sound material. The composer mentions in his interviews about the topographic map which fully represents the conditions of listening to *Inuksuit* (Davis, 2014, pp. 175-181).

Another category of movement in sound is designed routes of sound sources which suggests the movements within various directions among the static audience. In the piece *Circles* (1960) by Luciano Berio, the solo singer has to move from one music stand to another. In each position, she performs different musical materials (Harley, 1994).

An unusual form of the listener's mobility exists in *Elevator* Music by Elliott Schwartz (1967). In his work, twelve groups of performers are orchestrated for vertical arrangements of the 12 pitch-classes, where each pitch is assigned to each level in spatial effects of building up the set of the lowest and highest pitch. The area of performance are vestibules and lobbies outside the elevator doors, where the elevator has the role of the conductor in order to operate sound among the floors. The work lasts for one hour and there are glissandos, repeated notes, short musical phrases from well-known songs and "anything you choose". Each group of the audience hears a different segment of the piece. The unusual approach principally emphasizes spatial features by making sonic surveys rather than compositional means.

The illusion of imaginary spaces mostly is associated particularly with soundscape genre, where listeners are free to change their positions and find their own individual point of attention.

4. *Variable space, static auditors with mobile performers* relate to the sound works where musicians and audiences can change their positions during execution time.

There might be static viewers while performers are able to modify their positions in a framework of a compositional plan. However, there is a practical condition which demands consideration that only the musicians with transferable instruments may simultaneously perform and move. For instance, in the first movement of R. Murray Schafer's *Third Quartet* (1981), the cellist does not alter a position because the body of the instrument is too heavy to carry and play at the same time. The violinists are transferred from their initial positions by considering the cellist’s position as a principal point on the stage.

In cases where all participants are mobile, it should be considered that there are some limitations by the type of locations. For example, the traditional setup of concert halls with stages allows only to move along the aisles, which does not create comfortable movements or gestures. One of the most important aspects of mobile performing is the silent and attentive audition of spatial music. In fact, the movements of the listeners are impossible among fixed layouts of the seats. Any unrelated sound may occur due to acoustic disturbances during movements. Hence, concerts of contemporary music rarely allow their audiences to wander around during the performance. In the words of

Iannis Xenakis: “The problem is that when people move around, they cannot listen in the same way; they do not concentrate on the music. They do not know how to pay attention while walking and they do not notice the fact that when they change the position, they have a different aural perspective caused by the difference in location. Besides, they are distractive: they annoy other people who are listening when they move.” (Xenakis 1992, pp. 9-10).

There are movement schemes, which are also intended to move out of stage around the concert hall or even among the audience. If the performer's movements or any other actions prevail the sense of music and overshadow the sonic results, then the music is converted into a musical show. This motion may invoke theatrical associations. In other words, the musical meaning and sonorous results lose their significance and the actions of musicians become more important. Indeed, music becomes more theatrical rather than the music itself. Reinhard J. Sacher maintains that all spatialization of music is essentially theatrical and that visual conception of music dominates the aural one: “Spatialized music and musical theater are distinct: all theater is spatial but not necessarily spatialized, and not all spatialization is theatrical” (Harley, 1994, p. 202).

5. *Private and virtual space* mostly, isolated sound installation rooms or use of headphones during the performance time.

Undoubtedly, that visual information takes attention away from the morphological attributes of sound, which composers intend and focus on their work (Raskevicius, 2016, p. 30). It is not by chance that many creators of spatial music refer to have a performance of their pieces in a dark atmosphere in order to reduce the visual influence. They expect the audience to hear the situation of the imaginary sound world in a better way (Zelli, 2009, p. 37).

Eventually, the increasing significance of the mobility of performers and audiences in music often leads to a change in the music context and the disappearance of the traditional form of the concert. The informal, outdoor performances often transform musical works into theatrical actions and acoustic explorations. The division of performers and audiences disappears; the musical notation gives way to written guidance instead of precise scores, and the supratemporal musical work is substituted with a process or an action that cannot be replicated identically. The increasing

mobility of participants is associated with profound innovations in the perception of music, its artifacts, and social contexts.

3.3 Type of Sound Sources

There are several types of sound sources:

1. *A real sound source*, which is vocal and instrumental sources.
2. *A virtual sound source*, which includes electroacoustic sound sources or any type of electronic gadgets.
3. *Mixed sound-space,* which is defined as combined usage of electroacoustic and acoustical sound sources during a single performance.

Executions scheme:

1. Two ensembles in dialogue or antiphony
2. Several ensembles placed on the stage
3. Three or more groups placed symmetrically around the audience
4. A mixture of orchestra and public, where the audience is 'inside' the music
5. Several groups dispersed in various patterns on the stage, around and between the audience and at various levels within the whole three-dimensional performance space

Classification of spatial designs:

1. One-point source
2. Stereophony
3. Quadrophony
4. Multi-loudspeaker projection systems or multiplied acoustic sound sources from different directions

3.4 Sweet Spot

The sweet spot is a term used for the location that creates a focal point between several sound sources. It is created by equally arrived waves at the same time. On the other hand, harmony, texture, balancing and assonance of tones underlie classical music.

The overall conception of classical music suggests being perceived as a whole. However, spatialized music has another important aspect of the localization principle where certain members of the audience may take a position outside the sweet spot or with different arrays of sound trajectories. It may cause various distortions of sounds. Even in the case of very carefully localized sound sources or listeners, there are high potential risks of equivocal perception of sound by each listener. In interpreting this phenomenon, Brant claims that the ideas remain more like an expression of hope than reality (1967).

Iannis Xenakis expressed aural perspectives of the performers in his statements: "The conductor hears the orchestra in a certain way during the performance. He has certain instruments to the right or to the left. [...] The listener in the auditorium does not have the same sound image as the conductor and the conductor has to conduct for the listener, not for himself. How can he do this when he is not there? He should conduct from the auditorium and listen to the orchestra from that place" (1992, pp. 9-20).

3.5 Textural Transfiguration in Spatialized Music

The acting of musicians in fixed positions does not usually imply a static sound image. Without using the distant organization of sounds, there are some strategies to construct spatialized music. The musical movement mostly depends on the development of the linear structures as well as register and pitch space. Indeed, the textural transfiguration plays a role in spatialization as in Ligeti`s pieces. The composer used a large number of parts in divisi within the micropolyphonic texture in order to simulate spatiousness. Serialist composer Pierre Boulez designed his pieces in terms of abstract spatialization by utilizing a more complex texture. Generally speaking, Boulez ignores highly visual sound directions and resembles this phenomenon to playing tennis where elements have the same configurations. For the composer, music should not have clear comprehensible images. Collaborations of sounds with distinct values, times and other expressional meanings are much richer than using loops or same envelopes by passing left and right, which is too anecdotal for him (Bates, 2009).

There is an interesting method in the piece *Hoketus* by Louis Andriessen, where groups of five instrumentalists (pan flutes, electric pianos, pianos, bass guitars, and sets of congas) perform exactly with the same sound and volume (Harley, 1994). The groups are placed apart from one another, playing chords that are practically identical. They

are allowed to repeat a bar or group of bars as often as they wish. This intensive music transmutes into the musical game. The composer acknowledges that music is more powerful while participants are more interactive during a live performance, rather than music with "frozen" spatial shapes. Andriessen explains that only in this way one can hear what it is about, not only through the notes but through the musicians as well (1997). Consequently, it reveals inter-personal perspectives of spatialized music like body-subject music and experiencing the music in its complete gestural, personal and spatiotemporal articulation.

The circle is one of the major contours of spatialized music and it is applied in a variety of contexts. Other spatial geometry of music realized as in a triangle is in the piece *Alex* by Xenakis, a square for four choirs in *Belis of Ugh* by James Harley, or a cube shape in Julio Estrada's *Canto Naciente* for eight brass instruments. The geographic or architectural shapes might be simulated by spatial design, as in Charles Hoag's piece *Trombonehenge* of 1980, where thirty trombones surround the audience in a model imitating the boundary of the ruins at Stonehenge. All these pieces portray and evoke imaginary spaces. Geometric models are generally underwritten with a symbolic function and meant to convey a message through the articulation of sound in space. In Brian Femeyhough's *Transit* for six solo voices and chamber orchestra (1975), the orchestra is positioned in four semicircles on the stage. This placement renders an image from the Renaissance woodcut portraying the four spheres of the Universe (Harley, 1994).

Varèse maintained that in the future, new instrumental methods would make permissible creation of music with "the movement of sound-masses", which would replace linear counterpoint. Old conceptions of interplaying with melody would not exist. The entire composition will transmute, expand, contrast, flow, collide and interpenetrate with each other at different speeds and at different angles. In addition, the composer claimed that there are distinct zones and magnitudes which appear in different perspectives for our perception. The tone color becomes "an integral part of the form". He defines all these phenomena as "zones of intensities" in timbre and dynamics. His spatiotemporal understanding of music is the process of transformation through motions, which works within the movement of physical objects in physical space. Here is another notion of “space” which may exist in a three-dimensional area by occupying a certain space. Instruments, bodies, and sounds play the roles of objects

in the superficial area. Whatever the process of implementation, in his opinion, all strategies will have concreteness in manipulations and clearly established boundaries (Varèse, 1936/1967).

The spatial sound motions might be achieved by means of presenting a musical material in series from one ensemble to another. Boulez claims that if non-homogeneous groups are situated at the same distance and axis from the audience, that sound will not have symmetry in quality (1976). This technique has been remembered since the Venetian school of polychorality in the late Renaissance and even earlier periods. The variety of trajectories of movement is determined by the placement of players.

It is also possible to create the flow of motion introduced in instrumental music through dynamic shading by means of crescendos-decrescendos expressions and temporal overlapping of sounds. Stationary instrumental groups take positions around the public and successively play sounds of the same pitch and timbre with similar dynamic envelopes. It resembles rotation of sound in space and this effect appears in Stockhausen's *Gruppen for Drei Orchester, Carré*, and his four orchestras and continuum choirs.

Iannis Xenakis also used this technique in his pieces *Terretektorh* (1969) and *Persephassa* (1969), where performers encircle the spectator. Another example where musicians may perform axial rotations while standing in one position is in *Eonta* (1963) by Xenakis for brass and piano. Here, timbre has transforming purposes.

Nevertheless, the spatial organization of sound in contemporary music has textural differentiation and a variety of spatial designs. Recognizable sound-geometric shapes such as triangle, rectangle or oval might be realized in a complex score through sitting plans of performers and audience. Echoes, dialogues, contrasting volumes, and directions of sound all play a crucial role. Various images and variable manipulation tools offered by spatialized music are holistically interesting from the perspectives of both music creators and listeners, shaping musical memory and imagination. These new concepts pave the way for further developments and investigations in the process of understanding sound perception and forming sound expression. Many artistic techniques provide new languages to communicate the listener who learns to live

inside the multidimensional existence of a musical work. These facts contribute to an adequate perception of the music of the 20th and 21st centuries.

4. "PERSEPHASSA" BY IANNIS XENAKIS

4.1 Xenakis' spatial approaches

Usually, people juxtapose science and art in social life with arguments that science symbolizes reason and art exists in absolute freedom. What kind of artworks may emerge when mathematics and music interact with each other for the creation of new art? Pythagoras was the first to suggest that there is a direct link between music and the properties of the physical world. Therefore, according to him, it is necessary to study physics, genetics, mathematics, and other subjects in order to understand music. Everything in the world is music, and music is in everything (Xenakis, 1992, pp. 1-4). As it is known, there is always a strong connection between architecture and music. Scholars utilized almost the same terms for classification and descriptions of music and architecture during Renaissance, Baroque, and Modern periods. Johann Wolfgang von Goethe (1749–1842) once said: "Architecture is frozen music" (1839). The little elements and their formulation play a crucial role in building global structures. Music construction is similar to an architectural project according to Iannis Xenakis (1922–2001), and he was a creator whose oeuvre was tightly connected with mathematics. As an architect, he worked progressively for over 10 years and constructed a government building in Chandigarh in India (Teodori, 2012, p. 17).

Furthermore, Xenakis had changed the standard concert halls with unusual rooms or newly designed performance areas. In 1958, the composer was assigned to the project of the Philips Pavilion, prepared for Expo'58 in Brussels, commissioned by electronics company Philips. The Philips Pavilion was the ideology of progress in the technology of that period and it could hold at least 500 people and provide equipment for video, light, and sounds. The composer described the Philips Pavilion construction as an architectural 'translation' of the music of the 20 th century (Clarke & Davidson, 1998).

As a composer, Xenakis has an interesting story about his meeting with Arthur Honegger before his study in Paris. He volunteered a piano piece which he then wrote and played to Arthur Honegger who in turn told Xenakis that those were parallel octaves far from being music. After that meeting, Xenakis stopped attending his classes (Harley, 1994). His serious musical training started after arriving in Paris. Oliver Messiaen, teaching Xenakis at the Paris Conservatory, thought that he had advantages of being an architect and studying mathematics which he could apply in

his music (Mâche, 2002). Indeed, Xenakis`s music has a strong relationship with architecture. In his pieces, the performance area and other spatialization properties play a significant role. Ultimately, spatialization in Xenakis`s music became a prominent phenomenon. He was one of the first composers to work with sound spatialization both in instrumental and in electroacoustic music.

An analytical method such as conventional pitch-class organization theory is not applicable for analyzing his music. In fact, as an engineer, Xenakis used mathematics, logic, and probabilities in his compositional approaches by providing a variety of methods, which does not make his music random at all. He considered music as a chain of cells filled with sound events. These structures served as a starting point for Xenakis to build musical forms and develop musical material. He used and mixed Boolean algebra to create complex rhythms or pitch collections by consolidating the number of series (Kermit-Canfield, 2013). Those compositional devices underlay his work with spatiousness and other acoustic properties, which he used as an essential element in his pieces. Eventually, Xenakis invented his own new sound morphologies where he applied his musical techniques from the macro level to the micro and vice versa.

Iannis Xenakis is one of the brightest representatives of the world's music culture of the second half of the 20th century. The art of the past century was substantially influenced by his versatile masterpieces and it continues to influence the current contemporary music. He was a prolific composer who supplemented his works with theoretical writings as well. The output of his active creative life is about 150 musical works of various genres, a number of significant architectural projects, books, and spatial visual projects.

According to Dubov, the early period of the composer, which he terms as the "Bartok" period, covers the whole series of compositions until 1954. In the algorithmic period, he reveals the famous *Metastasis*. The morphological period is the end of the 1960s when Xenakis was interested in music morphology. The structural period marks the beginning of the end of his long and fruitful artistic life (2008).

This thesis intends to denote the main, creative and personal paths of Xenakis's music and his piece *Persephassa* through the references of numerous scholars who produced a number of new publications about Xenakis who, as an artist, made an outstanding legacy that requires investigations.

4.2 Persephassa

First, it should be noted that Western music does not have a long evolution and history of writing solely for percussion instruments. The earliest piece written for only percussion instruments is *Ionization* by the French composer Edgard Varese in 1931. In this piece, Varese expresses a new soundscape with a variety of timbres and a high degree of control of musical parameters (Lewis & Aguilar, 2014, p. 1). After about 30 years, the piece *Persephassa* by Xenakis stands as the next masterpiece for percussion instruments among other spatial compositions. The spatialization aspect is one of the most important features of Xenakis' pieces. It would be unreasonable to study *Persephassa* without considering the spatialization and visualization of geometrical polygons of sound shapes. According to the composer of the piece, it should preferably be played in the open air by distance from 50 to 300 meters. The name of the piece is one of the various names used to denote the goddess Persephone, Proserpina, Perseus, Perceval and "Persepolis". The piece was commissioned by the Office de Radiodiffusion Television Française and the Shiraz Arts Festival. The creation process took place in Persepolis, each of the percussionists being installed on the stump of a column of the palace of Darius I. *Persephassa* was premiered on September 9, 1969, and the French premiere was given on October 28 at the Contemporary Music Days (Teodori, 2012) (Figure 4.1).

Figure 4.1: Persepolis, Iran.

There is a significant amount of scientific research on the area of auditory cognition that shows humans have the ability to sever and detect the audio signals and to comprehend its content while the signals are spatially located at different distances. According to Bregman's auditory scene analysis theory, it is possible to segregate sounds into multiple distinct streams and represent the connection between those components. Moreover, the only two identical frequency components presenting the material from distinct locations could be heard as two separate sounds. If another additional element is included in the sound exposition, the degree of segregation will be increased. The elements positioned nearby together in space or time probably generate the same event and create the proximity effect (1990).

There are limits and potential conflicts in listening to the spatialized sound. Harley explains that the various sounds from disparate locations relate to the distribution of sound complexes. Spatial differences enhance the result of segregation of arriving sounds from different locations and may evoke the primitive principles of auditory analysis. Sometimes plan of sound localizations is ineffective and inaccurate when there is a high degree of reverberance and strong echoes in particular environments. In addition, if two sounds occur at the same time in space, their integration may depend on the spectrum and envelope of sound (1994). Furthermore, the tendency to segregate

sounds from different spatial locations cause the listener to lose the focus of attention (Bregman, 1990).

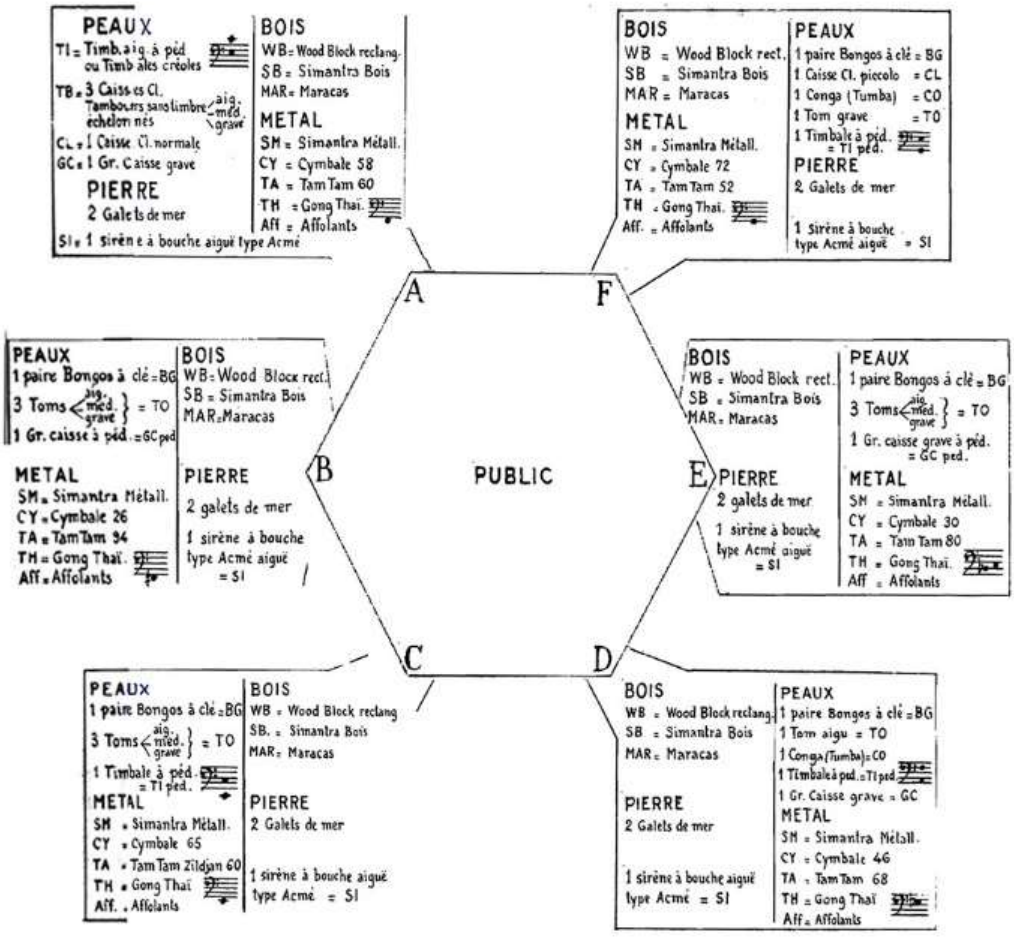
It should be noted that the conventions of European harmony and theory have another approach in the realization of sounds. Overall, they require unity and balance in sounding. Brant claims that the spatial division into widely separated points in the performance area clarifies the texture with its individual distinctive sonority scheme. In his opinion, the isolated groups from each other are difficult to coordinate in terms of accurate rhythmic synchronization. In addition, spatial separation is equivalent to the separation of textures in pitch space. It allows a greater complexity in the music. Spatial designs are mapped exactly, but they permit modifications of details (1967).

Impulse of a piece, constant dynamic strains, and interplays between highly characterized groups of various sonorities are the main features of Xenakis's music. The spatial positioning of the performers is a significant part of *Persephassa*: the piece is written for six percussionists spread around the listeners, forming a hexagon surrounding the audience. It also recalls the use of a circle which is one of the major contours of spatialized music, applied to a variety of contexts (Figure 4.2).

persephassa

NOMENCLATURE DES INSTRUMENTS

ET DISPOSITION DES 6 PERCUSSIONISTES



Les PEAUX sont désaccordées et classées en 6 hauteurs de haut en bas de la portée supérieure
Les AFFOLANTS sont des feuilles en acier très minces de dimensions 30 X 30 cm environ qu'on agite en les tenant à la main
Les SIMANTRA METALLIQUES sont des tiges d'acier trempé très dur de 20 mm de diamètre environ sur 11 cm suspendues et qu'on frappe avec une batte de triangle ou une tête de métal.
Les SIMANTRA BOIS sont des pièces de bois très dur et sonore de 60 X 6 X 2 cm environ suspendues, frappées avec une batte de bois ou une baguette à tête dure ou métallique.
Les GALETS de mer sont arrondis, de la taille d'une main posés sur un coussin et qu'on frappe avec un deuxième galet de même taille environ.

 M. C. 539

Figure 4.2: Instrument positions in *Persephassa*.

All six percussionists have nearly identical set-ups with a different collection of instruments which produce timbral variations throughout the piece. Each percussionist possesses six skins, six metals, three kinds of wood, two sea stones, mouth siren whistles which are high kettledrums, pairs of bongos, snare drum, three snare drums without snares, high, medium and low tom-tom drums, and bass drums. The bass drum is tunable by using a food pedal. Xenakis seemed to try to substitute a large timpani with differing degrees of tension. The wood family consists of maracas and woodblocks alongside wood mantras made of extremely hard resonant wood. The instruments Simantra Bois and Simantra are resonant pieces of wood and metal. They have implications for a liturgical instrument in Greek monasteries (Kanach, 2010, p. 194).

These instruments are grouped to create layers in texture and palettes of colors. According to the theory of Bregman, sounds with a similar timbre or frequency probably belong to the same event and they bring the principle of similarity effect and other outcomes (Bregman, 1990). The acting of musicians in fixed positions does not imply a static sound image. There are also some other strategies to construct spatialized music without using the distant organization of sounds. Scholars have indicated that musical movement mostly depends on the development of the linear structures as well as register and pitch space (Riemann, 2011). One of the most important aspects of Xenakis' writing style in *Persephassa* is a spatial atmosphere, visibility, and richness of the sound images. Xenakis composed the sounds, and he "sculpted" new spatial sonorous forms.

4.3 Acousmatic Mode of Listening

Listening to spatial music may evoke associations with ambiguous sound worlds. Seemingly, the human becomes an "eye-creature" and it is known that spatial cues are weaker than visible ones. Harley clarifies that ears interpret a process and synthesize faster than eyes. Humans are supposed to memorize an object of the source and organize the abstract material in the brain. The fast visual movement is not memorized while the sound trajectory makes the outlines of sound forms in a simultaneous process (1998). Furthermore, Chions studies show that vocal or any human speech has a dominating effect on perception. Hence, the difference in the speed of perception of eyes and ears has a strong influence on the overall human perception (1994). The

integration between audio and visual perception is a strongly individual notion, which strengthens the organization of material and also distributes space.

As a method, it is prudent to make an analysis of spatial music through acousmatic listening mode by the auditor. This is a new tendency in the 20th century. Acousmatic is a term of Greek origin coined by Jerome Peignot and theorized by Pierre Schaeffer. Acousmatic music is common in film music editing where the first sound evokes associations or sense of the subsequent appearance of the visualized scene. This technique is also utilized in operas and theatrical works. In order to simulate any visual scenario such as the off-screen space in film music, the sound makes the utilization of special characteristics of the particular image to be recalled. It is a complex type of creating music because the sound images do not carry any visual support. In spatialized works, the volume and other parameters give hint about the distances of imagined space. In short, acousmatic listening requires a high degree of attention, which means that this mode of listening is beyond standard conditions (Raskevicius, 2016, p. 1); as in electroacoustic music, the listener can only rely on ear and sound perception. Therefore, sound designers endeavor to stimulate a more relieved spatial image through various techniques.

In *Persephassa*, a listener can feel the simulation of pictures of various geometrical figures and can follow their motions by concentrating on the sound itself. The listener can keep track of the motions by following the attacks of similar timbre which are transferred from one position to another in various speeds.

4.4 Sound Gestures

Undoubtedly, it is imperative to consider the following factors, which are substantial to our ability to confine sound gestures: the type of audio signal coming from the source, the placement of the audience, the acoustic environment of both the source and the listener. Nevertheless, hearing, like vision, can encompass vertical and horizontal signals in addition to depth, which represents the difference in voices, dynamics, and timbre. Thus, people primarily determine the location of a real sound, then the vision of moving sounds in space.

Iannis Xenakis was one of the main pioneers introducing the idea of the “composability" of physical space. His music possesses transcendental, incantatory,

and physical aspects. Hence, it reveals the inter-personal perspectives of spatialized music like body-subject music. It also experiences the music in its complete gestural, personal, and spatiotemporal articulation.

Schaeffer's study in concrete music states that the sound gesture refers to several concepts and perspectives. Any simple attack undergoes a change of density, pitch, or resonance in various places in different ways. From the listener's perspective, the sound gesture is an experience producing a group of sounds, which occur together by creating musical materials. From the composer's aspect, the sound gesture is organized by a structure within its musical vocabulary of textures concerned with the positioning of sound sources. A performer who takes his/her own location is treated as a "physical object" in space. In spatialized works, it is admissible to speak about sound as an observed physical object (Raskevicius. 2016, p. 1).

Perception of sound gestures and their spatial forms require another vocabulary, too, which describes spatial attributes. In instrumental music, the physical synergy of the performer with the instrument is the spectromorphological form according to Smalley. The sound defines how the instrument is triggered by the performer. Each gesture is an energy-motion trajectory which is formed through various attacks and decay of the sound. The movement of the sound in space maintains the spectromorphological characterization of the sound gesture. A composition with a gesture-carried structure signifies a motion triggered by some external energy and takes the primary attention of sound gestures (2007, p. 35).

As an example of it, in *Persephassa*, constant transfers of gesticulations from one instrument to another visually keep the attention of the listener. This visual phenomenon also supports the audible results of rotations in sounding. As a result of human physicality, weak, slow gestures are perceived with more static means. In this respect, even the silent parts make part of the piece as well. *Persephassa* is an instrumental musical piece where performers execute the musical materials with their active gesticulations. In the meanwhile, the audience is surrounded by musicians and cannot always follow all sound gestures. This setting stimulates an active mode of listening where the audience members have to follow separate sound attacks and keep track of their physical positions to figure out sound gestures. This is how the illusion of geometric angles and figures is created at the performance place.

4.5 Geometrical Rotations and Sound Movements

In his book "On the Sensations of Tone as a Physiological Basis for the Theory of Music", von Helmholtz points out that the musical range is like geometric space. Any melody or chord retains its qualities until it is moved to another level. Moving them to another height is an analogy to movements of objects in space. Pitch movement is easily associated with movement in space; therefore, it gives the sensations of movement in the general sense (1863/1954: p. 370).

According to Bregman`s theory, sounds generated by the same event brings the principle of good continuation and completion in music. Mostly, it is prudent to rotate sounds between homogeneous instruments and the same systematic dynamic envelopes in order to reach complete mobility of sounds (1990).

The rotation is a fundamental type of form and the main characteristics of the piece *Persephassa*. Xenakis used complex accelerating and decelerating circular and semi-circular spiral-formed rotations. Each rotation is identified by its own timbral entity formed through the use of similar drums across the ensemble. Moreover, each rotation has its own set of durations and speed.

The first short rotation appears in mm. 22-26, and mm. 30-33, where the sound produces a small triangle shape extended to the larger rotation in bars 38-41 and 43-46. These rotations sometimes identify and highlight not only the triangle but also oval and other geometrical figures (Figure 4.3; Figure 4.4; Figure 4.5). Xenakis uses dynamic envelopes to increase the perception of the sound shifts by the audience: one group of instruments decreases the volume while passing the musical material to another group which receives the musical material with increasing volume. This form enables the listener to perceive a set of stationary sound sources as one single mobile sound.

The first rotation is shown in Figure 4.3., it lasts around 6 seconds and has pp dynamics. Apparently, it is a semi-rotation and in the following measures, the speed of rotation fluctuates and shapes undergo changes as shown in the examples (Figure 4.4. and Figure 4.5). Due to the analysis of the spirals, speeds, and pulsation speeds, it becomes evident that the music consists of two-time domains.

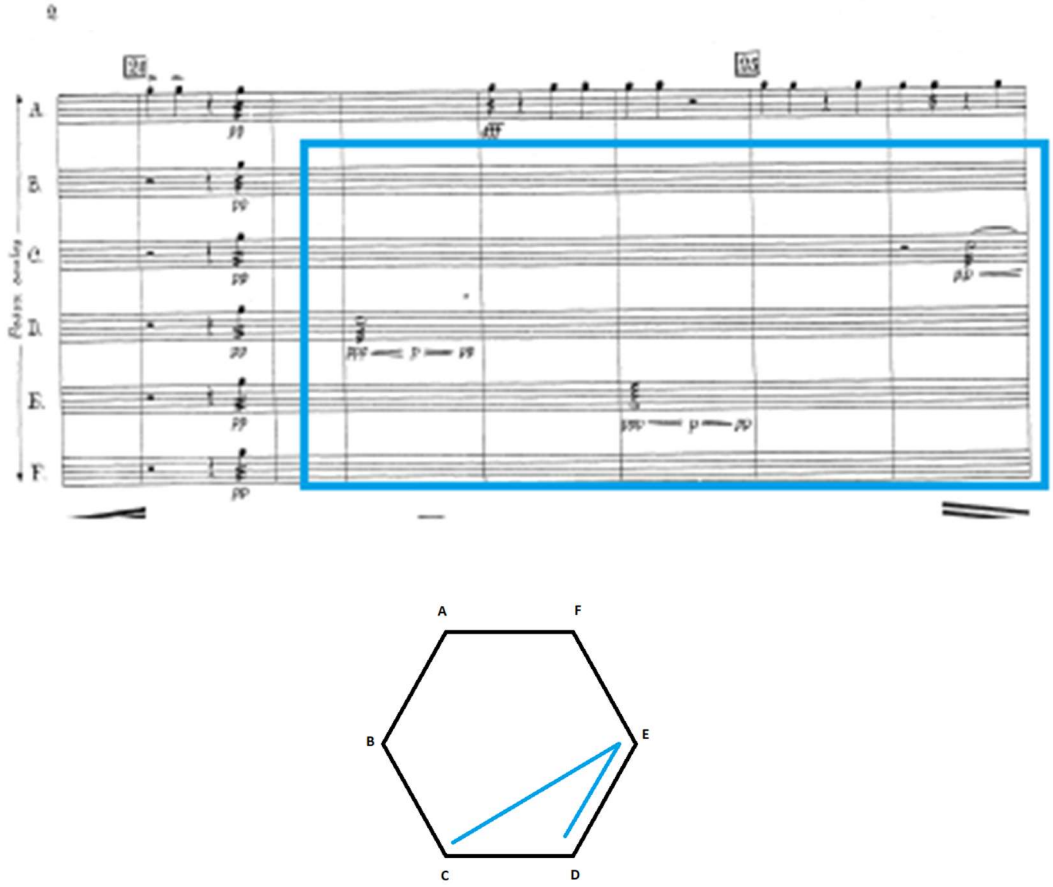
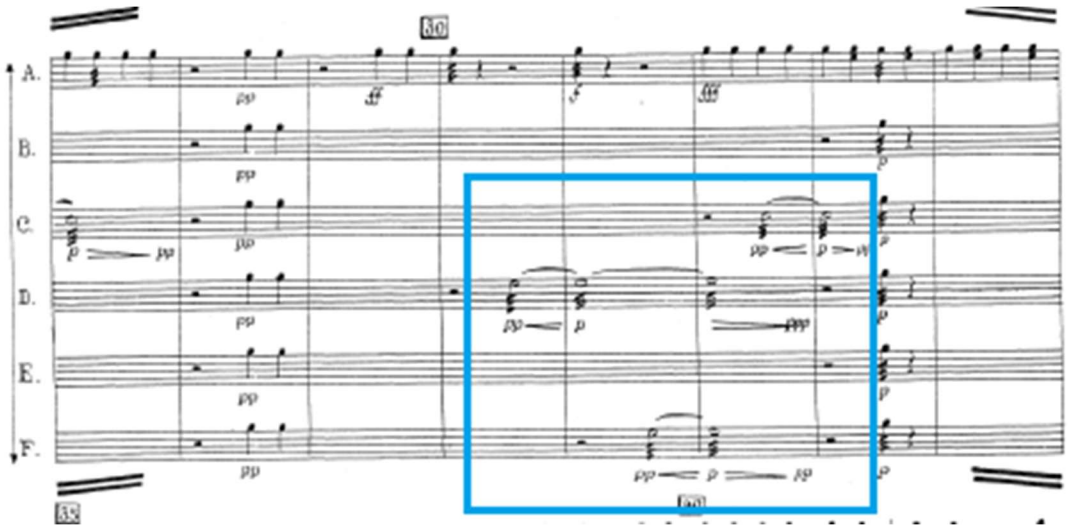


Figure 4.3: Semi-rotations 1.



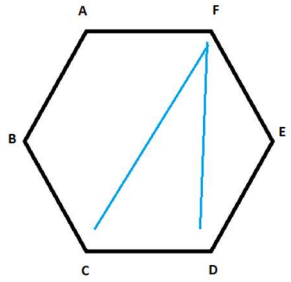


Figure 4.4: Semi-rotations 2.

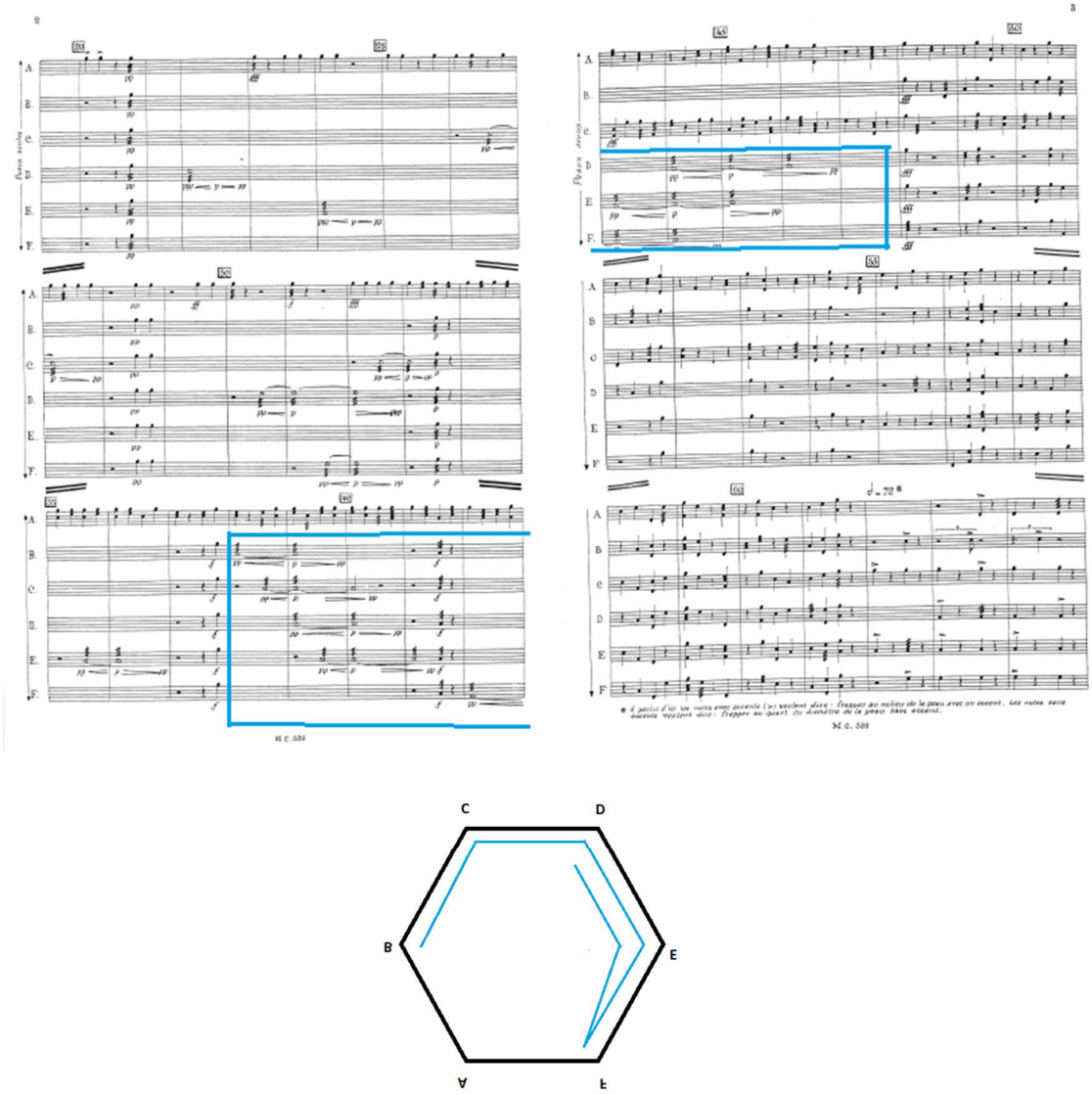


Figure 4.5: Semi-rotations 3.

The first full rotation arises between mm. 99–103 (Figure 4.6) where each percussionist performs a complex, one-measure polyrhythmic pattern and its variations. The pattern consists of duple, triple, and quintuple rhythmical structures.

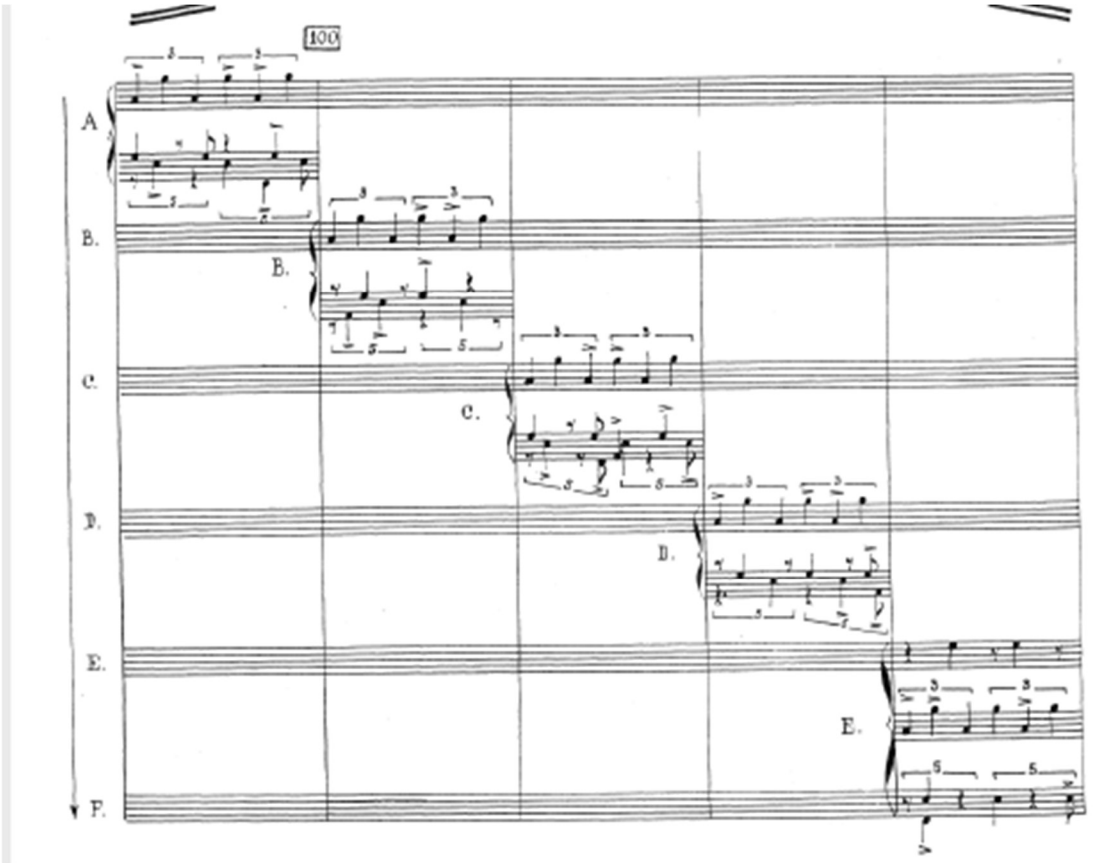


Figure 4.6: Full rotation.

The next rotation appears in measures 145, 178-187, 300-330, and 333-336. Musical processes incline strongly to the density of musical material by the end of the piece. From measure 352 until the end of the piece, there is an audible illusion of endless repetitions of a single rhythmic-dynamic cell and parallel circulations of sounds in different parallel layers (Figure 4.7). This type of music depicts a complete round of musical carousels and a "choreography" of sounds. Using various metallophones and cymbals played by six performers, different frequency levels are created. This procures the illusion that sound goes from low to high as in spiral shape and thus produces the vertical dimension of the piece. Thereby, a superimposed circle is achieved by a gradual and big acceleration, starting the rotation with 30 beats in one minute and

rising up to 240. The full density of texture is achieved with the addition of mouth sirens and dynamics.

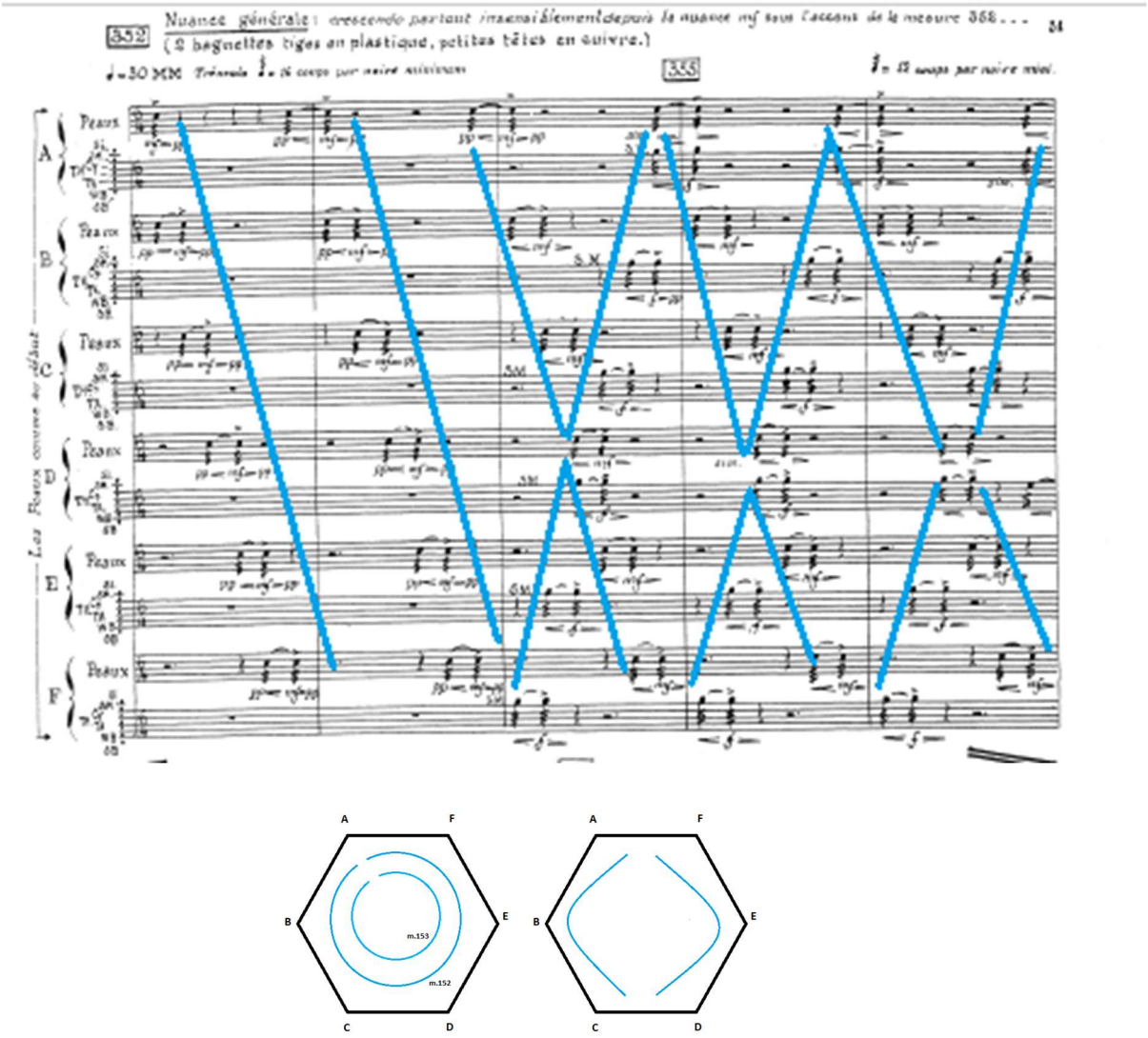


Figure 4.7: Rotations and Contrary Rotations.

Overall, the music conducts the audience in a huge vortex and the sound image evokes the dance of whirling dervishes, which immerses the audience to trance (Solomos, 2008, p. 59) (Figure 4.8.). The sound perceived from the aspect of the audience outlines the imaginable spatial surface which surrounds the auditorium. Steve Schick refers to the finale of *Persephassa* as "one of the most stunning moments in all of 20th-century music" (Kanach, 2010, pp. 165-194) (Figure, 4.10).

Throughout the piece, there are other highlighted geometrical sound shapes articulated through the transmission of sound gestures from one performer to another (Figure, 4.9,). Here, similar articulation and instrument choices characterize the sound objects

but the speed is varied. All these features provide extra dynamism to the piece (Figure, 4.11), (Figure, 4.9,).

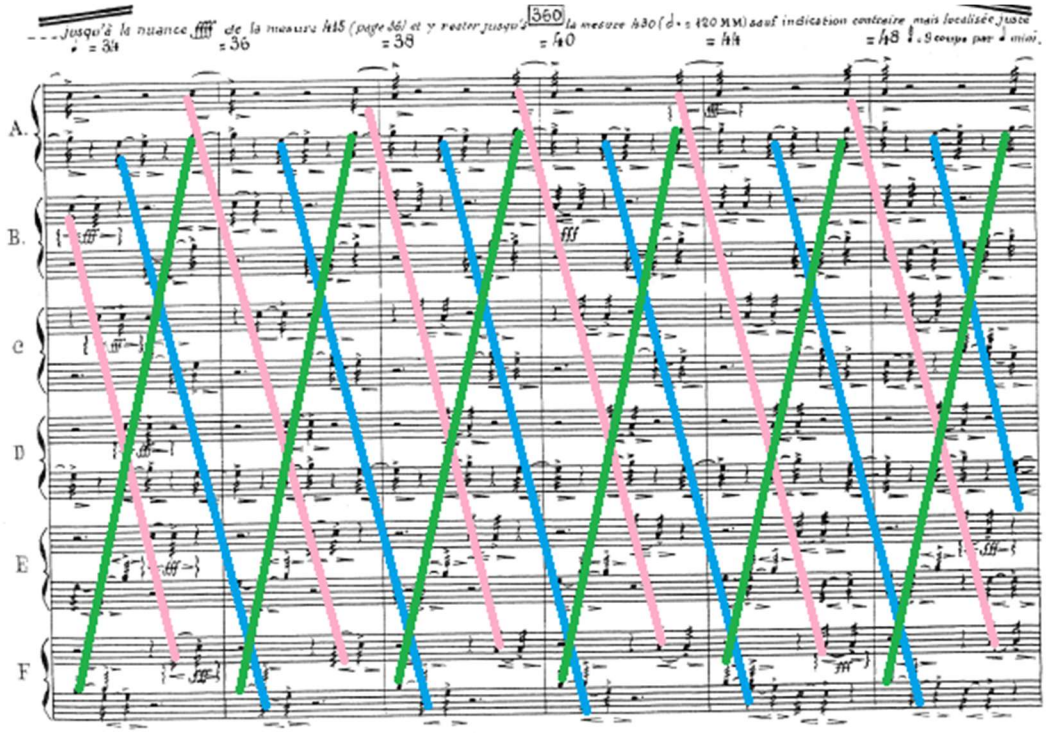


Figure 4.8: Parallel Rotations.

It should be noted that all sound figures which are drawn are audible from all listening positions and it is hard to underline one sweet spot. This phenomenon provides varied perception and interpretation possibilities for this music.

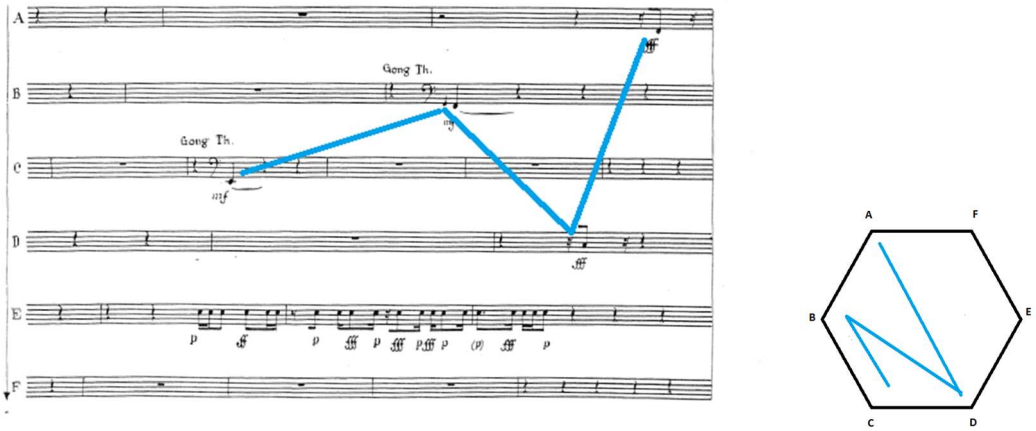


Figure 4.9: Sound Shapes 1.

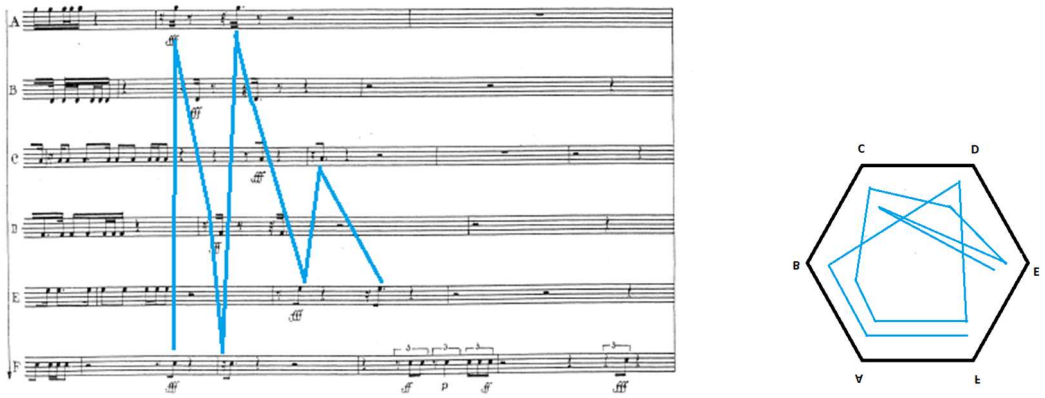


Figure 4.10: Sound Shapes 2.

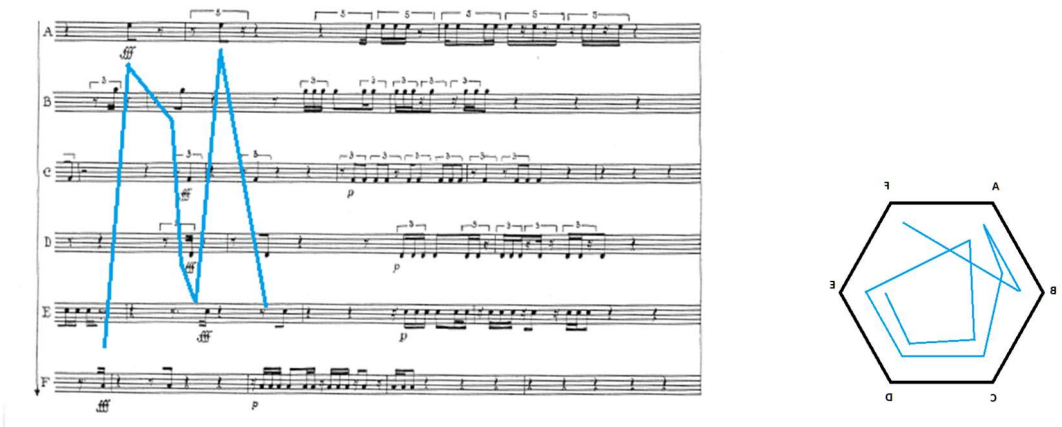


Figure 4.11: Sound Shapes 3

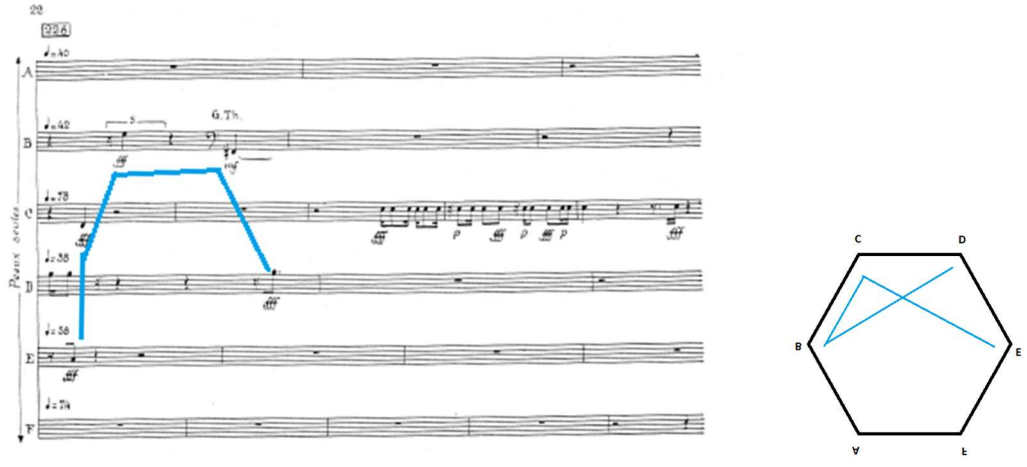


Figure 4.12: Sound Shapes 4.

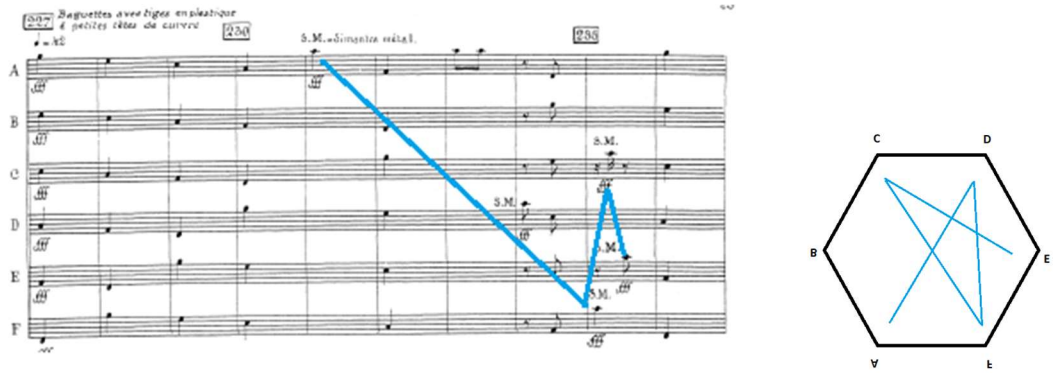


Figure 4.13: Sound Shapes 5.

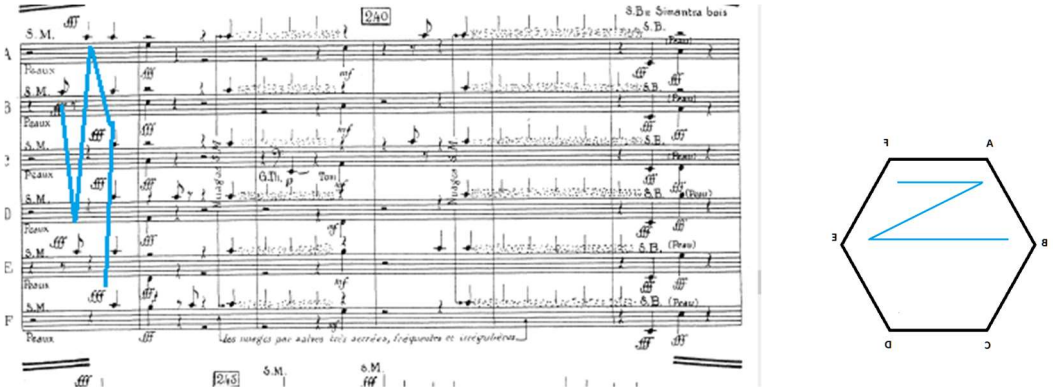


Figure 4.14: Sound Shapes 6.

4.6 Complexity of Time

Another important aspect of space is time. Space operates within a domain of time and it is experienced in time. Susanne Langer, who is an American philosopher, writer and educator, proposed that music makes time audible and continuity sensible (1953, pp. 104-120). Hofmann states that time is not universal gravity: it depends on space and the position of the recipient. Each listener gets his/her own experience (2006, p. 7). Space can be audible within the temporal progression. Time management by means of tempo and meter has a direct effect on human consciousness. The temporal senses of "space" primarily connect with the notions of time, distance and measurements. “A duration is something that can be moved around within time, it is therefore reversible, commutative. […] The difference between any two points is a concept that stems from comparisons and mysterious judgments I make about the reality of the temporal flow, which I accept a priori. The distance between the two points is what is then identified

as a duration. I displace this duration anywhere; therefore, it is reversible." (Xenakis, 1979, pp. 74-75).

Another statement by Xenakis is: "Music develops in time. […] Musical time can't be reduced to a stopwatch. […] The exact measurement, in seconds, of musical time and duration, is of little interest. … It is the interior of time that counts, not its absolute duration. ... Time is independently and simultaneously articulated by various musical events," (1994, pp. 9-20). He makes a difference between flow and duration, meaning unmeasured and measured time. In general, for him, time is an abstract dimension that enables him to construct the various musical events found in his music. Xenakis states, "The distance between the two points is what is then identified as a duration. I displace this duration anywhere; therefore, it is reversible. But the temporal flow itself is irreversible" (1979, pp. 74-75).

In one of Stockhausen's lectures about moment forming and integration, the composer explained that when certain characteristics such as register, region, dynamics, articulation, tempo or speed remain constant for a while, it determines a moment (1972). A related thought is expressed by Smalley, too. A listener needs time to scan, explore the spatial properties and to make progress from an initial listening unit to the rest of the material. Timing is determined by musical events. The listener can still perceive the total unit in one moment (2007, p. 35). For example, sustained moments in the piece suggest the perception of sound as spacious and expanded and thus lead to a feeling of timelessness.

There are several sections in the *Persephassa* that have their own time domain. By means of texture, in some particular moments, the piece has simultaneously more than one time domain. In addition to this, in *Persephassa*, music material use is often characterized by periodicity. Each performer has their own tempo and periodicity of the musical pattern. For instance, the texture shown in Figure 4.13 illustrates that each performer has their own metronome values and pulsations. In this moment of the piece, the listener may easily lose connection with the global tempo marking.

4.7 Progressive Rhythmic Transformations

Xenakis wrote several books, articles, and interviews in which he discourses on the principles of his compositional technique. All his methods have various implementations for different pieces. Therefore, consideration of his compositional

process should begin by defining the principles which he developed. In his theoretical writings, he systematizes his methods. Xenakis usually elaborates the musical material through gradual transformation. Arithmetic proportions, probabilistic models, and logical-mathematical models are his compositional tools. In the early 1960s, Xenakis used Boolean algebra to formulate pitch organizations. In addition, he began developing a technique that he called “sieve theory” for producing pitch series based on a series of repeating numbers. The sieve theory is a process of structuring pitch collections, durations, and dynamics. It is a parameter of music with various degrees of regular or irregular sequences of permutations. Most sections of the piece start with a unified line, but then each player gradually strikes out at an individual speed and rhythm, departing from one another. The individual layers maintain their integrity, but the interplay between them becomes unpredictable, irregular and chaotic. As a result, it creates various mutations and defusions of sound timbres and rhythms throughout the piece. The sieve modeling of musical material is based on the same principle as sampling, which is layered at different speeds, phases, volume, and frequency among other parameters. A large number of elementary sounds are adequately disposed in time (Xenakis, 1992, pp. 268-277). Apparently, *Persephassa* has passages of rhythmic imitation and mutations with superimposed complex textures. The imitative element originates from sieve structures, implemented by durations rather than pitch. One unit of a pulse is considered as one value; in the same way, the rhythmic patterns can be generated by employing the periods between points.

The piece starts with short chaotic drum tremolos with crescendos and decrescendos followed by intensive interlocking rhythms, creating a unified rhythmical pattern. One by one, the performers break the rhythms and create further polyrhythmic variations. A temporal rhythmical dissonance progresses and finally culminates in a turbulent and rhythmically dense cloud called "Nuages" in the score. The expression “Nuages” will be discussed in the following parts of Chapter 4.

The first appearance of sieves comes at m.151 and the pattern starts again in the last beat of m.155. Part B begins in the last beat of m.154; the second beat of m.157, E; the third beat of m.156; and F, the first beat of m.153. In m.162, all six percussionists play a fragment of the rhythmic sieve before breaking into a complex passage derived from that sieve. These types of formulation might be considered as a rotation of short rhythmical patterns. Another example of this use of rhythmic sieves appears in the passage beginning in m.221. The imitative material in m.221-222 is derived from sieve

structures (Figure 4.14). When the material is played by six percussionists each in a different tempo, there is a complex rhythmic counterpoint (Figure 4.15).

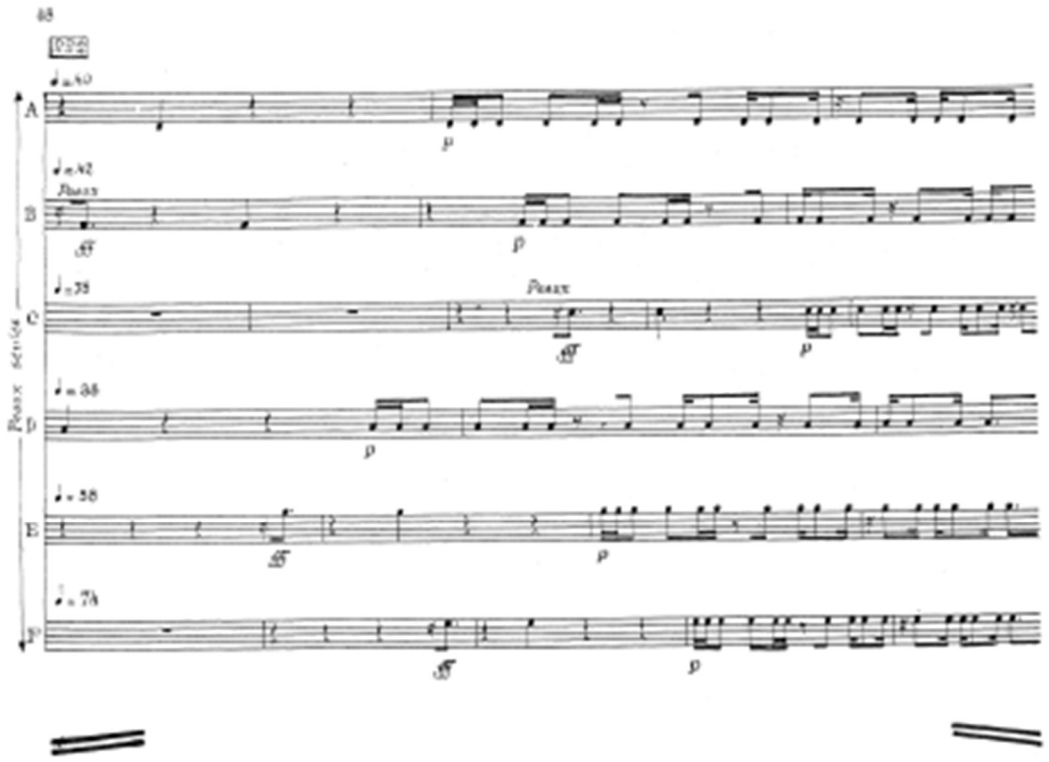


Figure 4.15: Sieves 1.

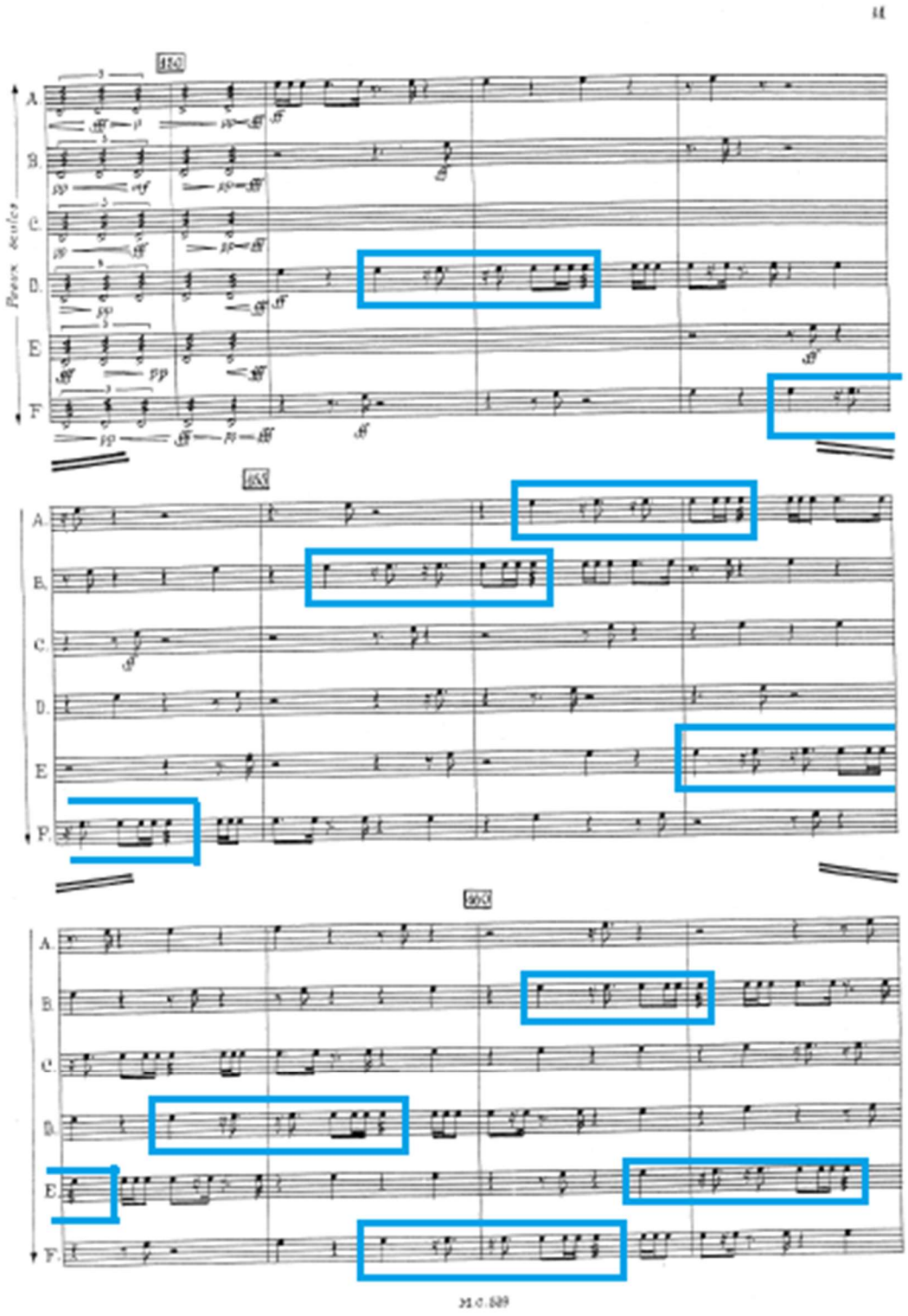


Figure 4.16: Sieves 2.

In *Persephassa*, Xenakis incorporates his concept of sieve structure by using a series of durations. He writes complex rhythms generated by sieves for six parts in different tempi and subdivisions of the beats. He also presents the sieves in augmentation and diminution. These patterns are meant to be recognized by the listeners and the counterpoint of multiple percussionists playing the same material in different tempi creates an extraordinary effect.

The layering of regular pulsations is Xenakis's primary discovery In *Persephassa.* A new formal section begins in m.191. After beginning in synchrony, each percussionist, at different points, shifts to their own individual tempo. To coordinate the six resultant tempi, Xenakis remarked in the score that "the six metronomes must be absolutely synchronized" (1994, pp. 9-20). Metronomes could have been the best solution in 1969, but later in his life, Xenakis would approve more up-to-date methods of synchronization by allowing musicians to perform without clicks. For instance, in m.192, each part starts the pulsation together but later on, they stop being synchronized and rhythmical distortions of pulses occur (Figure 4.16). Since each musician play at a different tempo, the duration of each sieve presentation is slightly different. At some moments it gives the impression of a big reverberation of sounds as the music is performed in a spacious area.

Consequently, the polyrhythmic elements create a motive which develops, transforms, and eventually culminates into a more complex and dense form of rhythms (Figure 4.17). The overlapping rhythmical figures illustrate the overshadowing effect in overall listening. In m.131, the sonic material transforms into an imitative texture which emerges out among six percussion angles with triplets and three in quintuplets. Percussionists switch between triplets and quintuplets in every beat, but the balance of triplets and quintuplets is maintained throughout the passage. Another obvious example of rhythmic imitation appears in m.151. Percussionist D plays a seven-measure rhythmic passage that is duplicated in the other percussion parts, which subsequently begins at different times (Figure 4.18).

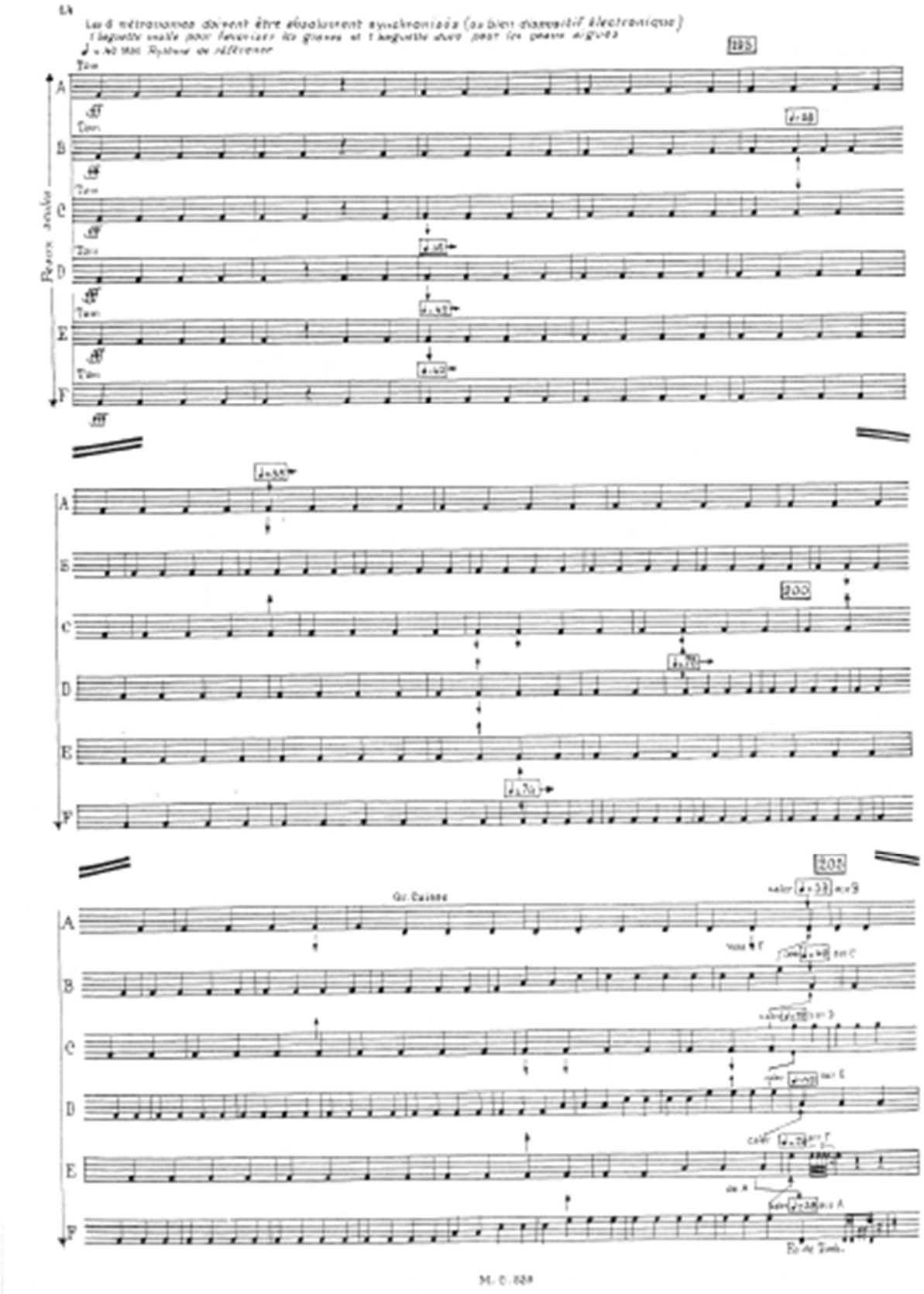


Figure 4.17: Unsychronized pulsations.

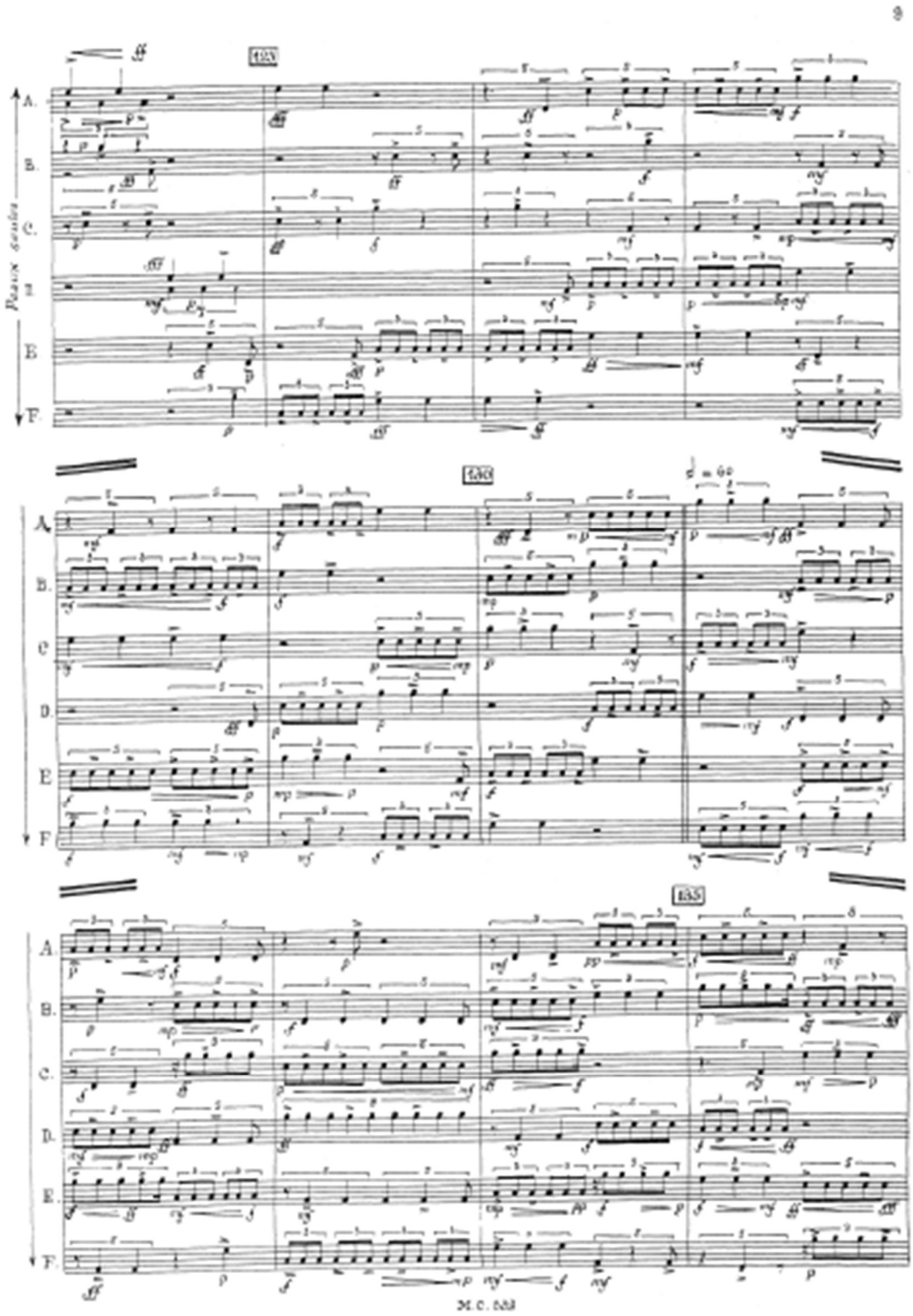


Figure 4.18: Polyrhythms

Iannis Xenakis is one of the pioneers who embodied in his writings the concept of free sound masses. He constantly practiced the concepts such as sound mass, independent sound gestures, density texture, and sound line. Like many of his contemporaries working on composition at different semantic levels, Xenakis constructed his essential features of musical language. For example, the siren whistles make their first appearance in m.297 with an irregular crescendo leading towards a series of Nuages on a variety of instruments, each with varying intensities, densities and durations. The first "nuage" (translated as "sound cloud") of the work appears in m.145. Xenakis invented the term as used in this context as an extension of his stochastic principles. "Clouds" is a concept like glissandi or cluster. It expresses sonic spatialization and spatial continuity through the integration of sound grains, ordered and disordered, regular and irregular cells and their sonic density (Xenakis, 1992, Chapter 2). His interpretational instruction in the score directs the performers to play irregular roles in very high tight bursts of sound. In the piece *Persephassa*, "clouds" appear in m.145, 238-241, 246-249, 270, 298-330, 428, 440, 449, 453, and 456 for 45 seconds. This concept of complex sound and multi-layered texture brings a new level of abstraction and continuous motion of sounds including different elements of a chord instead of a single pitch.

Through measuring XYZ angles, Raskevicius identifies three-dimensional surface which represents the phenomenon of spatialization. He explains that X represents a horizontal spectromorphology over time while Y indicates a vertical position of frequencies. When it comes to Z, it is representing the depth in the imagined space, and is identified as a separate identity of sound gestures at the same time. It is evident that the duration of the continuing X and representation of frequency Y events influence the level of Z, which is the level of the depth. By drawing its border lines, parallel polyphony between angles can be followed. Practically, in order to make morphological differences, it is advisable to keep the identity of sound gestures. It is presumable to identify spatiousness by dividing musical material into short samples (2006, p. 8).

It is very clear that for Xenakis, the epoch of tonality, harmonization, and pure tone is outdated. In his compositions, one can find textures that extend from noise to chaotic mass sound. The relation between tones and intonations do not have significance.

Xenakis erases the boundaries of the clearly defined high-pitched time positions of the sound, proclaiming a continuum in all sound parameters. The greater the number of musical events is, the greater the density music possesses, which affect the musical texture. By manipulating density and dynamics, Xenakis reaches the images of thick, thin, close, and far sound images. By modifying the waveform, envelope, duration, spatial position, and density of the grains, many complex sound characteristics are generated. Consequently, state and energy transfer changes the vector of sound movements. The degree of sound fabrications regulates depth movement (Raskevicius, 2016, pp. 11-12).

4.8 Space of Space

The architecture of performance area, its reverberations and especially the texture of the pieces play a crucial role in the spatialization of music. However, the space needs space in order to emphasize spatiousness. It possible to hear space inside the space by doing rests, where the listener may hear the environment. This kind of effect might be considered as a transition from one space to another. There is an opposition between physical space and metaphorical space, between virtual and real space. Xenakis was well aware of this concept. For instance, in order to emphasize the illusionary circulation environmental space, the composer leaves the audience in silence in m.421-422 (by noting “stop brutal”), in m.427 for 6 seconds and in m.429 for 4 seconds. Gapping portions of silence occur sporadically throughout the work. The part between m.7-21 might be considered as listening to the environment and reverberation of the sounds (Figure 4.15). The first full rest occurs in m.218 where musicians are supposed to have a rest for 6 seconds. The second and longer one comes in m.251. Also, m.255, 427, and 429 come with environmental silence. Furthermore, pauses give contrasts and emphasize the sounds of percussion. The musical processes almost always navigate among strong incline towards densities, extreme saturation, and silence.

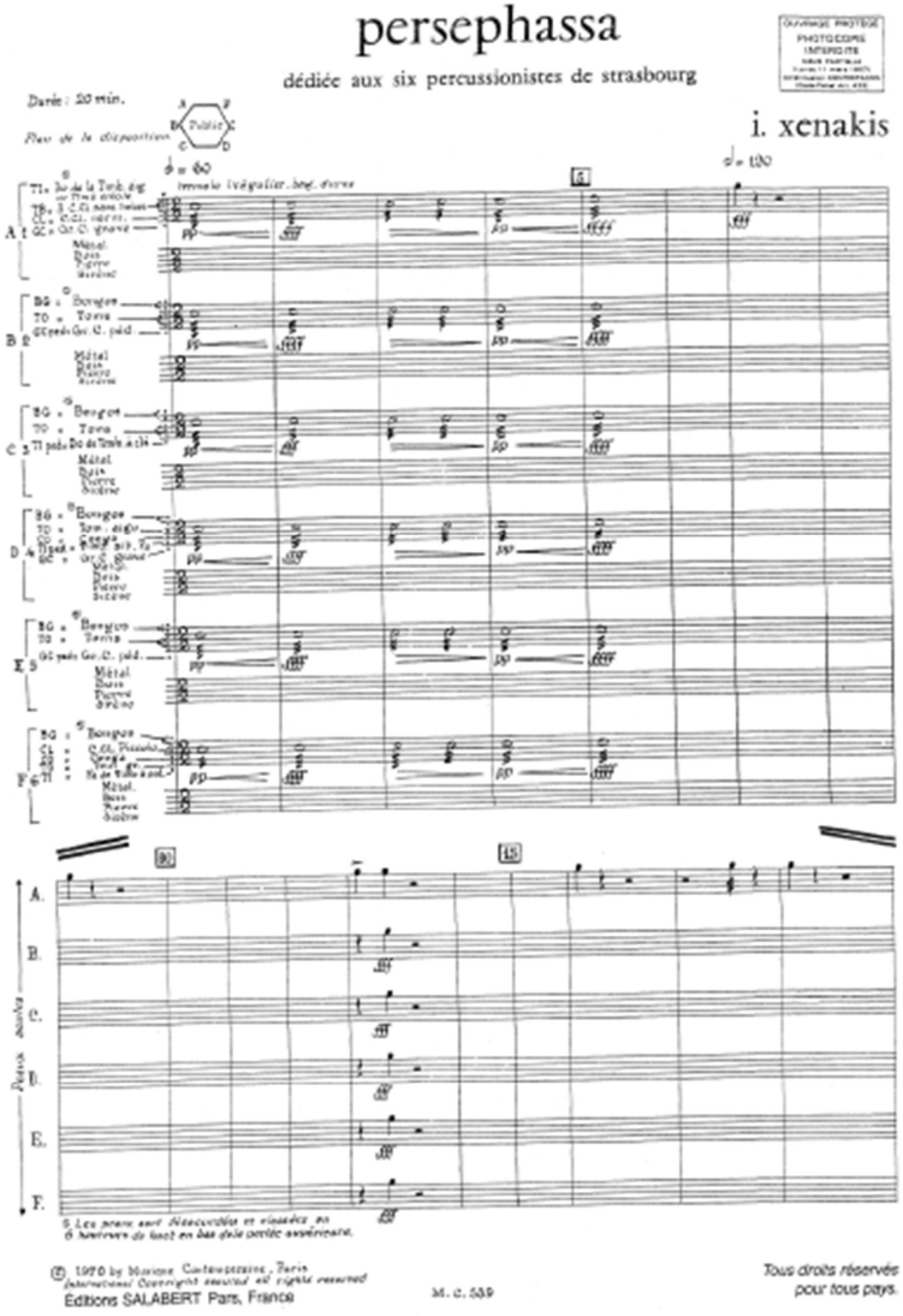


Figure 4.19: Listening to space.

4.9 Approximation effect

The effect of surround sounding is exaggerated with the effect of approximation of sound, and it emphasizes the physical aspect of sounding. By means of common dynamic techniques and smooth crescendos and decrescendos, the composer indicates loudness, softness, and a distance of sounds. Moreover, it gives an influence of proximation of sound to one's sense of its body, as the sound has the ability to touch the human body physically. From the first measures on, Xenakis noticeably shows that sound in the piece has a strong relationship with our physical area. The formation of dynamics indicates that sounds are moving towards and rearwards from the point of the listener and the distance is indicated by the level of dynamics, which means the softer the sound is, the farther the listener perceives it. The same idea occurs with a loud dynamic. The louder the sound produced, the stronger it fluctuates on the human body and ears. The effect is implemented not only with dynamic means but also with texture. It is advisable to use homogenous instruments in tutti with a balanced dynamic in order to reach the effect. The example from the score might be given in m. 1-5, 147-150, 174-175, 187-190, 278-280, 289-290, 293-294, 411-420, 440, 449, and 453.

4.10 Score and recording

Musical form is a very comprehensive subject, but its explanations incorporate with the relationship between structure and development of material. The success of the structure depends on a series of designed strategies. The notation of musical pieces is one of the crucial parts of the process in music making. In *Persephassa*, Iannis Xenakis utilized the standard form of notation which does not illustrate all spatialized aspects of his music. However, visually, his scores look like works of graphic art featuring various lines and different geometric figures. Without live experiencing of the sounding, there is no way to perceive sound images through internal hearing. Evidently, the graphical scores could probably be a more reasonable approach in illustrating spatial sounds. Traditional western music notation indicates the relative amplitude of notes. It does not display the spectrum, dimension, spatialized movements, inherent resonance of the sound gesture, external reflections and reverberations of sound itself. A disadvantage of graphic notation occurs in cases when sound movement is complicated and the trajectory overlaps with itself, thus creating a

complex image. In similar cases it becomes more effective to create one graph for each scene representation.

Problems arise when one tries to present the spatial features, sound directions and motions in Xenakis`s compositions to the listener through sound recordings. It is not possible with stereo recordings already, a multi-channel recording and surround music playback system is required. On the other hand, this is a fact that no digital system can fully recreate the impression of movements and spatialisation obtained through live performance, and the quality of the reproduction will depend on the "spatial resolution" defined by the number of surround channels recorded and played back. Nevertheless, the experience to listen to live performance attains more exclusiveness and significance.

Lastly, Xenakis's music is intensive and exhausting to play due to the distance between each musician and the lack of a conductor. It requires talented musicians and long rehearsals.

5 CONCLUSION

Spatial associations provokes new types of musical thinking and imagination. This is a state of mind which is essential for the creation of new music. In addition to this, it is also important to enrich the new musical vocabulary and to have an adequate perception of the music of the 20th and 21st centuries. Together with other innovators of the European post-war avant-garde music, Xenakis laid out a valuable path in the history of music. The musical career of Iannis Xenakis was extraordinary and unconventional in his time. He is often described as a "space" composer due to the spatialization features in his music forming a key structural component. As a modernist, he had very original thoughts in various musical directions and possessed a strong individualism in his experiments. Furthermore, his output is not limited to musical compositions: his writings revealing his theoretical, aesthetic, and philosophical thoughts were published. They still continue to be relevant and attract the attention of many researchers.

It is well worth saying that with *Persephassa*, Xenakis brings the percussion music into another level in the history of percussion chamber music. As a result of my thesis research, I would like to summarise and highlight several factors which were applied by the composer in order to realize spatialization aspects and geometrical sound movements in this piece:

1. By placing the musicians around the public, the composer introduced a spatial architectural aspect, emphasizing the significance of the acoustic properties of the piece. By this method, an imaginable territorial contour of the performance area can be drawn. Different auditoriums and variable distances among performers and listeners create unrepeatable acoustic results and listening experiences for each performance of the piece.

2. Spatial localization creates the embodiment of physical sounds for the listener. Through intensive dynamic range, sounding has a physical approximation effect. All those components contribute to active listening mode.

3. The similarity of the instruments of the six performers produces so-called "traveling" voices. The individual musical cues have imaginable movements and rotation in space. The angles and shapes of those rotations depend on the angles and shapes of transferring sound routes.

4. Xenakis' thinking process is manifested in his calculated compositions. The simplest sound events such as "grains" is represented as the integration of elementary acoustic particles. Each of these elementary particles possesses frequency, intensity, duration, and decays which are distributed adequately within the time level. The composer used musical grains to build a complex system of sound layers. He reached this phenomenon with smooth and gradual adaptation and transfiguration of sounds. The fact is that the granular approach, in Xenakis' aesthetic, is a theory and not only experimentation. It is found in many of his other works, in the form of precise sequences or sound masses, which are termed as "cloud of sounds". Through this approach, the composer reaches different sizes and depths of sounds.
5. Xenakis creates space inside space. The piece applies spatial configurations in the texture of the music. On the other hand, the composer also gives significance to the natural spatial existence and its reverberations.
6. The complex polyrhythmic transformations and overlapping of layers, speeds, rhythmical patterns, and tempo markings allow having two or more perceptual time domains simultaneously.
7. Through frequency changes in the piece, the music creates a vertical dimension as well.

Eventually, Xenakis' music possesses a complexity and inner richness. All musical applications truly represent the multidimensional movements of sounds. They serve as the essence of his spatial forms.

The broad topic of the thesis may propose further investigations in terms of the philosophy of music in *Persephassa*, the role of architecture, acoustic properties, applicable mathematical algorithms, music cognition, discussion on aesthetics and other thoughts. The compositional methods and applications discussed in this thesis could be implemented by young composers in various styles of music. The existence of the possibility to interpret the piece allows for more creative performances.

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