A PARAMETRIC ANALYSIS OF MEASURES 0-51 OF *PITHOPRAKTA* BY IANNIS XENAKIS AND AN ORIGINAL COMPOSITION— *Làng Táo Shā* (2019)

by

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July, 2020

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ABSTRACT: This Master's Thesis in Music Composition comes in two parts. The first part is a thesis discussing the analysis of Iannis Xenakis's *Pithoprakta*. The thesis includes three chapters. The first chapter provides background information about Xenakis and *Pithoprakta*. The second chapter discusses important scholarship about the piece and the methodology for my analysis. The final chapter is my original analysis focusing on measures 0-51 of *Pithoprakta*. The second part of this Master's Thesis contains my composition recital program and the score of my original composition for large ensemble which was to be premiered on April 4, 2020.

A PARAMETRIC ANALYSIS OF MEASURES 0-51 OF *PITHOPRAKTA* BY IANNIS XENAKIS

A Thesis

Presented to the Faculty of the Department of Music

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Master of Music in Music

by

Shupeng Cao

July, 2020

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ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis committee, Dr. Mark Richardson, Dr. Travis Alford, Dr. Kevin Moll and Dr. Mark Taggart for helping me with the realization of this thesis. I would like to give my special thanks to Dr. Richardson, my primary thesis advisor, for his dedication and support throughout the project. I would also like to thank my composition professors, Dr. Ed Jacobs and Dr. José Martinez, for inspiring and nourishing me during my study at ECU. Additionally, I would like to thank Dr. Scott Carter for helping me organize my recital, and many of my colleagues who have read or performed my music. Finally, I would like to thank my parents for their continuous support and allowing me to follow my dream.

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Introduction

Iannis Xenakis is always hailed as one of the most influential composers of the twentieth century. His music has been an interest to many musicians, composers, conductors, and scholars. With an engineering background, and working as an architect under the Swiss-French architect Le Corbusier for many years, Xenakis was able to synthesize his unique background with the way he approaches composition. His publication—*Fomalized Music (Musiques formelles)*, is one of the most important composition treatises in which he demonstrates the idea and procedures for "stochastic music"— a term that is often associated with Xenakis.

Pithoprakta (1955-1956) has a significant role to play in the Xenakis's repertoire. Measures 52 to 59 of *Pithoprakta*, cited in the opening chapters of his *Formalized Music*, mark the beginning of his stochastic composition. Analytical writings focusing on these measures seek to understand Xenakis's stochastic processes based on the brief text he provided on page 15 of *Formalized Music*. Mathematical and statistical approaches are most commonly used in analyzing measures 52 to 59. Other analyses, however, are more interested in the construction *Pithoprakta* as a whole. Their approaches often are more musical, focusing on how different music elements interact with each other.

It is my attempt, in this thesis project, to provide a gateway to understand Xenakis and *Pithoprakta*. The thesis will be broken into three chapters. In chapter I, a general survey of the historical and biographical background of Xenakis and *Pithoprakta* will be provided. In chapter II, important scholarship and analytical issues revolving *Pithoprakta* will be further discussed. And, finally, in chapter III, I will supply my own analysis on the opening section of *Pithoprakta* branching off from existing literatures.

Chapter I: Background Information on Xenakis and *Pithoprakta*

Iannis Xenakis was born on May 29, 1922 to a wealthy family in Brăila, Romania. His father, Clearchos Xenakis, was the eldest son of the twelve children in his family.[1] Although he was interested in theology, Clearchos instead became a businessman because of his family's financial situation.[2] He quickly rose to become "a prosperous member of the Greek community" and married Photini Pavlou, "the daughter of a mill-owner in Brăila whose family originated from the Greek island of Lemnos."[3] Both parents of Iannis Xenakis are interested in music. Clerachos was a zealous fan of opera and admired Wagner.[4] Iannis's mother was a proficient pianist.[5]

However, the happy everyday life did not last long during Iannis Xenakis's early childhood. Pavlou passed away giving birth to the fourth child.[6] Her death was traumatizing for the 5-year-old Xenakis as he was old enough to "suspect the truth."[7] "Since then, Xenakis "clung to the few experiences he had shared with his mother," including her gift of a flute that Xenakis later explained in a conversation with Varga "gained a certain magic in my eyes."[8]

At the age of ten, Xenakis was sent to a boarding school on the island of Spetses, Greece, where he learnt Greek and English.[9] Although his school life was a misery, Xenakis was able to learn solfeggio, music notation and some singing.[10] His first Swiss music master, although not decent as a teacher, impressed Xenakis with his piano skills and inspired Xenakis to learn

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[1] Matossian, *Xenakis*, 22.
[2] Ibid., 23.
[3] Ibid., 23.
[4] Varga, *Conversations with Xenakis*, 8.
[5] Matossian, 23.
[6] Harley, *Xenakis His Life in Music*, 1.
[7] Matossian, 23.
[8] Varga, 8.
[9] Harley, 1.
[10] Varga, 11.

piano.[11] This experience provided Xenakis with some fundamental music knowledge during his early adolescence. Because Xenakis was always made fun of by his accent, he turned to the library, reading Flammarion's astronomy, and classical Greek poetry and drama.[12] It was during this time, Xenakis started to feel connected to his Greek heritage and discovered his interest in Math and Science.

In 1938 at the age of sixteen, Xenakis left Spetses and moved to Athens where he continued his musical studies while also preparing for the entrance exam at the Polytech School.[13] His study at Athens Polytechnic was disrupted several times by the war-time conditions.[14] In 1940, immediately after his acceptance at the Polytechnic School, the Italian occupation of Greece shut the school down for a year.[15] Greece then turned into a police state under the fascist dictator General Metaxas, resulting the triple occupation of the country under Italy, Germany, and Bulgaria.[16]During this time, Xenakis participated in resistances and demonstrations. He first joined a right-wing group, but later, after realizing that the Communists "questioned social matters, reasons for war and had more effective activity against the Germans," he became an active Communist.[17] Since then, Xenakis wholeheartedly engaged in political activity, participated in large-scale demonstrations and mass propaganda, most noticeably battling German's forced labor.[18] In late 1944 when the British Army took control over Athens, the Communist Party and ELAS, Greek People's Liberation Army, were asked to

[11] Varga, 11.
[12] Matossian, 25.
[13] Varga, 13.
[14] Matossian, 28.
[15] Varga, 16.
[16] Matossian, 28.
[17] Ibid., 29.
[18] Ibid., 30-31.

surrender.[19] War broke out between the Greek Communists and the British, and eventually the Communists lost. It was during this battle that Xenakis was injured hitting by a bomb shell.[20] During the two-year period that followed, there was a civil war in Greece. In 1947, Xenakis was finally able to obtain his diploma in civil engineering from the Athens Polytechnic in civil engineering.[21] It is the same year Xenakis's father smuggled him to Italy. [22] Xenakis then illegally entered France with the help of the Italian Communist Party from Turin, Italy.[23]

On November 11, 1947, Xenakis arrived in Paris.[24] Xenakis was fortunate enough to gain employment at Le Corbusier's studio that December after his arrival.[25] The experience accumulated these years in engineering, helped Xenakis to "perceive the inter-relationship of engineering and architecture."[26] After working five years as an assistance, Xenakis was then able to collaborate with Le Corbusier on an important project—the Couvent de la Tourette.[27] During this period, Xenakis was continuously seeking opportunities to study composition. Xenakis approached Nadia Boulanger to study composition but was rejected for being too old.[28] Xenakis also tried to study with Arthur Honegger, but Honegger's conservative taste in music pushed Xenakis away.[29] Finally, Annette Dieudonné, a friend of Boulanger, recommended Xenakis to Messiaen.[30]Messiaen was unorthodox and wildly unconventional. He amazed Xenakis in every possible way in music that Xenakis states "He had a very detached approach to music… He

[19] Ibid., 33-35.
[20] Varga, 18.
[21] Ibid., 19.
[22] Matossian, 40-43.
[23] Ibid., 41.
[24] Ibid., 43.
[25] Charles Turner, "Xenakis in America", 2014, xvii.
[26] Matossian, 53.
[27] Ibid., 65-66.
[28] Ibid., 54.
[29] Varga, 27.
[30] Ibid., 31.

produced his own rules… He was a free mind and was writing music freely at that time."[31] Xenakis's composition Metastasis (1953-1954) was a synthesis of such experiences.

During 1953 to 1954, Xenakis was also interested in *Musique concrète,* for he was convinced that "The physical properties of sound required at least the same degree of analysis and study as the building materials which he handled daily."[32] Xenakis made multiple attempts to join the studio of Pierre Schaeffer. Finally, it was the reference letter of Messiaen and Xenakis's latest score *Les Sacrifice* which gained Schaeffer's acceptance into his studio.[33] Pierre Henry, the assistant of Schaeffer at that time, examined the score and introduced it to Herman Scherchen. It was this very instance that later made Scherchen "a close friend and a tireless champion of Xenakis's talent."[34] Xenakis later recalls:

> Scherchen was the only conductor at that time to support my music… New music was in the hands of serialists who prevented any other trend from making itself heard. The German radio stations defended serial music to prove for themselves, too, that German music still had something to say. Then appeared composers like Boulez who believed they had found absolute music. Anything that was different didn't count. The French, the Germans and the Italians had formed an influential and exclusive club, that of serial music. Scherchen was then the only one who liked and supported what I was doing and who invited me to Gravesano to attend the meetings and give lectures. And, what as most important, he asked me to write articles for his journal the *Gravesaner Blätter,* this way forcing me, as it were, to formulate my ideas, also for myself. Otherwise I would probably never hand done that.[35]

Two year later comes the birth of *Pithoprakta*, written for 46 strings— 12 first violins, 12 second violins, 8 violas, 8 violoncellos, and 6 contrabasses, with an addition of 2 trombones, a xylophone, and a set of wood-blocks. The first performance of *Pithoprakta* was given on 8th

[31] Matossian, 61.
[32] Ibid., 86.
[33] Ibid., 86.
[34] Ibid., 87.
[35] Varga, 35.

March 1957 at Munich (Herakles-Saal der Residenz) as part of the Music Viva concerts with the Bayerischer Rundfunk Symphony Orchestra under Hermannn Scherchen, to whom the work is dedicated.[36] It was then performed next year at Darmstadt in 1958.[37] "*Pithoprakta* is a jump into the unknown. It has no musical basis of any kind," Xenakis says, "I wrote *Pithoprakta* primarily for strings because it's easier to produce mass events and various timbres within them than with any other instrument." Later in his "*Formalized Music*," Xenakis demonstrated the mathematical aspect behind measures 52-57 of *Pithoprakta,* utilizing and drawing inspiration from probability theory, Maxwell and Boltzmann's kinetic theory of gasses and Gaussian Distribution (See Literature Review of Linda Arsenault's research). Matossian praised that "*Pithoprakta* is Xenakis's first work of genius."[38]

The following decade witnessed the break between Xenakis and Le Corbusier over the authorship of the Philips Pavilion, the publication of *Formalized Music*, and many performances of Xenakis's works in the United States and around the world. Through Copland's unexpected invitation, Xenakis was able to teach at Tanglewood in 1963.[39] *Pithoprakta* received four performances by Bernstein at Lincoln Center with the New York Philharmonics orchestra that winter during Bernstein's avant-garde series.[40] Other conductors, such as Aaron Copeland, Gunther Schuller, Yuji Takahashi, Steven Schick, Lukas Foss and his student Charles Zachary Bornstein all conducted Xenakis's compositions (including *Pithoprakta*) from 1960s and beyond.[41] In 1967, Xenakis became a member of the faculty of Indiana University at Bloomington where he established the CMAM (Center for Mathematical and Automated Music)

[36] *Pithoprakta*, Bossey & Hawkes.
[37] Varga, 35.
[38] Matossian, 119.
[39] Turner, 24.
[40] Ibid., 52-57.
[41] Ibid., 57.

in an attempt to create a studio similar to that of Schaeffer's.[42] Following his resignation from Indiana University (after five years of teaching), the 70s and 80s were "glamourous and productive" for Xenakis.[43] His later works, *Eonta, Nomos Gamma, Evryali* and many more continued to explore new possibilities. As Matossian concludes in her last paragraph of her book:

> Xenakis has never stopped being a Resistance fighter. He simply moved his field of battle into music, he transformed physical and political combat into the struggle of ideas and sounds and therein forged his own aesthetic with a lyric passion of which he never stopped to give account.[44]

[42] Ibid., xix.
[43] Matossian, 278.
[44] Ibid., 292.

Chapter II: Literature Review

Iannis Xenakis, composer of some one hundred and fifty compositions, is also known for his treatise "*Formalized Music*," on the concept of "stochastic theory." First published in Paris in 1963 as *Musiques formelles*, the volume was then expanded and published in English in 1971. The sophisticated nature of Xenakis's Music with respect to mathematical principles does not scare away music theorists from analyzing his music. On the contrary, the mathematical foundation in his treatise provides scholars with a gateway into understanding his composition. Many recent analyses on *Pithoprakta*, especially, have taken this path due to Xenakis himself presenting measure 52-60 of *Pithoprakta* in the opening chapter of his *Formalized Music* while explaining his stochastic law.

Important Scholarship

Linda Arsenault is among the first who attempted to "reconstruct" Xenakis's original compositional procedures for these 9 measures in *Pithoprakta*.[45] In her PhD dissertation "An Introduction to Iannis Xenakis's Stochastic Music: Four Algorithmic Analyses (2000)," her analyses cover three compositions: *Pithoprakta*, *Achorripsis*, and *Analogique*.[46] Her main goal in the first chapter of her dissertation, focusing on measure 52-60 of *Pithoprakta*, is to "discuss the theory of using a Gaussian distribution to produce music" and to "demonstrate the algorithm, together with the musical score produced by the algorithm."[47]

[45] Arsenault, 16. In the next paragraph, Arsenault admits that "…without Xenakis's direct input into the enterprise, any attempt to answer such a question is entirely experimental in nature…"
[46] Ibid., 3. Arsenault particularly chooses these three pieces because "these are the pieces which Xenakis submits as fundamental examples of stochastic music in the opening chapters of *Formalized Music*" and "the discussion (in *Formalized Music*) does not lead directly to the score."
[47] Ibid., 11-12.

Arsenault points out the importance of working with the published score, rather than purely through Xenakis's technical text in "*Formalized Music*."[48] She first examined the six points of summation Xenakis presented in his "*Formalized Music*" on measure 52-60 of *Pithoprakta*:[49]

> There are 46 stringed instruments, each represented by a jagged line. Each of the lines represents the speed taken from the table of probabilities calculated with the formula
>
> $$f(v) = \frac{2}{a\sqrt{\pi}}\, e^{-v^2/a^2}$$
>
> A total of 1148 speeds, distributed in 58 distinct values according to Gauss's law, have been calculated and traced for this passage (measures 52-60, with a duration of 18.5 sec.). The distribution being Gaussian, the macroscopic configuration is a plastic modulation of the sonic material. The same passage was transcribed into traditional notation.
>
> 1. The durations do not vary.
> 2. The mass of pitches is freely modulated.
> 3. The density of sounds at each moment is constant.
> 4. The dynamic is *ff* without variation.
> 5. The timbre is constant.
> 6. The speeds determine a "temperature" which is subjected to local fluctuations. Their distribution is Gaussian.

This text, along with the sketches Xenakis supplied in *Formalized Music* and other publications, provide pertinent information to measures of 52-59 (See Fig. 2-1). The text discloses the technical information, while the sketches are graphical realizations of these measures. Therefore, based on what is already known, Arsenault sets out a two-step principle: first, to discover from what is already known and to construct a hypothesis based on what the analysis logically suggest; second, based on the findings, conduct an experiment to test the hypothesis.[50]

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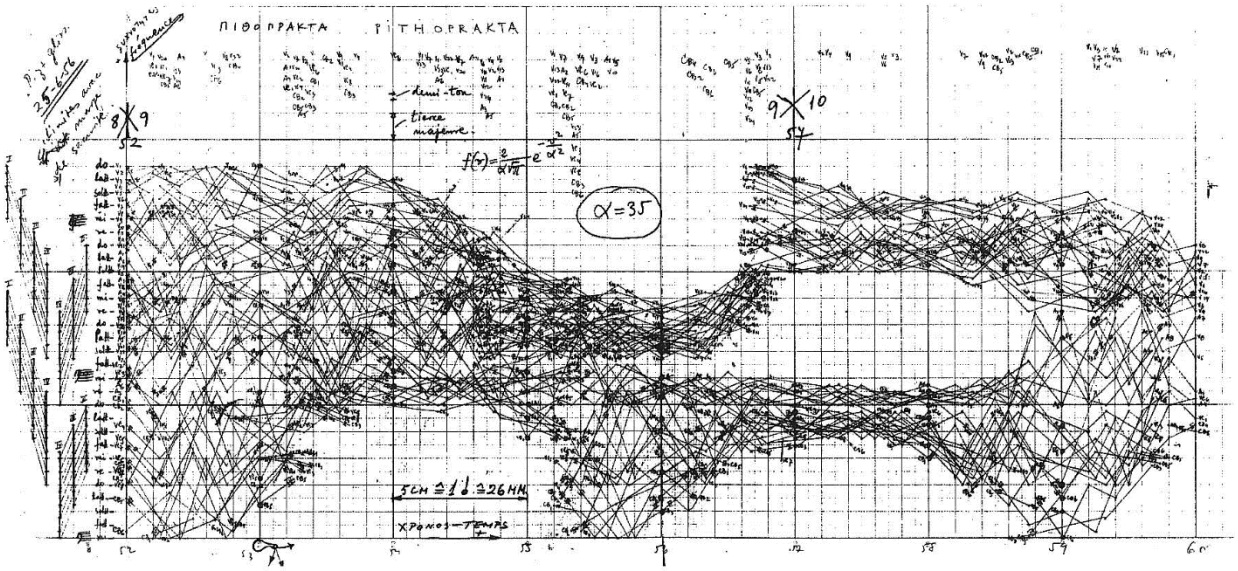
[48] Arsenault, 17.
[49] *Formalized Music,* 15.
[50] Arsenault, 16. Arsenault says that any analysis without "Xenakis's direct input into the enterprise (with regard to these measures) is experimental in nature."

Figure 2-1. A Sketch of measures 52-60 of *Pithoprakta*[51]



Arsenault examines the score first. After a brief examination on the layout and notation, she then turns to the six points illustrated by Xenakis. She found the first 5 statements of Xenakis's to be true and easily perceivable with the score and recording and some explanation. [52]

1. "The durations do not vary."

   True. "Each measure is divided in to 3,4 or 5 beats, once an instrument is assigned a particular duration, that duration is maintained throughout the passage." [53]

2. The mass of pitches is freely modulated.

   True. "…; although no pattern for the choice of pitches is obvious, it is clear that, as time progresses, the pitches move up and down freely, apparently without accent." [54]

3. The density of sounds at each moment is constant.

[51] Xenakis, *Musique Architecture*, Tournai, Casterman, 1976, 167.
[52] For example, for Point 1, the author analyzes the distribution of attacks of *pizzicato glissandi*. Although there are clusters of string changes, the overall passage has no "semblance of rhythm." She observes that there is no regularly or patterns to be found in series of pitches each line which is aligned with Xenakis's own words that the piece is devoid of serialism.
[53] Arsenault, 18. Here what she meant by "each measure is divided into 3, 4 or 5 beats": for some instruments, the measure is divided into quarter note triplets, some into quarter notes and some into eighth note quintuplets. The division of measure for a specific instrument does not change throughout the passage.
[54] Ibid., 20.

True. "It must be remembered, however, that whether a sound is heard at the beginning, at the end, or in the middle of a glissando, the density of sound is constant."[55]

4. The dynamic is *ff* without variation.

   True. Although in the score there are *fff* indications in this passage for the violins, Arsenault indicated that these are due to the consideration of balancing the volume of high pitch instruments to the rest of the ensemble.

5. The timbre is constant.

   True. 46 stringed instruments play *glissandi* continuously and simultaneously without an interruption from other sounds.

The sixth point, however, because of the nature of the terminology being unfamiliar to musicians, requires explanation.[56] The meanings of unfamiliar terminology in Point six will be explored in greater depth below.

6. The speeds determine a "temperature" which is subjected to local fluctuations. Their distribution is Gaussian.

Xenakis is using mathematical tools to aid him in achieving his sonic goal—the law of probability simply provides Xenakis with a mean. Such way of approaching and solving a problem or "a process of transformation" is considered, in the philosophy of science, as "substitution by analogy."[57] To quote Arsenault: "Just as the laws of probability can be used to determine probable outcomes of events such as dice-throwing, so they can be used to calculate mass events, such as the irregular movements of particles or molecules in an enclosed space."[58]

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[55] Ibid., 20. Here Arsenault raises the question that one might conceive the density to be NOT constant because "there are glissandi which continue across the downbeat of each new measure." The notation in the score might give readers this impression. However, she thinks since the sound is continuous for each string instrument, the density is constant.
[56] Ibid., 20.
[57] Matossian, 92.
[58] Arsenault, 22-23. "The Concise Oxford Dictionary defines probability as the extent to which an event is likely to occur, measured by the ratio of the favorable case to the whole number of cases possible." Using totally

As Matossian confirms: "Xenakis used the word 'stochastic' to express the idea of masses tending towards a mean or a goal such as a stable state…"[59] The fact that Xenakis's intention for *Pithoprakta* is to create a sonic event which resembles the movement of mass molecules[60] connects with his use of the probability theory, by which it is possible to calculate, not the movement of individual particles, but the movements of particles as a mass.[61]

In this case, the terminologies in Xenakis's sixth point— "speeds," "temperature" and "Gaussian distribution," are applied analogously to music. Arsenault interprets the terms as following:

1. "Speeds" — "pitches (or, more accurately, distances between pitches)." [62]

Because the duration, or beat division for each instrument is constant, which means the length of a glissando is fixed. For example, throughout this passage, the first violin of violin I plays glissandi in quintuplets (See Fig. 2-2). Therefore, the duration for any singular glissando is fixed. And thus, the distances between pitches— intervals, now determines the speed of the glissandi, or more specifically, the speed of the finger gliding from the starting pitch to the ending pitch.

Figure 2-2. Measures 51-56 of the first violin of violin I in *Pithoprakta*[63]

mathematical reasoning to derive the probability of potential outcomes of an event- the conclusion, of an event is called a *priori*, whereas conducting an experiment to measure its probability is called a *poesteriori*.
[59] Matossian, 106.
[60] Xenakis, *Formalized Music*, 15.
[61] Arsenault, 23.
[62] Ibid., 25.
[63] *Pithoprakta*, 10.

2. "Temperature"— "a state of equilibrium provided by the constancy of duration, density and timbre." [64]

"Temperature" is a term coming from the Kinetic Gas Theory, which Xenakis utilized in the construction of this piece. Xenakis imagines each note as a molecule. "Temperature" is a visualization of the environment of an enclosed space in which all the molecules interact. When molecules move, they generate heat, which is then measured as temperature. Therefore, this is consistent with Arsenault's interpretation of "temperature" as a "state of equilibrium provided by the constancy of duration, density and timbre," or simply, the atmosphere of these eight measures.

3. "Gaussian distribution" — often called "normal distribution" or known as a "bell curve", a distribution which depends on two mathematical variables- the mean and the standard deviation (See Fig. 2-3). [65]

The nature of normal distribution is that the outcome of samples is distributed in a fashion that 68% of the outcomes falls within the one standard deviation from the mean, 95% of the outcome falls within two standard deviations of the mean, and 99.7% falls within three standard deviations of the mean. For example, the distribution of the height of human beings is similar to that of a Gaussian Distribution. If we take a large enough sample of white males from

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[64] Arsenault, 25.

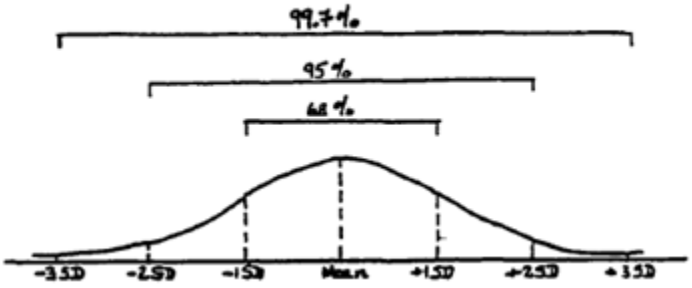
[65] Ibid., 26. In statistics, the standard deviation is a measure of the amount of variation or dispersion of a set of values. A low standard deviation indicates that the values tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the values are spread out over a wider range. Standard deviation may be abbreviated SD, and is most commonly represented in mathematical texts and equations by the lower case Greek letter sigma σ, for the population standard deviation, or the Latin letter s, for the sample standard deviation.

The formula for standard deviation is $\sigma = \sqrt{\frac{\sum(x_i-\mu)^2}{N}}$, where μ is the mean, x_i is each value from the population, and N is the population size.

age 20-40, we will find that around 68% of the height of the population would fall within one standard deviation from the mean, 95% will fall within two standard deviations from the mean, and only about 5% will fall outside two standard deviations, which means there are always more around the center and very few extremes. Arsenault states that:

> To represent his idea of equilibrium Xenakis has imposed an arbitrary structure in which duration, density, dynamics and timbre held constant. Although we know that the pitches are distributed according to a Gaussian distribution, we still do not have a clear idea of how the process is accomplished and, as noted earlier, the published score does not reveal any recognizable pattern or rationale to account for pitch placement. It is now imperative to examine Xenakis's sketch.[66]

Figure 2-3. Graphic Representation of Gaussian Distribution[67]

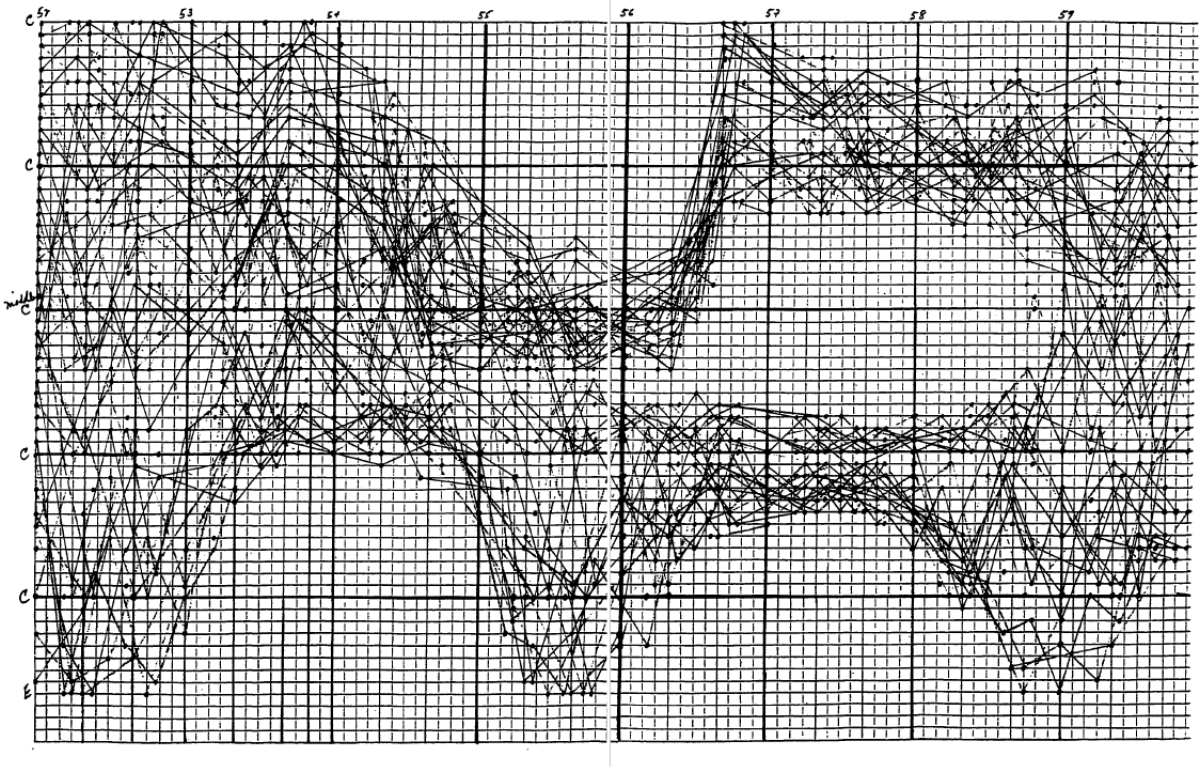


However, because of the differences between different versions of sketches, Arsenault decides to create her own her own sketch based on the published score (See Fig. 2-4).[68] The Y axis represents pitch from E^1 up to C^6—each line is a half-step. The X axis represents duration—18.5 seconds, which is then subdivided into 2.3 seconds per measure and 0.2 seconds per grid.[69] The 46 strings each have their own individual line.[70] Arsenault comments on the shape of the sketch:

[66] Ibid., 27-28.
[67] Ibid., 26.
[68] Ibid., 28-29.
[69] Ibid., 29.
[70] Ibid., 31.

> A general survey of the sketch shows that, as the excerpt begins, there is a fairly even distribution of pitches throughout the possible ranges of the instruments. Almost immediately, however, the distribution of pitches becomes more concentrated in some areas, while other areas are left completely devoid of pitches. The direct result of this pitch movement is the formation of fascinating shapes: two bridge-like envelopes in the lower range, the first between measures 53 and 55, and the second between measures 56 and 58.5; ad a lacuna in the central region between measures 56 and 58.5. From the point of view of the capabilities of the instruments, there is no practical necessity for the formation of such shapes.[71]

Figure 2-4. Arsenault's reproduction of the sketch based on the published score[72]



This leads to the question of how these shapes are formed and whether the process of their formation relates to the processes that Xenakis has undergone. From her graphic transcription of Xenakis's measures 52-59 of *Pithoprakta*, Arsenault notes the following two Rules/Principles:

1. "The same two pitches are not repeated consecutively in the same voice."[73]

[71] Ibid., 31.
[72] Ibid., 30.
[73] Ibid., 32.

2. "The same two pitches are not permitted to occupy the same place at the same moment."[74]

With further investigation of Rule 1, Arsenault reaches important conclusions:

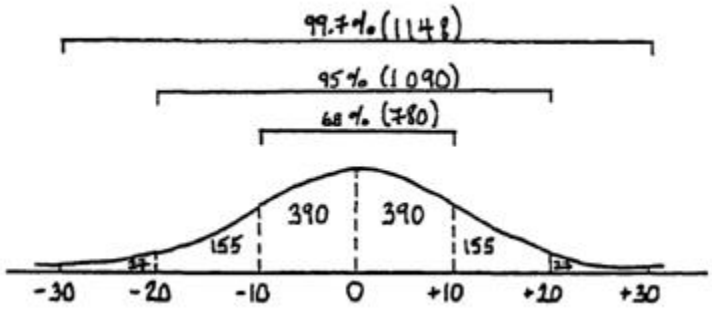
1. Starting from the first pitch of the glissandi, each consecutive pitch must represent the new mean of the distribution. "In other words, the placement of each pitch, no matter how many semitones it moves up or down, is calculated from a number based on the previous pitch as a starting point."[75]
2. "According to Xenakis introductory text to *Pithoprakta*— 'A total of 1148 speeds, distributed in 58 distinct values according to Gauss's law.' Distance between pitches in each line are randomly selected from a pool of numbers ranging from +29 to -29, but without the possibility of selecting 0 (the mean) or the starting pitch."[76]
3. "Each instrument group is confined to a range of 30 semitones. (2 octaves and a tritone)" In the footnote, Arsenault further explains: "Note, however, that the range of movement is, as Xenakis states, from plus 29 to minus 29 (58 distinct values), because the distance a pitch moves from one point to another is calculated from the starting point; it does not include the starting point."[77]

Because the range of pitches lies within -29 and +29 from the mean, and in Gaussian distribution, three standard deviations capture 99.7% of the samples, therefore, the standard deviation is estimated as 1/3 of that which is from -10 to +10 semitones. 1148 "speeds" (pitches)

[74] Ibid., 32.
[75] Ibid., 38.
[76] Ibid., 38.
[77] Ibid., 38.

should follow the following graph, that 68%, approximated 780 pitches falls in the first standard deviation and so on (See Fig. 2-5).

Figure 2-5. Gaussian Distribution of 1148 Numbers with Mean = 0 and SD = 10 [78]



However, Arsenault finds that after tracing all the pitches, 964 pitches are found within first standard deviation, 1132 pitches are found within two standard deviations and 1148 pitches within plus or minus three standard deviations. The result doesn't match with her hypothesis.[79] Such discrepancy has led Arsenault to consider two potential reasons: one being that Xenakis has utilized a much larger table of pitches in which the distribution is Gaussian, but only 1148 pitches were randomly chosen: the other being that Xenakis has willfully changed his system.[80] Arsenault has considered another potential possibility that if 24.8 is the standard deviation, then there must be numbers generated by chance to be discarded, since some of them will simply not be playable as it will exceed the range of the instrument.[81] However, Arsenault states that experimenting with using 10 as the standard deviation has its own reasons. First, "it is important to consider the implications of the relationship between the standard deviation and the size of the

[78] Ibid., 39.
[79] Ibid., 44.
[80] Ibid., 45.
[81] Ibid., 47-48. The value 24.8 of the standard deviation is calculated from *a* divided by the square root of 2. Xenakis provides the value of *a* which equals 35, and the equation to calculate the standard deviation on page 15 of *Formalized Music*.

allowable range of the instrument."[82] Second, "it is also important to answer the questions: how, in strictly practical terms, does this relationship affect the composition process for measure 52 to 59 of *Pithoprakta*?"[83] Arsenault gives the main takeaway here:

> 1) The selection of the numbers which determines the pitches is random; 2) each number or pitch is limited in its scope by the preceding pitch; 3) The creation of restrictive upper envelopes, together with the restrictive lower envelopes (imposed only partially by the natural capabilities of the instruments) will limit which number can be used. The limits imposed by these restrictions will have a profound effect on the standard deviation.[84]

The second rule—the same two pitches are not permitted to occupy the same place at the same moment—is not always held true as well. The author has found places where two pitches from different instruments do occupy the same space at the same time. [85] However, in order to recreate this passage, Rule 2 stands.

According to the 6 principles that Xenakis states in *Formalized Music* and, in conjuncture with the various findings and hypothesis through score analysis, Arsenault then carries out an experiment to recreate measures 52-59, which she calls Experimental Score #1. Followed by a statistical comparison between the mean and the standard deviation of her Experimental Score #1 and Xenakis's Score, she finds that because of the "imposition of the envelopes and the lower limits of each instrument group," despite the supposed standard deviation being used across these measures are 25, the actual standard deviations for each measure in shown in the figure below (See Fig. 2-6).

[82] Ibid., 47.
[83] Ibid., 47.
[84] Ibid., 48.
[85] Ibid., 50.

Figure 2-6. Values of Mean and SD for Experimental Score #1 and Xenakis's Score[86]

	Experimental Score #1 (SD=25)		Xenakis's Score	
	Mean	SD	Mean	SD
Measure 52	+0.2000	11.4610	+0.2290	10.2158
Measure 53	+0.6667	10.1980	+1.0137	8.3418
Measure 54	+0.0205	9.3044	-2.2827	8.0232
Measure 55	-2.9797	7.5327	-2.2483	7.2366
Measure 56	+3.0276	8.0294	+3.5238	7.8149
Measure 57	-0.5417	5.3256	-0.6759	3.8004
Measure 58	-0.7862	5.9933	-0.5724	6.0182
Measure 59	-0.7042	7.8684	-0.0069	8.0567
Measures 52-59	-0.1932	8.5125	-0.1245	7.7860

Arsenault's attempt to recreate a similar sounding result to measures 52-59 of *Pithoprakta* was a success. Looking at Figure 2-6, it is not difficult to notice that the mean and SD of each measure in Arsenault's Experimental Score #1 is very close to those in *Pithoprakta*. It is important to note that Arsenault, in her Step 1 of recreating the score, states that: "In light pencil, outline the general shape of Xenakis's sketch on the graph paper. This will help to decide whether or not a number for pitch placement may be used."[87] This gives us the insight that, perhaps, Xenakis also created the general shape of this passage before implementing the probability theory which is also subject to realistic concerns. The discrepancy between the result of the music from the preconstructed system is, therefore, explained, as Matossian notes:

> Although some critics have genuinely misunderstood his intentions, Xenakis never claimed that a rigorous mathematical or analytic basis is sufficient to produce a well-formed piece of music. Those who are partially informed about the mathematical theory expect the music to be a mirror of mathematical processes and equations. *Pithoprakta* is no more a translation

[86] Ibid., 61.
[87] Ibid., 59.

> of Probability Theory than an artichoke or a celery heart is a translation of the Fibonacci series or a flowing river is a translation of random function. [88]

In addition to the mathematical approach to analyzing measures 52-59 of *Pithoprakta*, scholars have also attempted other methods of analysis to *Pithopratkta* by Xenakis. Benoit Gibson, in his book—*The instrumental Music of Iannis Xenakis*: *Theory, Practice, Self-Borrowing*, reveals some of the most prevalent compositional procedures Xenakis utilizes in his composition, borrowing existing material from one piece to another. The way in which Xenakis borrows can be described as the following: [89]

1. Xenakis does not borrow from other composers or styles;
2. Xenakis does not borrow any connotation, symbolic or extramusical meaning;
3. The borrowed materials are not self-quotations and are not to be recognized.

Xenakis, like many preceding composers, uses this as a common practice but rarely admits it.[90] In the first half of Gibson's book, the author categorizes many methods of self-borrowing such as montage, manipulations, and transformations. According to New Oxford American Dictionary, montage is a process or technique of selecting, editing and piecing together separate selections of film to form a continuous whole.[91] Xenakis brings this technique to his musical compositions. "Xenakis encouraged the practice of montage by developing a conception of form based on the juxtaposition or superimposition of predefined textures," says Gibson in Chapter I of his book.[92] This technique mostly concerns creating objects or textural contrast by selecting and rearranging "a selection among a set of pre-existing items."[93] The types

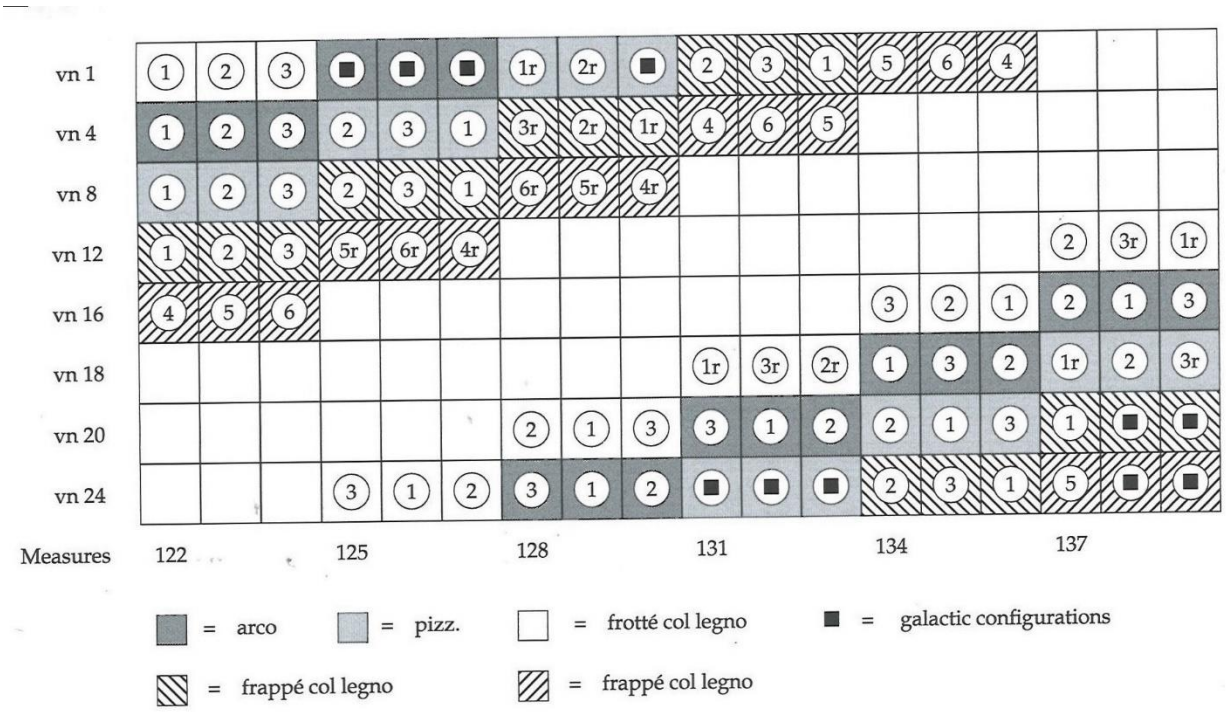
[88] Matossian, 117.
[89] Gibson, introduction xx.
[90] Ibid., introduction xix.
[91] New Oxford American Dictionary, Third Edition, 1133.
[92] Gibson, 3.
[93] Ibid., 3.

of materials selected are fragments or passages, which when combined, will the produce new objects and textures.[94]

Chapter II of Gibson's book focuses on "the way borrowed excerpts are assembled with regard to the formal manipulation of the medium, the score."[95] A few procedures concerning manipulation, such as retrogression, horizontal or vertical manipulations, and micromontage, are being discussed in this chapter.[96] Retrogression is similar to retrograde, but the source material is borrowed from other pieces.[97] Vertical manipulation means to "maintain the horizontal organization of lines but not the vertical relationship between them."[98] Micromontage is "a combination of the two preceding operations" that "elements of limited size are extracted from different places and assembled to recreate a similar texture."[99] These manipulations can occur in elements, textures, and objects. However, those items being manipulated will retain their intrinsic qualities. In discussing micromontage, Gibson cites a passage of *Pithoprakta* from measure 122-171, where the texture consists of "four superimposing clouds."[100] He states"to ensure that the nebula undergoes a constant variation, Xenakis permutates the elements and presenting them in prime or retrograde forms".[101] Within each family of instruments, the elements pass successively throughout the instruments that are assigned the same subdivision of the unit of time (See Fig. 2-7).[102]

[94] Ibid., 4.
[95] Ibid., 21.
[96] Ibid., 21.
[97] Ibid., 21.
[98] Ibid., 27.
[99] Ibid., 29.
[100] Ibid., 30.
[101] Ibid., 30.
[102] Ibid., 35.

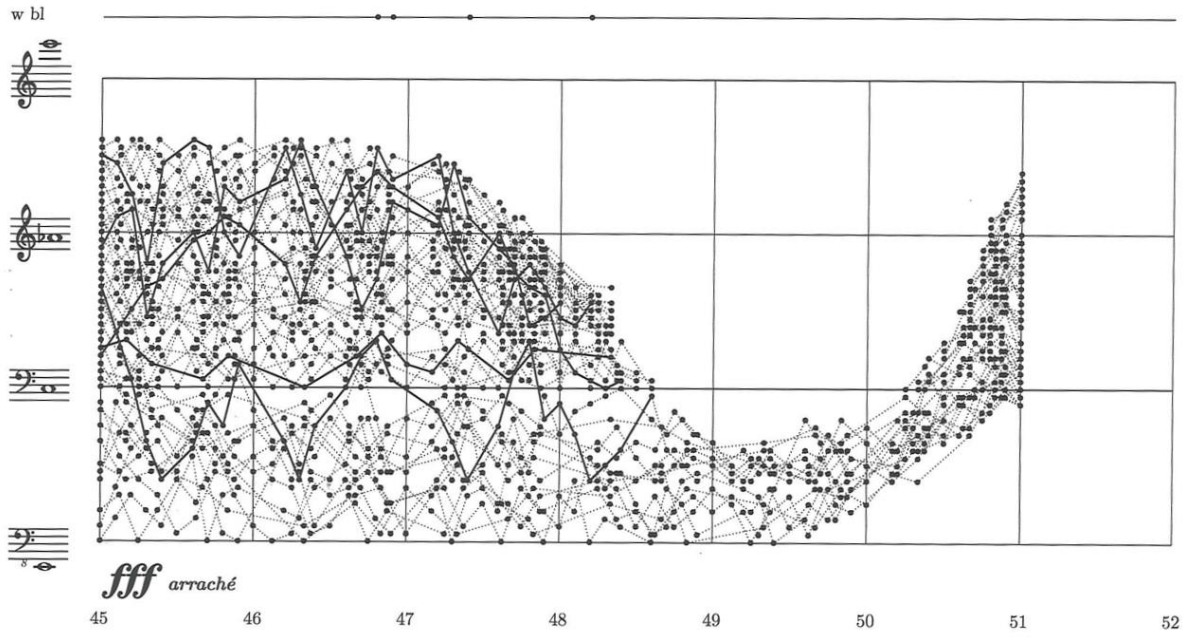
Figure 2-7. *Pithoprakta*, measures 122-239: distribution of the elements[103]



Chapter III refers to the transformations Xenakis does to his materials. Gibson states that transformation specifically refer to things such as transposition, density, register, modulation, instrumentation, and playing techniques.[104] In illustrating the transformation of playing techniques, Gibson compares measures 45-51 of *Pithoprakta* to measures 5-7 of *Aroura* by graphing different elements.[105] Gibson uses dashed lines to trace the pitch contour in *Pithoprakta*, and bolded lines to trace the pitches in *Aroura* (See Fig. 2-8). He finds that despite the difference in playing technique and the dynamic markings, these two excepts look extremely familiar on paper.[106]

[103] Ibid., 31.
[104] Ibid., 35.
[105] Ibid., 60.
[106] Ibid., 60.

Figure 2-8. Comparison between *Pithoprakta* mm. 45-51 to *Aroura* mm. 5-7 [107]



While Arsenault and Gibson's analyses focus on a specific passage(s) of *Pithoprakta*, other theorists such as John McLachlan and Gwyneth Roberts discuss the piece as a whole. Both McLachlan and Roberts dedicate one chapter in their dissertation to the analysis of *Pithoprakta* focusing primarily on various music parameters such as rhythm, pitch, harmony timbre, texture and form. Their analyses will not be discussed here. Instead, they will be referenced whenever proper in the analysis chapter.

Methodology

In chapter III "Analytical Approaches and Procedures," of Robert's dissertation, "*Procedures for Analysis of Sound Masses,*" she introduces several analytical methods, and their respective strengths and weaknesses. For example, an aural approach to analysis advocated by Phillip Batstone has the advantage of "destroying the analyst's preoccupation with such things as

[107] Ibid., 61.

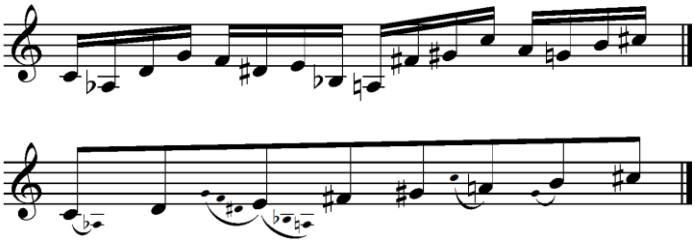
tone rows in twelve-tone music and forcing him/her to confront the music itself – sound," but has a danger of not "going into detail" and thus leading to "description rather than to a full examination of the structure of the music."[108] Parametric analysis, for example, lend a hand to music that is difficult to analyze by traditional methods, although "concentration on separate elements" might lead to the analyst overlooking the interaction between elements, thus missing the structure of the music.[109] Set theory can be used to define any collection of events, but has mostly been applied to pitches.[110] Additionally, information theory, can be applied in many ways as an statistical survey, but the possibility of involving false assumptions and multiple interpretations of the results make it problematic. The analytical method Roberts takes is a synthesis of all the aforementioned methods, "from a 'parametric' viewpoint."[111] The analysis chapter of this thesis will take a similar approach to Robert's approach. This will be discussed further in the introductory paragraph of chapter III.

Roberts then proceeds to identify the word *sound mass* and its main characteristics. She goes through terminology regarding sound mass in the following order: 1) pitch, 2) pitch organization, 3) relationship of lines, 4) rhythm and meter, 5) texture, 6) density, 7) loudness and timbre and 8) form and structure. Starting with pitch, she points out that according to Henry Cowell, the important pitches of a sound mass will always be those of the outer-most two voices, "unless an interior pitch or group of pitches is set off in some manner, by dynamic for instance, from the other pitches."[112] Vincent Persichetti also possesses the same view, stating that "when a large cluster is used, handling the voices is accomplished solely by considering the two-part

[108] Gwyneth Roberts, "Procedures for Analysis of Sound Masses," Music Doctoral Dissertation, Indiana University, 1978, 33-34.
[109] Ibid., 35.
[110] Ibid., 35.
[111] Ibid., 37.
[112] Henry Cowell, "*From 'New Musical Resources*,'" in Contemporary Composers on Contemporary Music, 145.

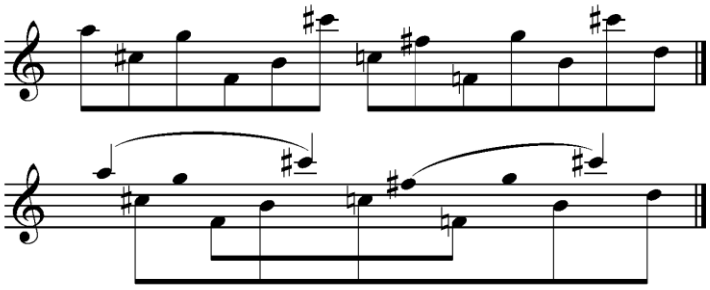
counterpoint formed by the outer voices."[113] The author states that pitch is important not only in terms of its scale basis and of the outer voices, but also the direction of the pitch.[114] Roberts illustrated in her Ex. 14a. and Ex. 14b. (See Fig. 2-9) that the melody possesses a general direction even if it is not manifested at the very local level.[115]

Figure 2-9. Directed Motion in a Melody and its Reduction[116]



Roberts also gives a counter-example of a melody without directed motion in her Ex. 15a and Ex. 15b (See Fig. 2-10).[117]

Figure 2-10. Melody without Directed Motion and its Reduction[118]



These examples show a relationship between melodic lines distinguished by register, an aspect of pitch organization that is different from set theory. In her Ex. 15a and Ex. 15b (Fig. 2-

[113] Persichetti, Vincent, *Twentieth-Century Harmony*, 126.
[114] Roberts., 40.
[115] Ibid., 41.
[116] Ibid., 41.
[117] Ibid., 42.
[118] Ibid., 42.

11), the outer voices remain constant while the inner voices move in random directions.[119] Roberts specifies in her dissertation that "texture" refers to the relationship of lines.

Roberts also examines *sound mass* in the aspect of rhythm and meter. An important notion she presents is that rhythm is hierarchical, and important events happens at different levels.[120] "The relationship of all the musical elements plays a lead role in any analysis of structural rhythm."[121] Meter is always obscured in two main ways either (1) through cross rhythms, or (2) through proportional rhythm or long sustained notes.[122]

Regarding form and structure, Roberts states that structure is "the basic underlying framework of music". Structure is the element which enables us to determine why one event logically follows another. [123] Structure is most often created by pitch organization, but can sometimes be governed by extra-musical concepts. Form, on the other hand, refers "how the material and ordering of the various elements shape the music." Repetition, unity, or "gradual shaping of the music" are some common ways to create form.[124]

Structure of *Pithoprakta*

Despite the many ways of analyzing *Pithoprakta*, structure is something that is commonly discussed. Although there are minor differences with regard to structure, the differences are more a result of ambiguity and personal interpretation.

James Harley, in his book, *Xenakis*: *his life in Music*, claims that *Pithoprakta* clearly falls into three main sections separated by long silences. The first section constitutes "a number of

[119] Ibid., 44.
[120] Ibid., 48.
[121] Ibid., 48.
[122] Ibid., 49.
[123] Ibid., 53.
[124] Ibid., 56.

different passages, some overlapping, some shifting abruptly," from measure 0 to 119.[125] Within this section, multiple distinct passages can be discerned. First is the opening passage from measure 0-51, which can be characterized by an interplay of "unpitched knocks, plucks, and short bowed attacks."[126] This passage is followed by the well-known measures of pizzicato glissandi from measure 52 to 59. The next passage is formed by the first stable sonority of a large, sustained cluster in which each string instrument holds a distinct pitch. This texture is disrupted by the introduction of an increasing number of pizzicati on repeated notes, which then turns into bowed glissandi as "a kind of resonance of the plucked attack" from measure 60 to 119.[127]

The second section, ranging from measures 122 to 204, is considered by Harley to be the more continuous, featuring "first five, then six distinct sonic entities combined to form an almost opaquely thick texture."[128] This complex sonority suddenly turns into "a sudden outburst of frenzied clouds of *col legno battuto*" at measure 172, which is paired with two sustained notes in the trombones. As the trombones drop out, the strings "settle into a more stable sonority with each instrument sticking to a single pitch, switching one by one to pizzicato and then dripping out."[129] This is followed by a few isolated gestures alternating between *battuto* and pizzicato.

The last section introduces three distinct layers—"sul ponticello–tremolo–glissando" from measures 208 to 236. These layers gradually give way to the returning sustain cluster starting at measure 231, which then reverts back to a "teeming mass of sul ponticello–tremolo–glissando." The lower instruments eventually drop out as the register goes higher and higher

[125] *Pithoprakta* starts on measure 0, instead of measure 1.
[126] James Harley, *Xenakis his life in Music*, 14-16.
[127] Ibid., 15.
[128] Ibid., 16.
[129] Ibid., 16.

ending on the pitch D8, which is then repeated with alternating techniques—harmonics, tremolo, and sul ponticello-tremolo. To summarize, Harley interprets *Pithoprakta* in a three-part form, shown in Figure 2-11. Silence does not belong to any section.

Figure 2-11. A Representation of Harley's Structural Outline of *Pithoprakta*

Section 1	Silence	Section 2	Silence	Section 3
m. 0-119	m. 120-121	m.122-204	m.205-207	m. 208-268

Gwyneth Roberts, however, gives a structural outline that is a little bit different. She separates the piece into four parts by textural contrast and silence. Part two, three and four are divided into multiple sub-sections.[130] She omits the measure numbers for silence:

Figure 2-12. A Representation of Robert's Structural Outline of *Pithoprakta*[131]

Part One measures 1-51 (0-51)

Part Two measures 52-119

Section One measures 52-59

Section Two measures 60-104

Section Three measures 105-119

Part Three measures 122- 195

Section One measures 122-171

Section Two measures 172-195

Transition measures 200 -204

Part Four measures 208-268

Section One measures 208-230

Section Two measures 231-268

[130] Roberts, 93.
[131] Ibid., 93.

John McLachlan, in his dissertation, *Determinism, Aleatorism and Tradition: The relationship between the analysis and compositional technique of selected music from 1954-64,* also separated *Pithoprakta* into four major areas. He uses timing figures derived from the recording by the *Orchestre National de L'O.R.T.F* (Chant du Monde CD 2783668).[132] However, with the assistance of the graphic representation he provided, it is not too difficult to pin down the measures numbers. According to McLachlan, the four respective areas are 1+1a, 2+2a, 3+3a and 4a+4 as shown on his graph. The missing measures numbers are silences.

Figure 2-13. A Representation of McLachlan's Structural Outline of *Pithoprakta*

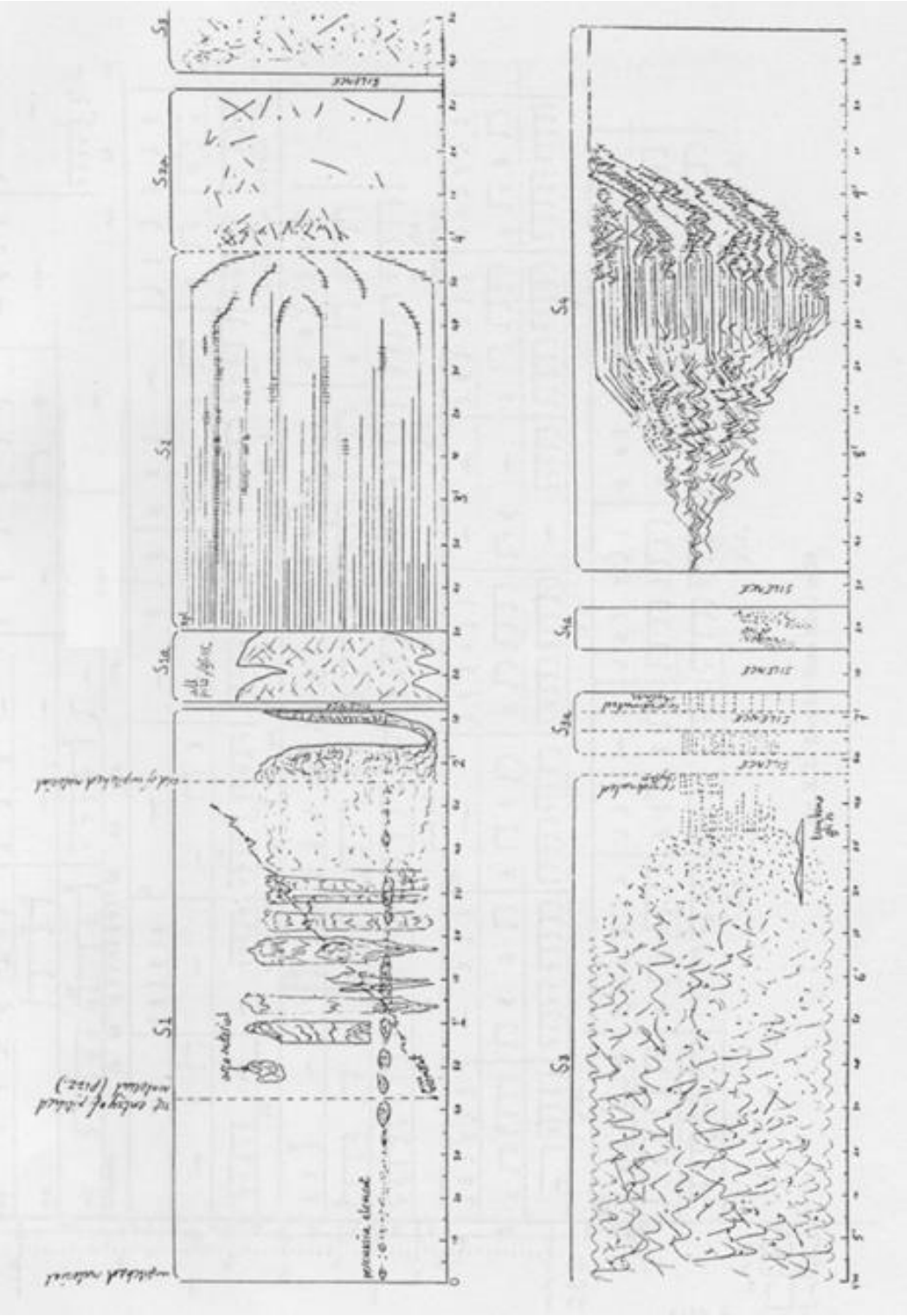
Area 1+1a	Area 2+2a	Area 3+3a	Area 4a+4
m. 0-59	m.60-119	m.122-195	m.200-268

What scholars have agreed upon is sectional division through textural contrast and insertion of silence. The main disagreement among scholars lies within the first and the last sections. While Harley proposes the first section to be from the opening to measure 119, Roberts and McLachlan subdivide the first section. Roberts combines measure 52-59 with the sustained cluster coming afterwards, while McLachlan thinks that the pizzicato glissandi is a continuation of the opening. Regarding the last section of *Pithoprakta*, Harley combines measures 200 to 204 with the previous passages. Roberts treats these four measures as a transition. McLachlan points out ambiguity regarding these measures between S_3 and S_4 (See Fig. 2-14), corresponding to measures 189 to 204, saying that there is "even more blurring of boundaries, emphasized by four long silences."[133]

[132] John McLachlan, "Determinism, Aleatorism and Tradition: The relationship Between the Analysis and Compositional Technique of Selected Music From 1954-1964," Music Doctoral Dissertation, Trinity College Dublin, 1999, 257.
[133] Ibid., 257.

I, personally, agree with McLachlan on the separation of Sections I and II at measure 60. The pizzicato glissandi passage from measure 52-59 could be interpreted as a transformation of the pizzicato texture in the previous measures. The introduction of the static cluster at measure 60 is a clear disruption in continuity. Regarding the ambiguity from measure 189 to 204, I agree more with Roberts that measure 200 to 204 is a transitional passage. Measure 189 to 195 is a closure of the previous passage, as the music returns to order from chaos. While the first gesture, from measure 189 to 191, still contains three types of beat divisions, the following gesture at measure 193 contains only the triplet beat subdivision, reaffirming the closure once again. Then comes four and half measures of silence followed by two gestures, one in pizzicato, the other in col legno. Although the playing techniques are the same as the preceding gestures, but the gestures are drastically different in contour and organization. Its function is to set a stage for departure.

Figure 2-14. Graphic representation of *Pithoprakta* by John McLachlan[134]



[134]McLachlan, Volume II, 30.

Chapter III: Analysis

In this chapter, a detailed analysis will be made on measures 0 to 51 of *Pithoprakta*. The methodology employed here would be similar to that of Robert's which was mentioned in the previous chapter. The analysis will have a parametric focus, looking at four key musical elements—rhythm, pitch, texture and form. The analysis of rhythm receives the most attention, while the discussion of the rest will draw from the evidences made in the rhythmic analysis.

Rhythm, Motif, Rhythm Organization

Rhythm plays an important role in the organization of *Pithoprakta*. Glancing over the first few measures of *Pithoprakta*, the immediate noticeable feature is Xenakis's usage of polyrhythm. The meter of *Pithoprakta* is 2/2, unchanged throughout the piece. Each beat, in this case, a half note, is subdivided into three, four or five equal parts (See Fig. 3-1).

Figure 3-1. Beat subdivisions in *Pithoprakta*

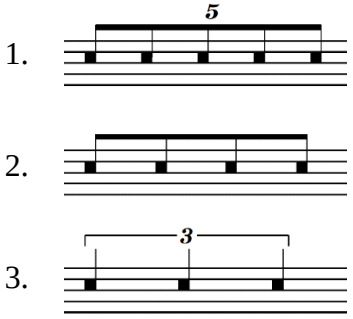
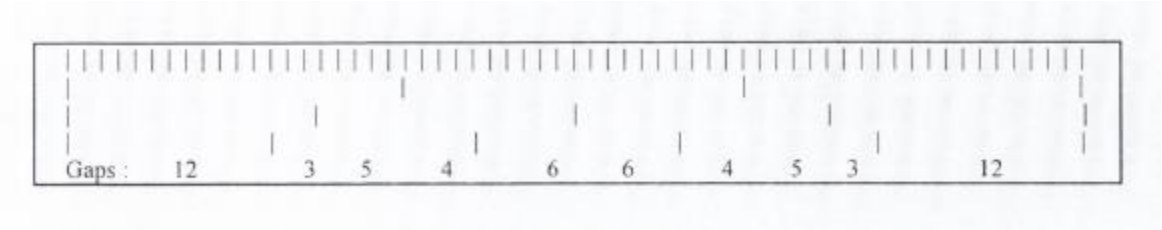


Figure 3-2 shows an array of durations between each attack for this basic rhythmic figure within one beat (a half note). The arrangement of durations is symmetrical.[135] Durations that are derivatives of this array, such as 15 (12+3), 8 (3+5), 9 (5+4), can be generated.[136]

[135] McLachlan, 279.
[136] Ibid., 279.

Figure 3-2. Durations between each attack of 3 against 4 against 5 [137]



Each instrument group has several parts that are grouped as follows (See Fig. 3-3) into either a quintuplet, eighth note, or triplet subdivision. From measure 0-51, the assignment of beat subdivisions for each instrument is shown in Figure 3-3:

Figure 3-3. Beat subdivision assignment

	Quintuplet	Eighth note	Triplet
Violin I	1,2,9,10	3,4,7,8	5,6,11,12
Violin II	1,2,9,10	3,4,7,8	5,6,11,12
Viola	1,4,7	2,5,8	3,6
Cello	1,6	2,4,7	3,5,8
Contrabass	1,4	2,5	3,6

According to Figure 3-3, three types of beat subdivision are distributed evenly among all 46 strings and within each instrumental group. There are 15 instruments which receive the quintuplet beat subdivision; 16 instruments which received the eighth-note beat subdivision; and 15 instruments which received the triplet beat subdivision. The assignment of different beat subdivisions within an instrument group does not seem to follow any particular order. If we combine every two lines in Violin I and II for easier comparison, the order of beat subdivisions for each instrument group looks like (See Fig. 3-4): [138]

Figure 3-4. Order of beat subdivisions in each instrumental group

	Order of beat subdivisions
Violin I	5-4-3-4-5-3

[137] Ibid., 279.
[138] In Figure 3-4, the number "5" represents the quintuplet division; the number "4" represents the eighth note division; and the number "3" represents the quarter note triplet division.

Violin II	5-4-3-4-5-3
Viola	5-4-3-5-4-3-5-4
Cello	5-4-3-4-3-5-4-3
Contrabass	5-4-3-5-4-3

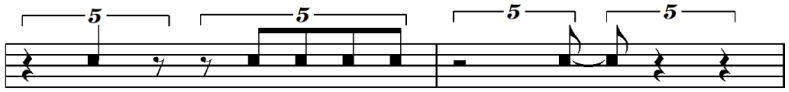
A purpose of having the three types of beat subdivision distributed evenly might be to have each subdivision blend in with one another so that any single type is not distinguishable to the audience. However, we do see that all instrument groups start with the order of "543 (quintuplet–eighth note–triplet, for violins in groups of two)", but the pattern does not seem to persist after the first cycle except for viola. If the pattern were to persist, for example, then the fourth line in the cello group should receive the quintuplet beat subdivision. However, Xenakis skips the quintuplet subdivision and gives the fourth cello the eighth-note subdivision until this pattern returns again from the sixth to the eighth cello. If what Xenakis wanted was simply to have an equal number of lines for any of the three given beat subdivisions across all instruments, he could have made the following arrangement so that the order of "543 (quintuplet–eighth note–triplet)" remains unchanged (See Fig. 3-5). It is difficult to believe that a composer with an engineering background would arbitrarily break the pattern he sets out. If this arrangement of lines among the eight cellos does have its own reason, then uncovering it might reveal Xenakis's compositional thinking in some way.

Figure 3-5. Actual and hypothetical assignment of beat subdivision in cello

	Quintuplet	Eighth note	Triplet
Cello (on the score)	1,6	2,4,7	3,5,8
Cello (possibly)	1,4	2,5,7	3,6,8

The rhythmic material found in the first two measures governs all the rhythmic material for the rest of the piece.[139] The ways in which Xenakis forms motifs out of these rhythmic figures are through various transformations. But if one look more closely, on top of that, Xenakis also uses two basic computations from set theory—complement and subset, to generate materials. For example, the following except can be found in the first two measures of the first, second and ninth violin in Violin I. Notice that the first measure and the second measure are in complement to one another (See Fig. 3-6).

Figure 3-6. First two measures of the first, second and ninth violin in Violin I

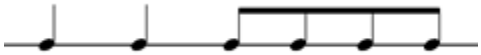


Therefore, if we combine the first two measures, we will get the full set (See Fig. 3-7):

Figure 3-7. Rhythmic motif after combining measures 1 and 2

If we maintain the relationship among all the events, and reduce the set into quarter notes and eighth notes, we will get the primary rhythm motif (See Fig. 3-8):

Figure. 3-8. Primary rhythmic set



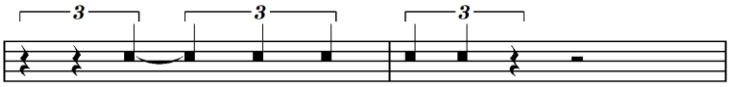
There are two important features of this set:

1. It is divided into two parts of equal duration.
2. The first half of the set is made of events at a duration twice the length as those in the second half. The second half of the set is a subdivision of the first half.

[139] Roberts, 95.

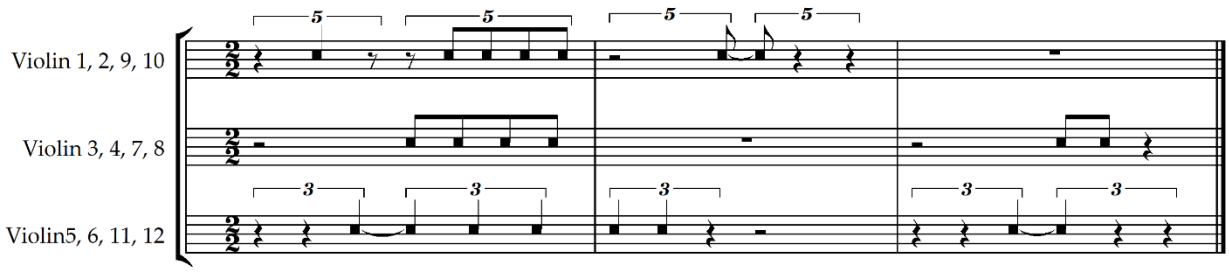
It is noticeable that Xenakis applies these ideas—1) complements and subsets, 2) 2:1 ratio, 3) four consecutive accents—to all the rhythmic motifs found in the first three measures. Looking at the eighth note subdivision, the prominent motif is the four-consecutive-eighth-notes and, sometimes, its subset—two-consecutive-eighth-notes. Not only are the most prominent triplet idea in Violin I and II, in the first two measures, complement to each other, the two triplets in the second measure combined with the two previous triplets also forms the four-consecutive-accent motif (See Fig. 3-9). Figure 3-9 is also a subset of Figure 3-8.

Figure 3-9. Triplet idea in Violin I and II in the first two measures



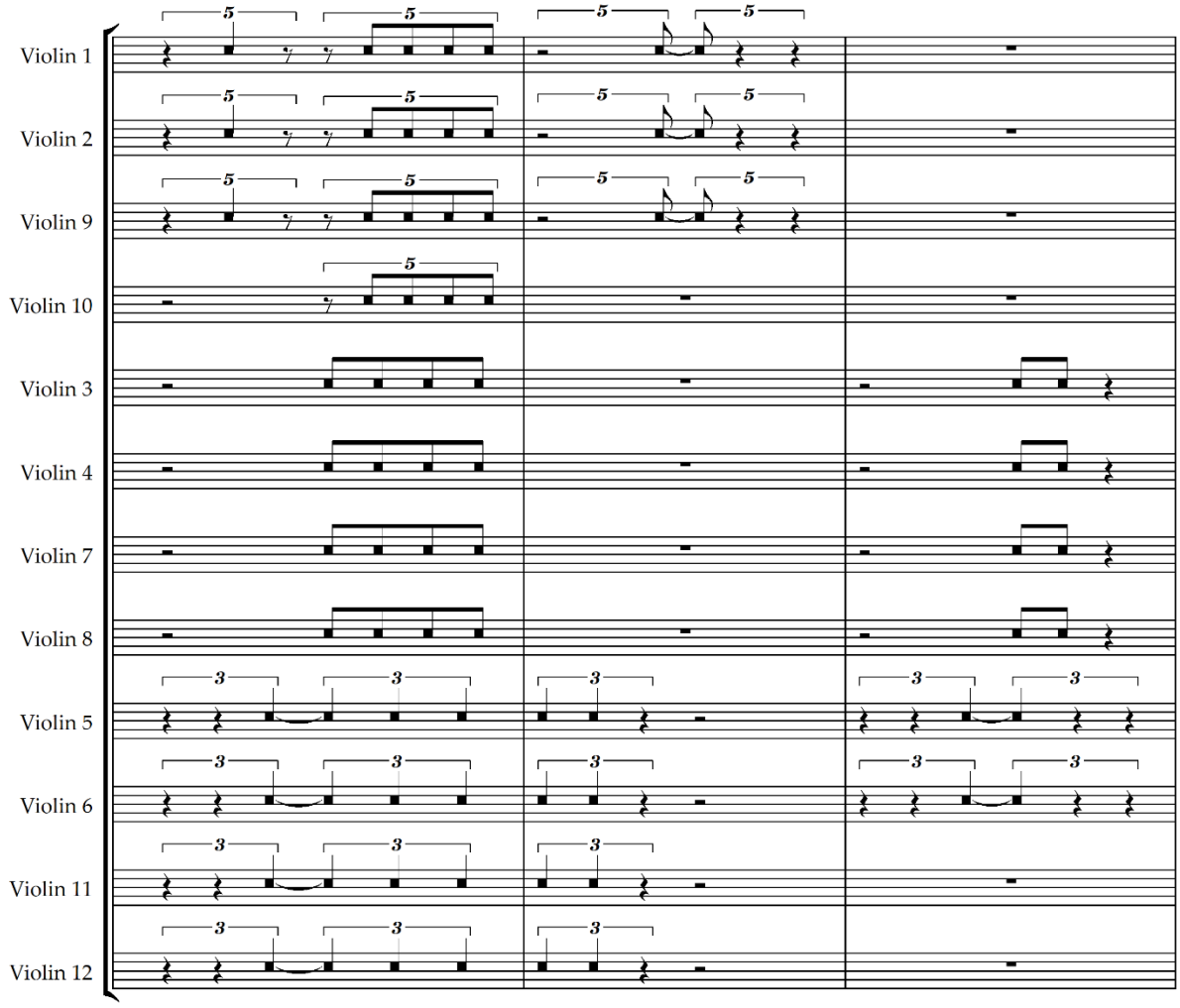
A reduction of the first three measures of Violin I is shown in Figure 3-10. The first line represents the quintuplet idea, which is repeated exactly in the first, second, and ninth violin in Violin I. A subset of this quintuplet idea contains only the second beat of the first measure is played by violin 10. The second line, or the eighth note idea, is given to violin 3, 4, 7 and 8. The third line is given to violin 5, 6, 11 and 12, except that violin 11 and 12 don't play the third measure.

Figure 3-10. A reduction of the first three measures of Violin I



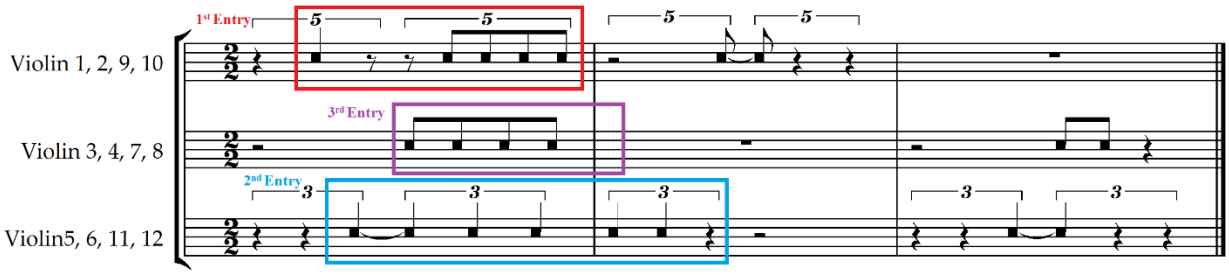
If we rearrange these lines in the order of quintuplet–eighth note–triplet; and that the complete lines always come first followed by its subset, we can create a rearranged score for Violin I (See Fig. 3-11). Violin II are given very similar lines if not exactly the same as their Violin I counterparts, the only difference is that some part of the lines is taken away. For example, the fifth and the sixth violin in Violin I play the exact same triplet line, but the sixth violin in Violin II only plays the first two measures of that line.

Figure 3-11. Rearranged score for the first three measures of Violin I



The first three measures can be broken into two main gestures. The first gesture occupies most of the first and second measure. The second gesture falls completely in the third measure. A brief moment of silence between measure two and three separates them. Horizontally, Xenakis repeats the transformed primary rhythmic motif in stretto (See Fig. 3-12). The quintuplet lines come first, followed by the triplet lines, then the eighth note lines. At each level, a portion of the primary rhythmic motif is taken away. The quintuplet lines in the first two measures contains the complete motif, only that part of it (the complement) is displaced into measure two. Going to the triplet lines, the first triplet half note disappeared. At the end, in the eighth note lines, the first two quarter notes are taken away from the motif.

Figure 3-12. Stretto entries of the primary rhythmic motif



Vertically, this process of subtraction also happens consistently. At the change of each instrument group, part of the lines is discarded. For example, in viola 1, 4 & 7, the attacks in beat one of measure 1 and the attacks in measure 2 are taken away. In the first cello, the last quintuplet of the four-consecutive accent idea is taken away in comparison to the quintuplet line of viola. It is also worth mentioning that there is a decreasing number of instruments at the change of every instrument family—12 Violin I and IIs, 8 Violas, 8 Cellos and 6 Contrabasses, which coincides with idea of subtracting something at each level.

There are other rhythmic devices Xenakis' employs later in this section. In those passages, the usage of rhythm also ties more closely to other parameters such as pitch and form. They will be discussed in the respective sections in this analysis.

Pitch, Register, Pitch Organization

Pitch is another important aspect of the opening section. In the hand-tapping gestures, aside from their rhythmic aspect, there is also a pitch aspect built into them. Because of the size difference among the instrument bodies of the string family, the sound of a hand struck on the back of a violin should sound higher in pitch than a hand struck on the body of a double bass. This is first made audible from measures 4 to 12. This passage contains two similar gestures. Unlike the cluster-like gestures in the opening three measures, in which individual pitches are indistinguishable, these following gestures are linear which makes pitches more discernable. Both gestures start from the Bass and gradually work their way up to Violin I. The pointillistic nature together with the careful orchestration establishes a clear rising pitch contour.

In addition, there is also a spatial aspect to these gestures. Consider, for instance, the seating of a regular string orchestra: the Contrabass section is seated in the back, while the rest of the sections sit in a fan-shaped area usually with the Cello section on stage left and the Violin I section on stage right. The movement of the gesture is a sweep of sound first stepping forward from the back and then quickly moveing from the right to the left in the stereo field. These pointillistic gestures are formed by sounds tossed around from one player to another. They are sparkles of sounds that connect in space. Matossian comments on the same passage that "…the

simple tapping which gives a powerful sense of movement and hesitation like small groups casing each other in different directions on a vast wooden floor…"[140]

The rise in pitch is an idea Xenakis explores in various gestures in *Pithoprakta*. Only in the opening section, both the pizzicato texture and bowed(arco) texture explore this idea. Halfway into measure 15, Xenakis introduces the pizzicato texture in Basses 2. Starting with low E, the pitch gradually rises (E-F, F#, G, Bb, A, G#-B), until measure 18, which eventually reaches C natural above the bass clef in bass 1 spanning all 12 chromatic pitches. McLachlan calls this a "skew-ways chromatic ascent," that "each pitch of a chromatic ascending scale occurs, but not quite in strict ascending order."[141] According to him, this approach to pitch material is reminiscent of Carter's *Ritornello A*, Ligeti's *Lamento Ostinato* and some of Varèse's music.[142] Roberts also demonstrates this technique—Directed Motion in a Melody, where the direction of a melody line can be discerned although it is obscured (See Fig. 2-9).

Unlike the pizzicato texture which consists of isolated pitches primarily forming a scalar pattern, the bowed texture doesn't seem to form a linear pattern. No definite melodic patterns can be found within individual lines in the bowed texture.[143] Pitch direction in an individual melody or small groups can be found. However, it is always contradicted by other lines happening simultaneously. For example, towards the end of measure 23 to 24, the arco patterns in the Violins and Violas possess a rising direction in pitch. However, it is countered by the acro patterns in the Cellos and Basses which seem to be stationary.

[140] Mattosian, 114.
[141] McLachlan, 264.
[142] Ibid., 264.
[143] Roberts, 97.

Instrumentation is another device that helps with pitch organization. Unlike the pizzicato texture, which starts with E1 in the Bass and moves all the way up to F#6 in the sixth violin of Violin II, the pitches in the bowed texture mostly remain within the clef for each instrumental group. The leaps between pitches are mostly within a sixth with a few exceptions. The movement of pitch, therefore, is defined by instrumentation since the register is fixed for each instrument group. A sense of pitch movement is created by adding or subtracting instrumental groups. For example, the introduction of the bowed texture from measures 16 to 24 sees the expansion of pitch from the middle growing into both the high and low. From measure 26 to measure 41, we see several rounds of compression and expansion of register with gradually more lines being introduced across the spectrum until we finally reach the climax at measure 45 with everyone sounding in all registers. A sudden dive in the middle of measure 48 compresses the pitch profile to the registers of cellos and basses filtering out all the upper registers but bounces back dramatically to a mesmerizing close.

Texture

The opening section of *Pithoprakta*, measure 0-51, can be summarized as a cluster of hand-tapping on the body of string instruments out of which a pizzicato and a bowed texture gradually emerges. Three textures coexisted roughly from measure 14 to measure 41. The staccato bowed texture slowly grows in density and eventually took over as the other two recede. The hand-tapping texture starts with composite rhythms, but changes into playing unison starting at measure 14. Figure 3-13 is a graphical representation that traces the evolution of the pizzicato and bowed texture from measures 14 to 51. Measure numbers are labeled on the top of each graph. Each measure is subdivided exactly as it is on the score. Each cell is equal to the smallest given note value in its respective beat subdivision (eighth-note quintuplet, eighth note, quarter-

note triplet). Pink represents the pizzicato texture, while green represents the bowed texture. The letter "v" represents the points of attack. If the duration of a note is longer than the smallest given note value, the full duration of the note is colored with the attack point marked only once at the beginning. For example, at measure 15 in Bass 2, there is a letter "v" in the fifth cell of the measure, and the following three cells are colored only, which translates to a half note on the second beat of measure 15.

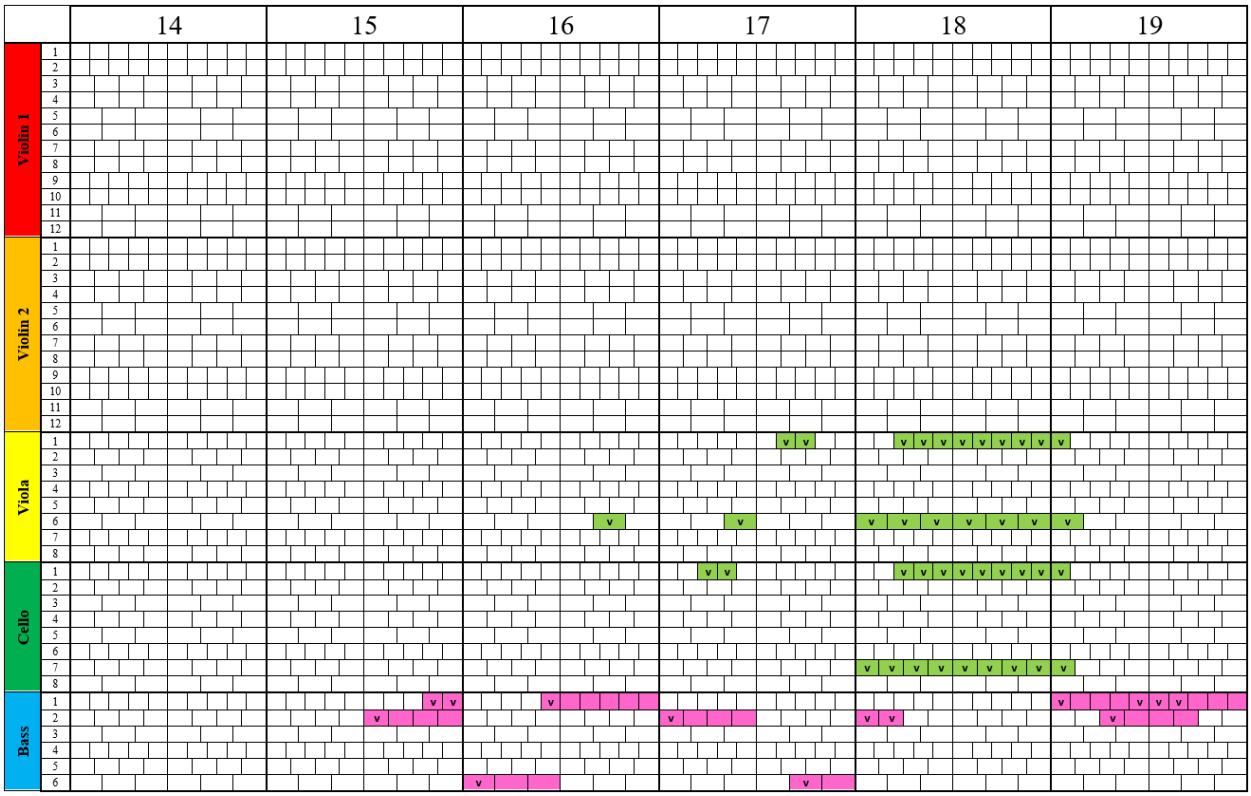
Sometimes, Xenakis ends a phrase on a note, the value of which is inconsistent with the predominant note value of its line. This phenomenon only happens on the beat. For example, on the downbeat of measure 22, the ninth violin of both Violin I and Violin II end on an eighth note; however, these two lines receive the quintuplet beat division. At the same place, the eleventh violin in Violin II ends on a quarter note instead of a quarter-note triplet. A possible reason could be that Xenakis wishes to simplify the counting for the performers. However, there are also multiple locations where he refrains from this practice, such as on the downbeat of measure 35 and 42 in the bowed texture where he explicitly writes out the triplet and quintuplet beat subdivision.

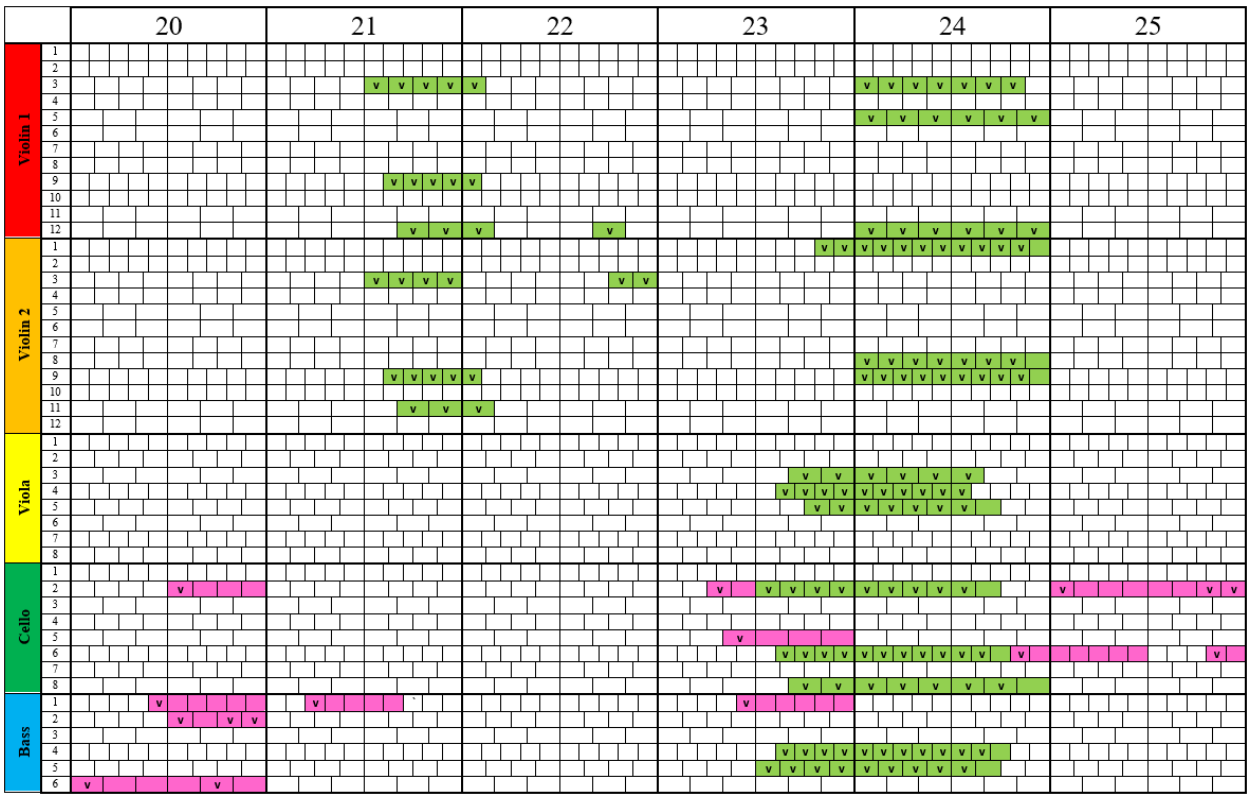
Despite all the details, the development of this section is rather straightforward. McLachlan comments on the texture of this section, saying it "builds up in a relative traditional way, by accumulating layers of different elements" and that "the most traditional aspect is the use of phrasing in the bowed material."[144] Clearly, Xenakis treats individual textures like voices in traditional western music. The texture themselves form interesting counterpoints to one another, each claiming foreground, middle-ground, and background as they develop. The

[144] MacLachlan, 283.

superimposition of three layers of textures also corresponds to the juxtaposition of three types of beat subdivision which enhances the unity of the passage. The use of different articulation and playing techniques separate the timbre of these textures, which later evolves into other sound entities, creating contrasts as well as some compelling overarching connections.

Figure 3-13. The evolution of the pizzicato and bowed texture

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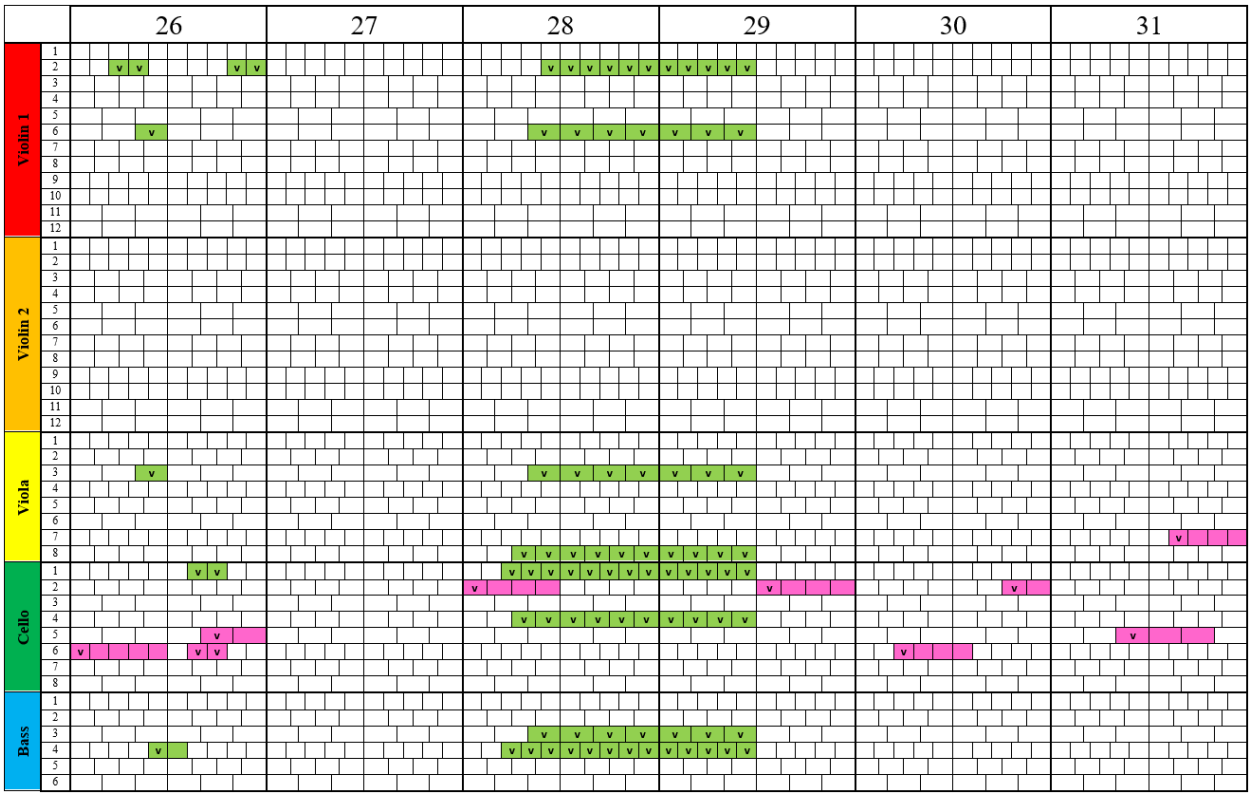
24
25
Violin 1
Violin 2
Viola
Cello
Bass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28
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31
Violin 1
Violin 2
Viola
Cello
Bass


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35
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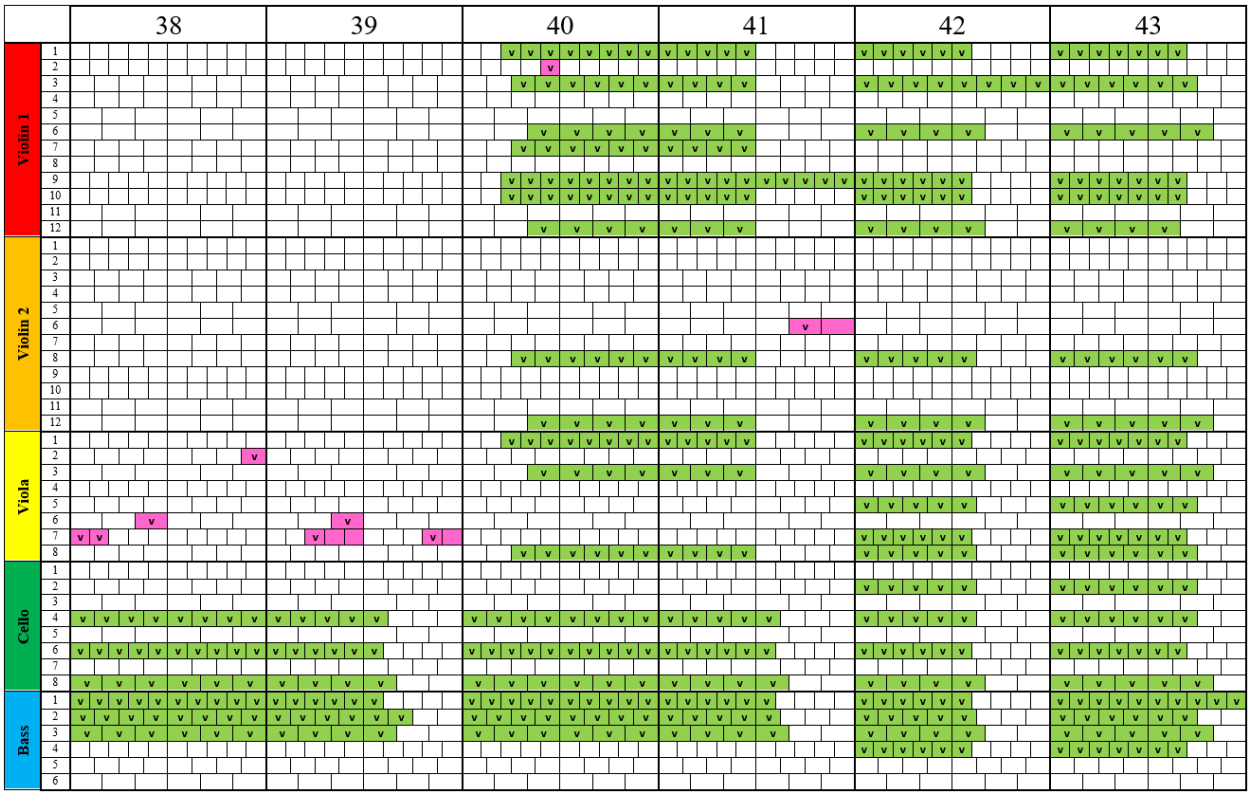
37
Violin 1
Violin 2
Viola
Cello
Bass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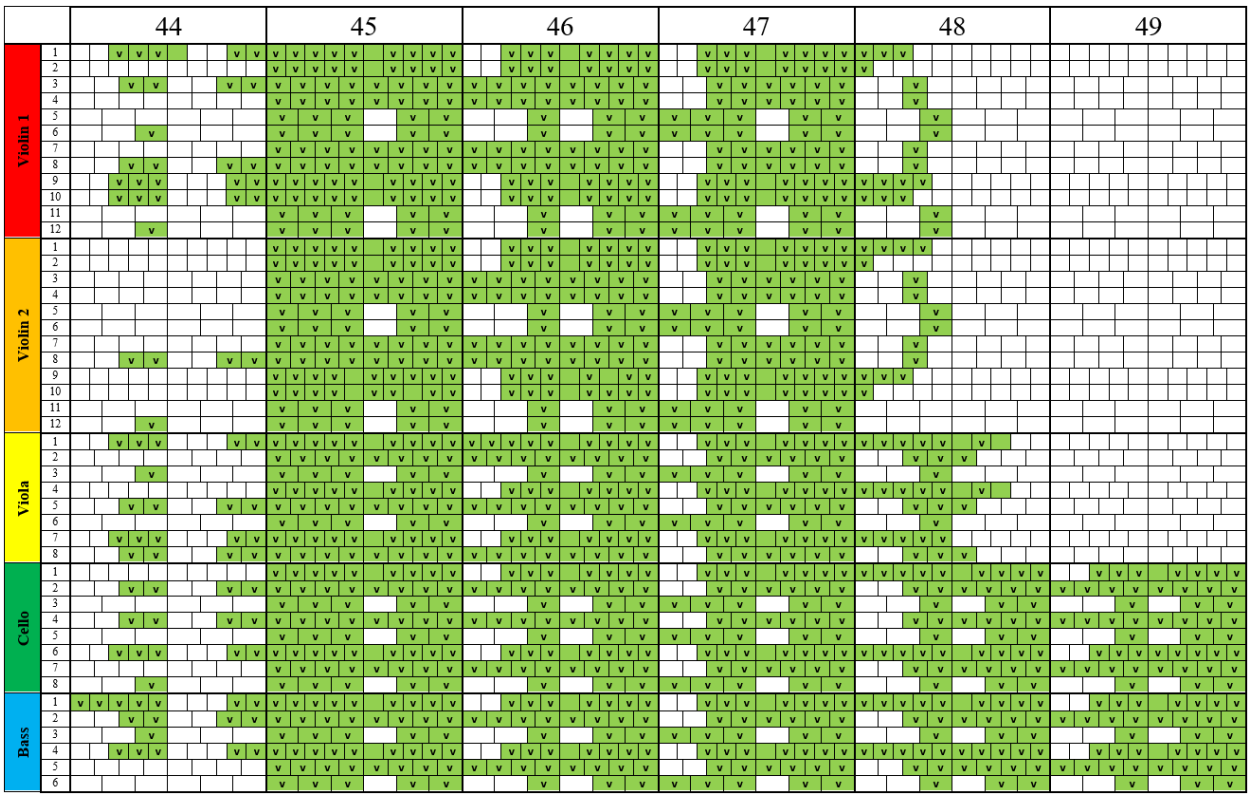
43
Violin 1
Violin 2
Viola
Cello
Bass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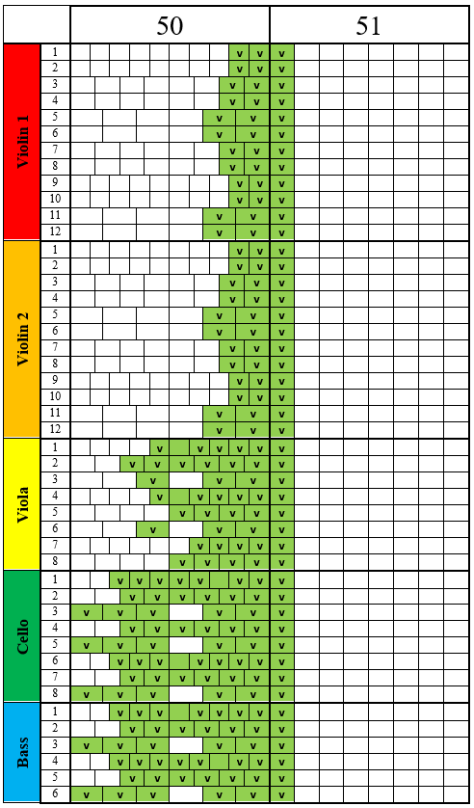
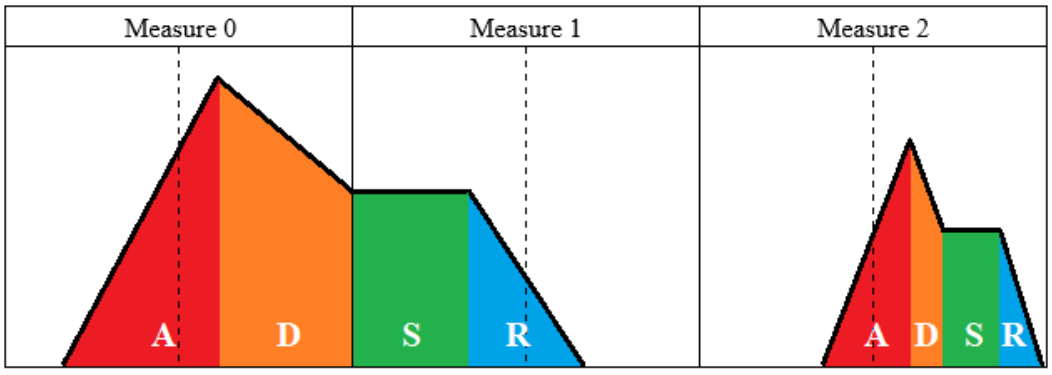
45
46
47
48
49
Violin 1
Violin 2
Viola
Cello
Bass


50
51
Violin 1
Violin 2
Viola
Cello
Bass

Form

In the first section alone, Xenakis uses many parameters to inform formal design. Rhythm plays an particularly important role. In the first three measures, Xenakis creates a concentrated mass from the sound of tapping within a rather confined period of time. The main body of the first gesture consists of a big accent on the upbeat of the first measure within some sparse tappings happening before and after. The following gesture looks very similar. It has a main accent on the upbeat of the third measure except that it is much weaker with less sound surrounding it. Figure 3-14 shows an approximation of the ADSR (Attack/Decay/Sustain/ Release) envelope of the two described sonic events. It is obvious that the first gesture has a bigger amplitude due to more instruments playing at the same time. It possesses a relatively longer attack, decay, sustain and release than the second gesture. If we look more closely at the reduction (See Fig. 3-11), the second gesture is a subset of the first one. For example, all the four consecutive eighth notes in the violin groups on the upbeat of the first measure now become two in the third measure. Some eighth-note lines in the violin groups have been taken out completely. Similar treatment can be found in the quintuplet and triplet division as well. Therefore, the second gesture look like an immediate reminiscence of the first one. The pairing of the two rising ideas following immediately afterward adopted similar design.

Figure 3-14. ADSR envelope of the two gestures found in measure 1-3



Measure 14 is the first structural downbeat of the piece. Here, Xenakis has finally made a firm entrance for the cluster of tapping with everyone playing except for the Basses 1, 2 and 6. Unified rhythms are created according to beat subdivision. This moment serves as a contrast to the opening measures and signals the entrance of other textures in counterpoint to the hand-tapping texture.

Another important rhythmic technique to realize on a macro level to inform formal design is the usage of a composite line. For example, the second beat of measure one is a composite line created by all 46 strings. Some attributes of this composite line are 1) all the sound produced at the moment uses the same performance technique; 2) all the sound starts and ends roughly at the same time, no more than half of a beat (a quarter note) apart. The first point is not difficult to explain. Since *Pithoprakta* is a textural piece, if a sound in a section is produced with the same technique, then the sounding result is homogenous, thus belonging to the same texture. The second point is also rather straightforward. Composite lines found in the measures 0-51 are all juxtapositions of lines of similar length. This technique of superimposing lines on top of each other with an approximated starting and ending point is then used primarily in the bowed texture to create phrasing. Looking at Figure 3-13, there are reoccurring instances of overlapping composite lines that are marked by green. The ending points of these bowed phrases often coincide with the tapping background. For example, at the downbeat of measure 25, the second beat of 29, the second beat of 47, a brief pause of the hand-tapping texture is crafted through inserting relative silence, creating moments of repose.

The most traditional way of shaping form comes at the climax at measure 45. Not only does the moment receive the biggest range, from E^1 to Ab^5, and loudness—*fff*, marked by arraché, the moment also sees the most instance of attacks on the downbeat. This arrival is well

prepared by the bowed texture, first with an expansion in register at measures 40, followed by two brief emphasis at measure 42 and 43 which is then reduced to two quicker and lighter attacks as an upbeat leading into the final climatic moment.

Conclusion

Despite the well-known stochastic passage of measure 52-59, the rest of the piece is just as mesmerizing. An analysis of the opening section, measures 0-51, shows us the intersection of old and new. Xenakis's usage of rhythm is particularly innovative, governing the whole piece while controlling the events on multiple levels at the same time. Together with pitch and articulation, he creates textures in counterpoint, gestures, and shapes that transform. (Make more of that) The detailed and logical organization in the opening section displays a seasoned architect at work who now pours his intelligence and fine craftsmanship into his music. The striking climax at measure 45 is perhaps the most traditional moment in this section which is well prepared through rhythm, pitch, articulation, timbre and texture combined.

Due to the limitations of this study, many other aspects of *Pithoprakta* have not been fully undiscussed. A further study might result in a comparison between sections or between different works of Xenakis. The foundation provided by recent scholarship and the findings in this project will hopefully lend a hand to future investigations of *Pithoprakta* and music by Xenakis.

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Appendix — Composition Recital

presents

Shupeng Cao

Composition recital

Saturday, April 4th, 2020 • 9:00PM
A.J. Fletcher Recital Hall

Program

The Break of Dawn 2017

Christopher Reid, guitar

Triangles 2020

The UnCaged Ensemble

The Soon to be Forgotten Sounds 2020

Fixed Media

Làng Táo Shā 2019

Juliano Aniceto, conductor
Jordan Cartrette, voice
Kimberly Smith, flute
Katja Beebe, clarinet
Kyle Newell, bassoon
Jacob Hartman, horn
Eileen Snyder, piano
Janita Lynch, violin
Andy Billings, viola
Meredith Steele, cello

Translations/Notes

The Break of Dawn (2017) is an impressionist composition for classical guitar in the spirit of capturing the scenery of an early morning of Williamsburg, VA. This piece is an embodiment of a period of my composition during which the sound is connected intuitively to the visual image.

Triangles (2020) is an improvisational piece composed as a result of a combination of a series of lesson with Prof. Martinez on triangles and the three-years' experience of performing with the UnCaged Ensemble.

The Soon to be Forgotten Sounds (2020) is a soundscape composition based on the materials I recorded on my way to and back from School of Music during my study at ECU. The intention is to capture the regularity and irregularity of the sounds during my 12 minutes of commute on foot everyday in memorial to my life in Greenville.

Làng Táo Shā (2019) is a search for genuineness. This piece is composed during a time of disturbance a few months after the outbreak of June 16, 2019 Hong Kong Anti-Extradition Bill protest. It is a reflection on the movement itself as well as its global ramifications. The poem is a famous one by the last emperor of the Southern Tang Dynasty— LǏ Yù, when he was held captive. Chia-ying Yeh specifically praised LǏ Yù's poem during this period for his genuineness and his bravery of showing his true emotions under that circumstance. I wish, through the piece, to spread the message that people would stay true to themselves.

Shupeng Cao

Làng Táo Shā

浪淘沙

For Mezzo-soprano and Large Ensemble

Làng Táo Shā 浪淘沙 (2019)

Text LI YÙ 李煜 (937-978)

帘外雨潺潺,	Outside the window, a mizzling, drizzling rain,
春意阑珊,	Spring is on the wane,
罗衾不耐五更寒。	The chills before dawn, my silk quilt cannot long sustain.
梦里不知身是客,	In dream, unaware I'm none but a guest of my captor's,
一晌贪欢。	For a while I while in vain.
独自莫凭栏,	Alone: from looking afar, I must refrain,
无限江山,	Fair was my kingdom's terrain,
别时容易见时难。	A paradise lost so readily, so very hard to regain.
流水落花春去也,	Like petals falling on rippling waters, spring is no more:
天上人间。	'Twas heaven, now a world profane.

Performance Notes

Accidentals affect only the notes they precede, except for repeated notes. Accidentals do not apply to notes in different octaves.

: quarter-tone sharp

 : three quarter-tone sharp

: quarter-tone flat

Microtones in this piece are ornamental. They do not have to be played at the exact pitch.

c.l.b.: col legno battuto

 Measured vibrato

 Flute (mm. 72-74): Full air sound, no pitch.

 Flute (mm. 72-74): Half air sound, half pitch.

 Piano (mm. 5): Stopped note

Violin (mm. 70), Cello (mm. 32): Left-hand pizz.

 Strings (mm. 62-68, mm. 72-74): Bow on the bridge.

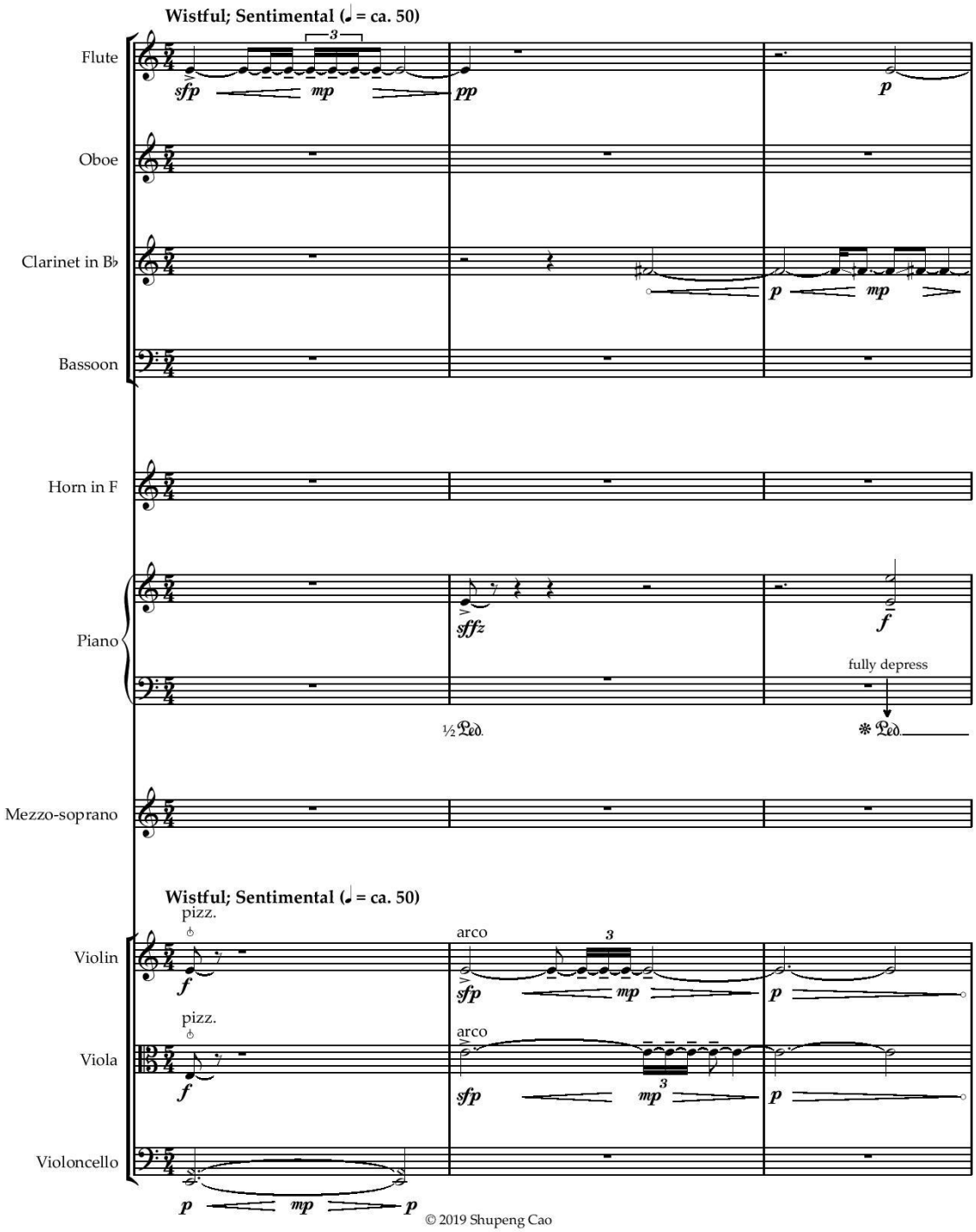
Transposed Score

Làng Táo Shā

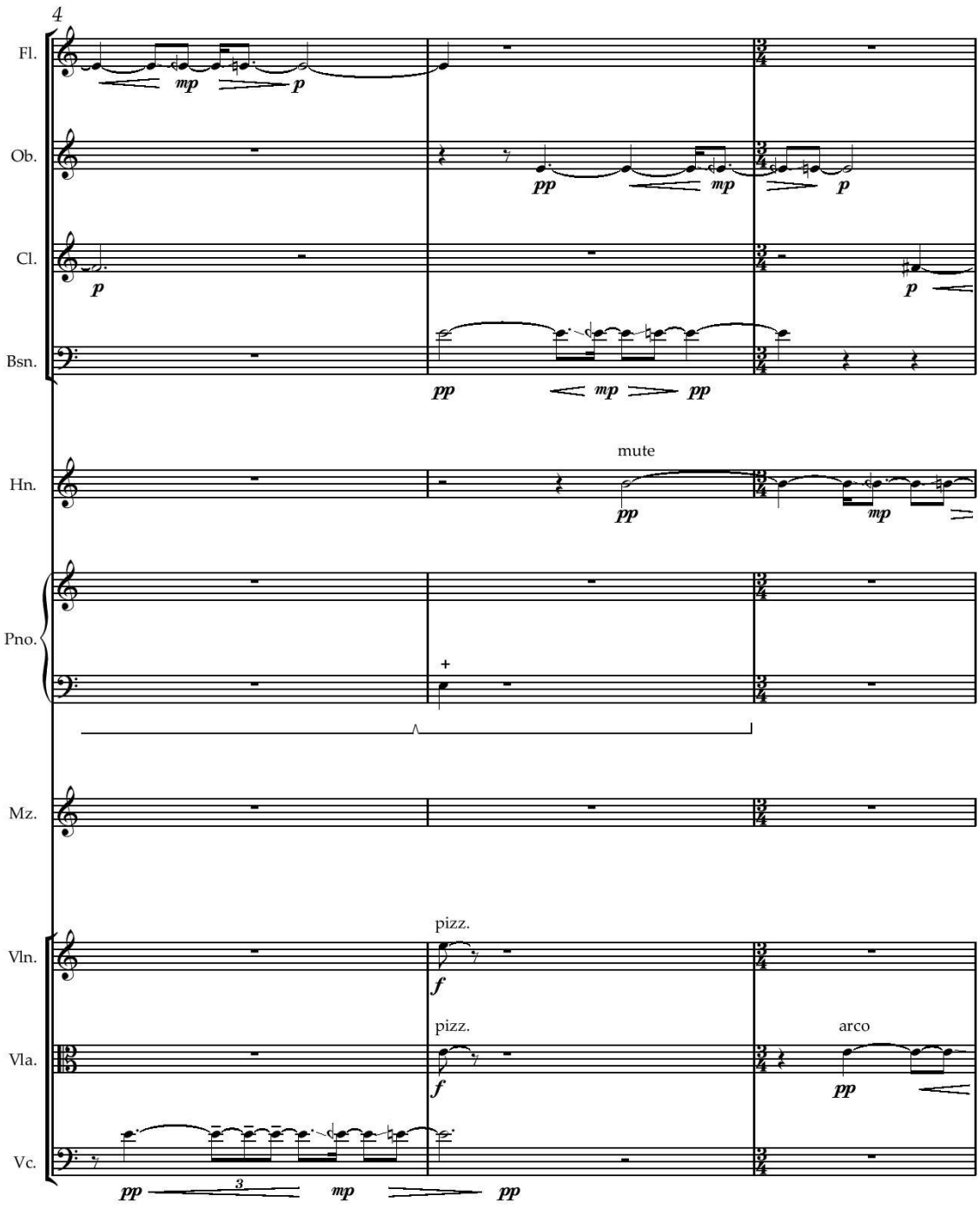
浪淘沙

for Mezzo-soprano and Large Ensemble

LI YÜ (937-978) SHUPENG CAO



© 2019 Shupeng Cao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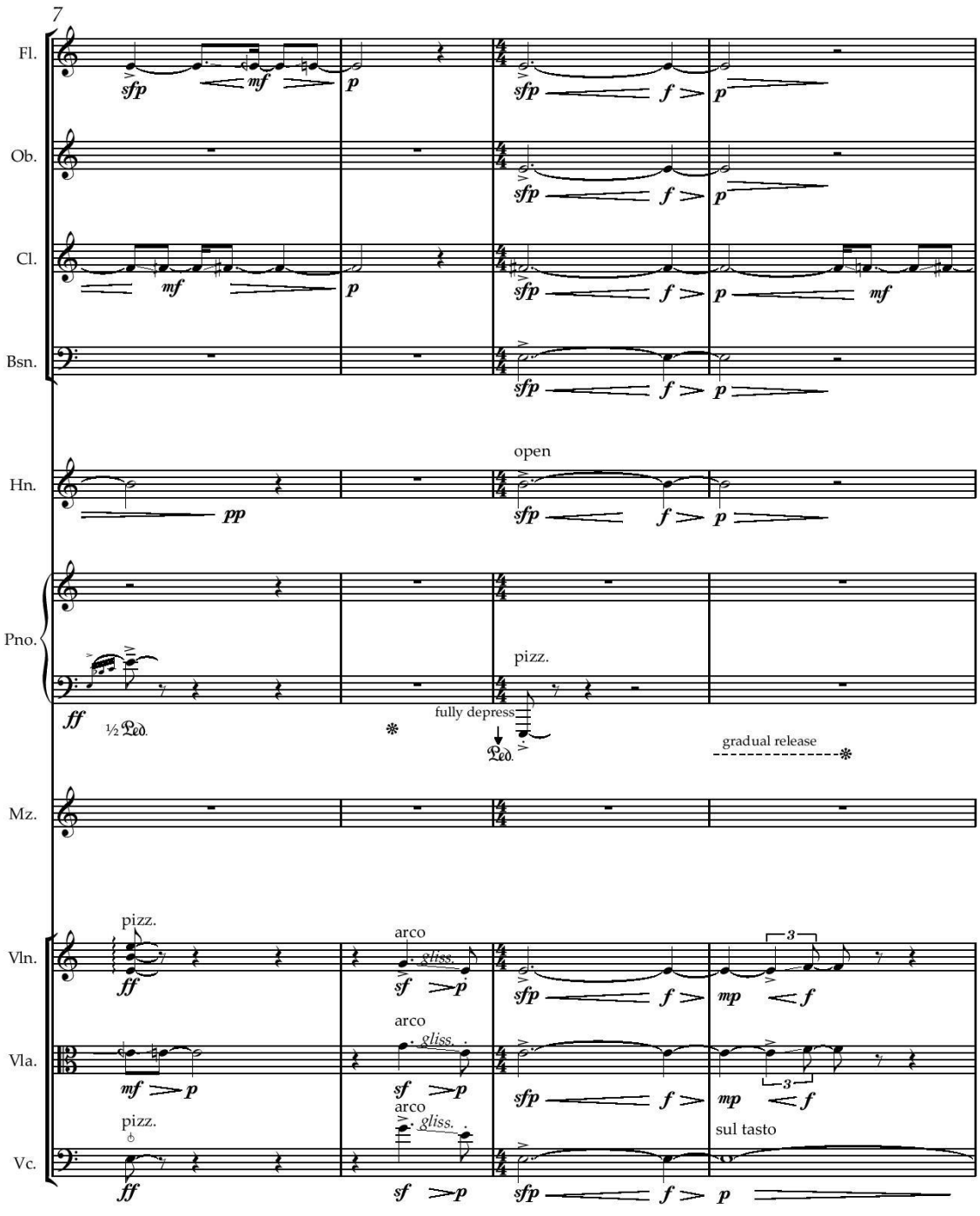
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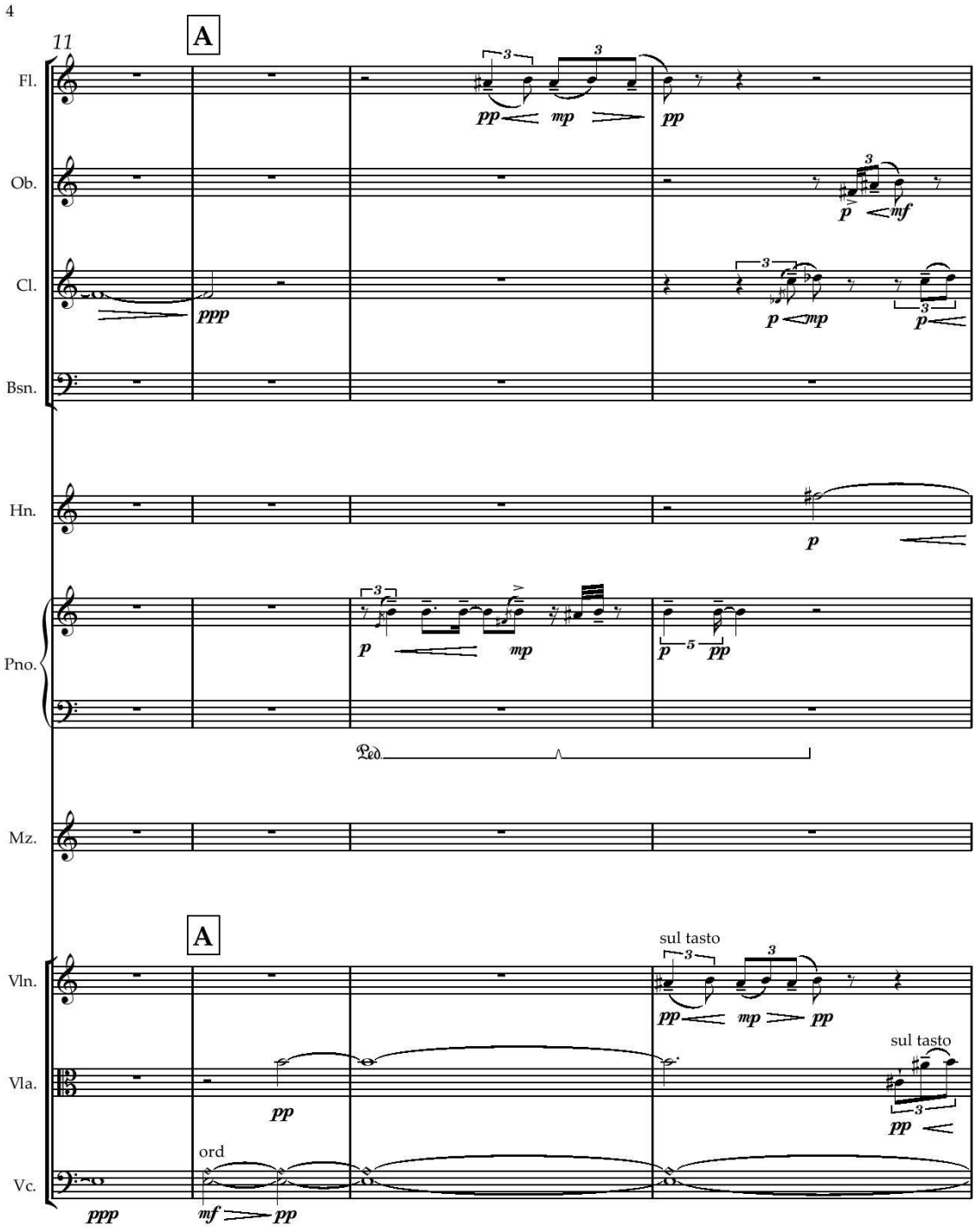
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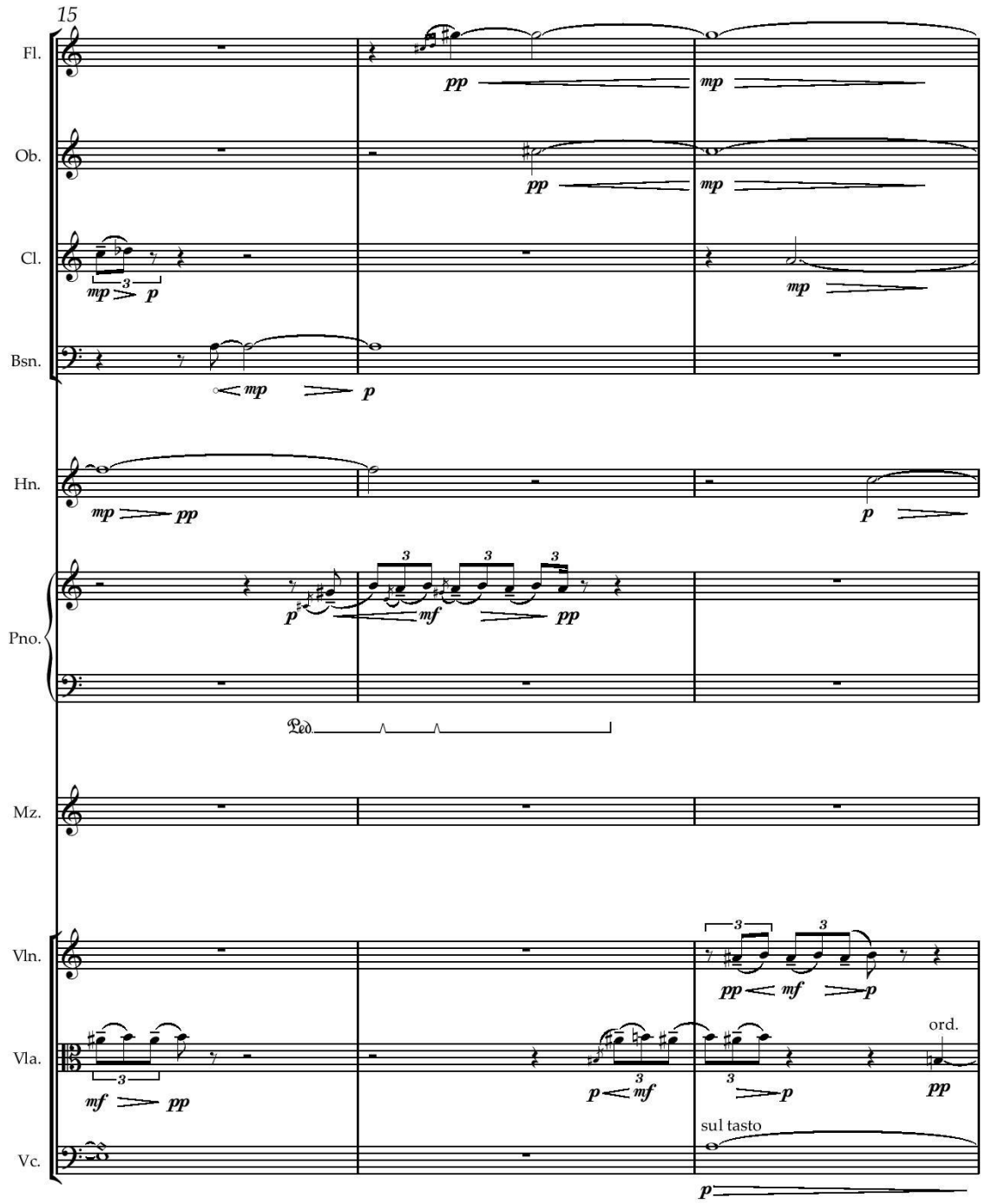
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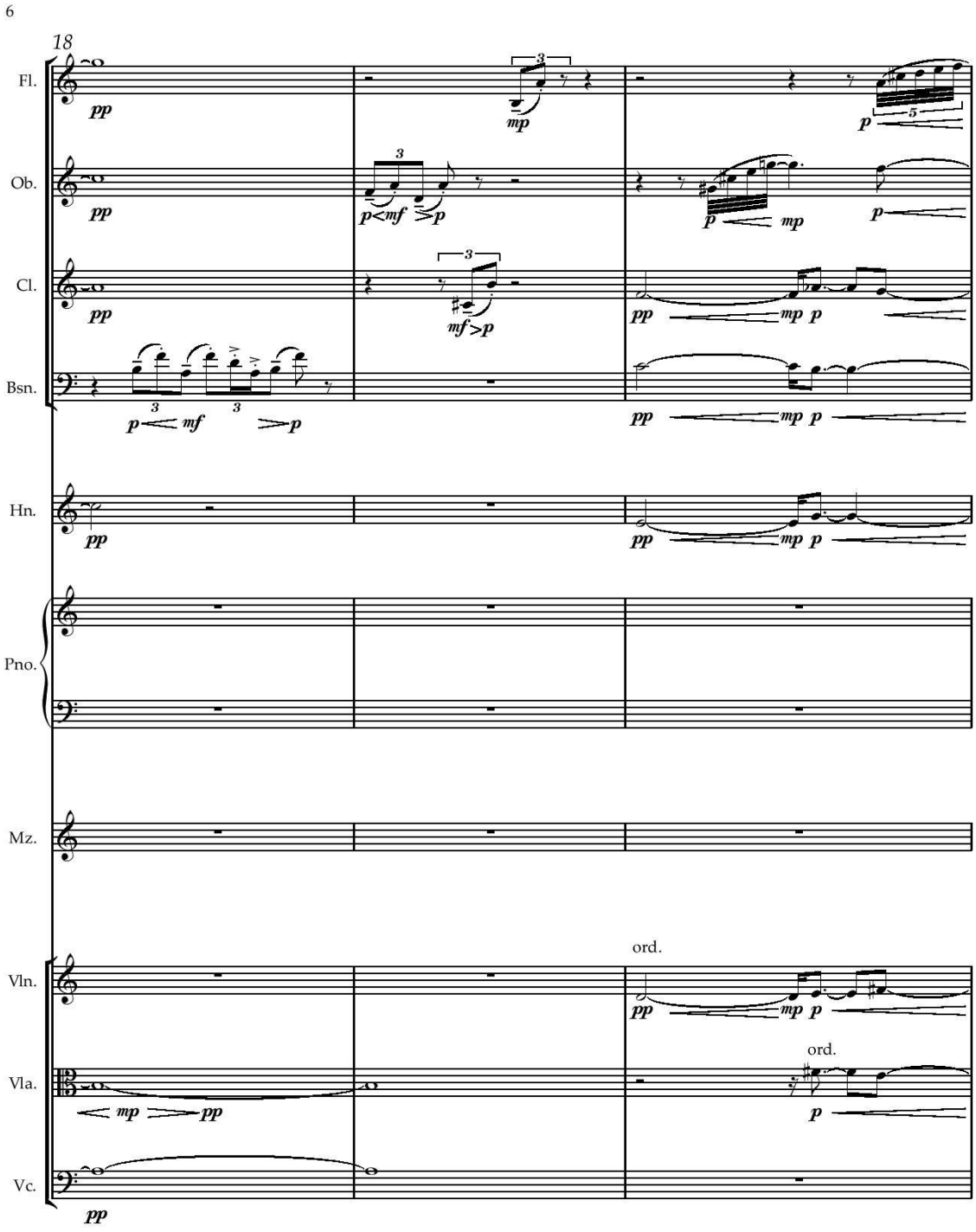
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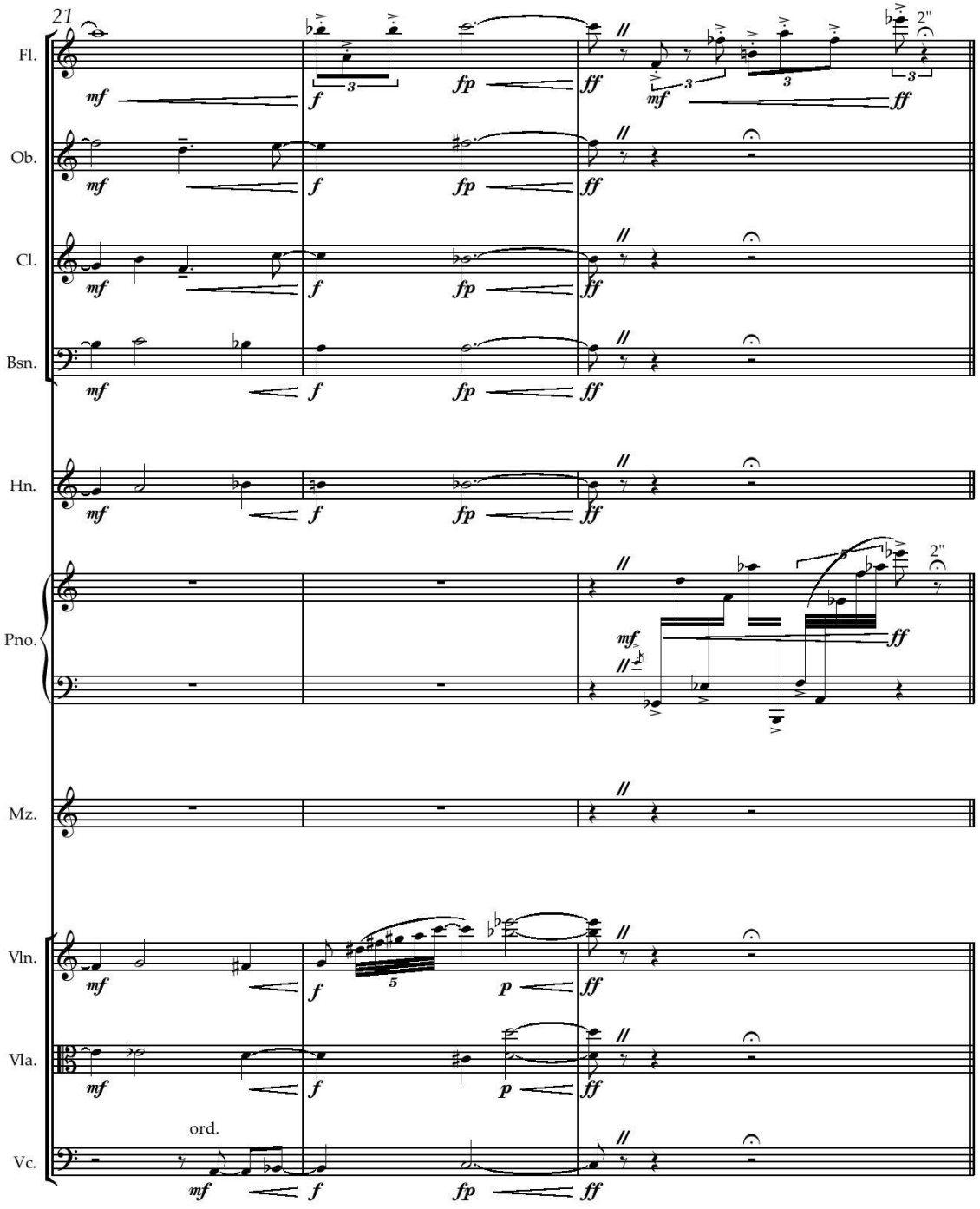
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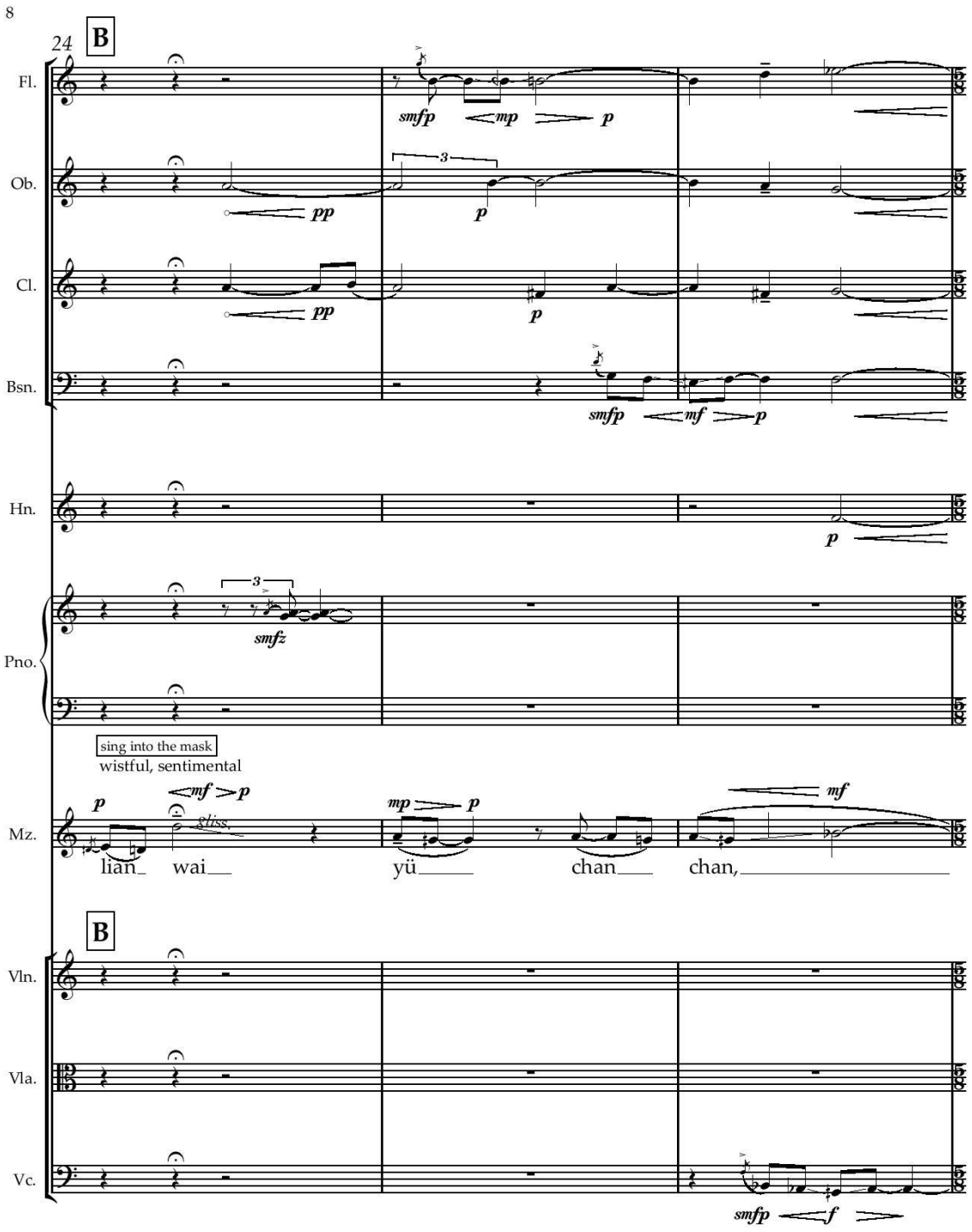
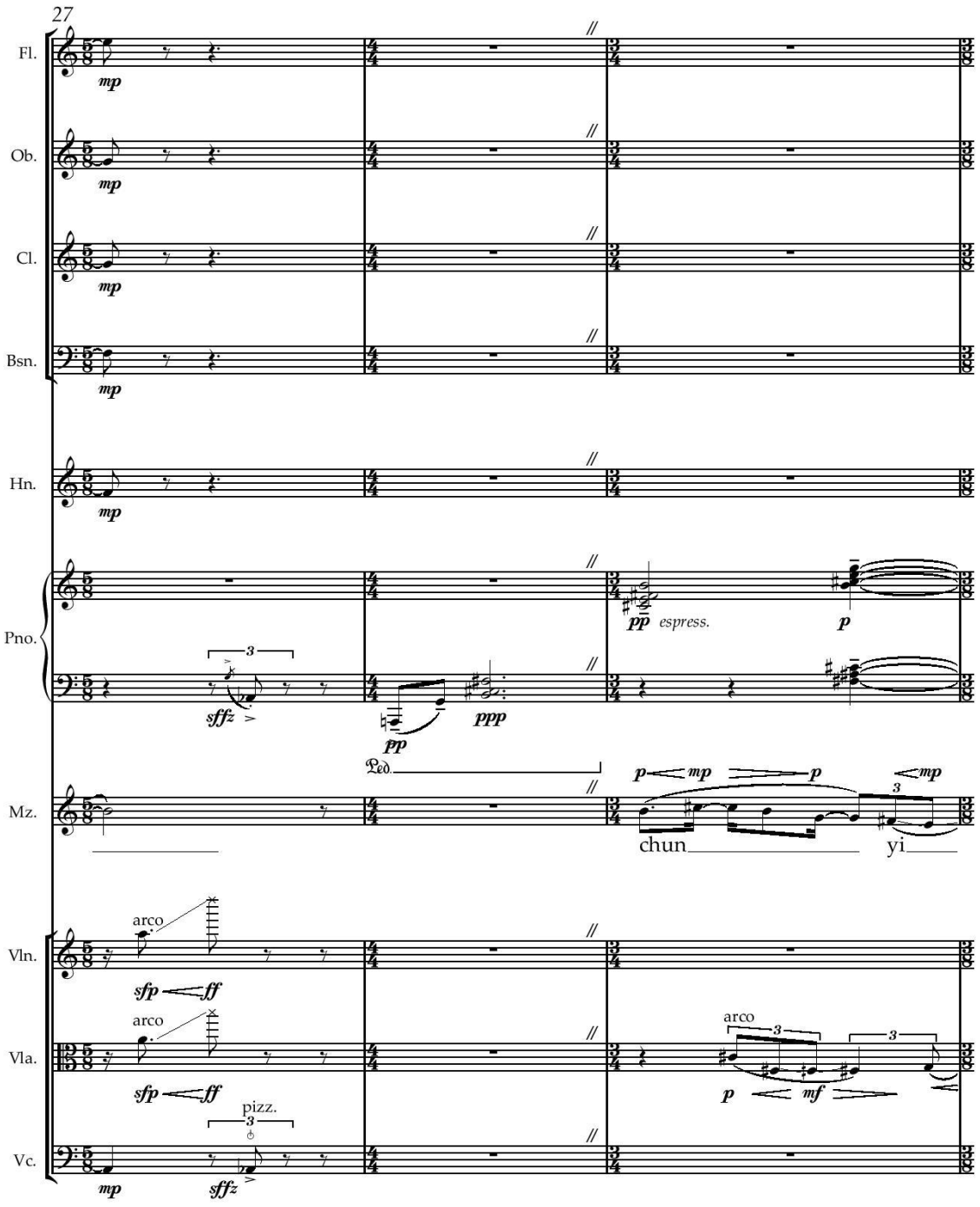
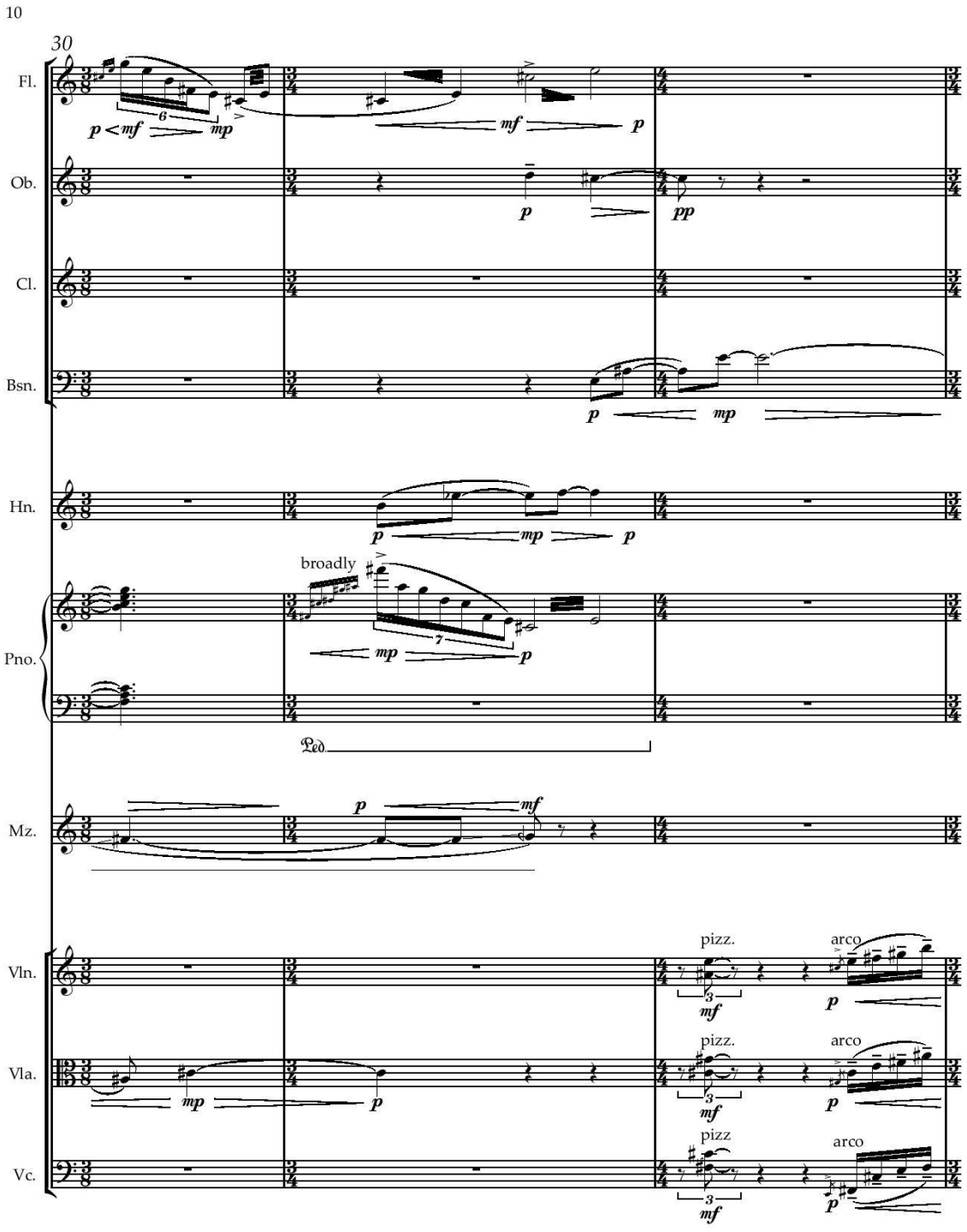
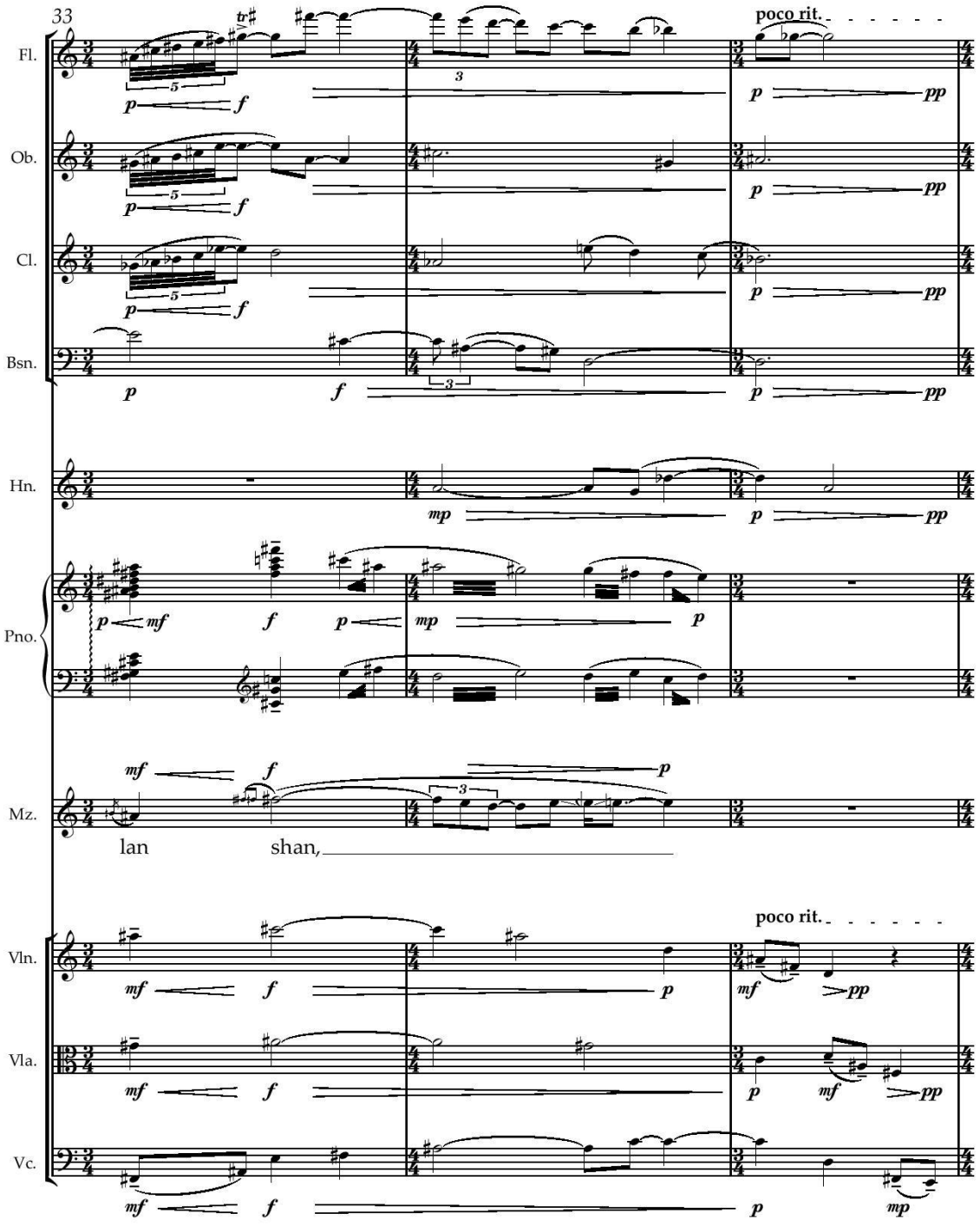
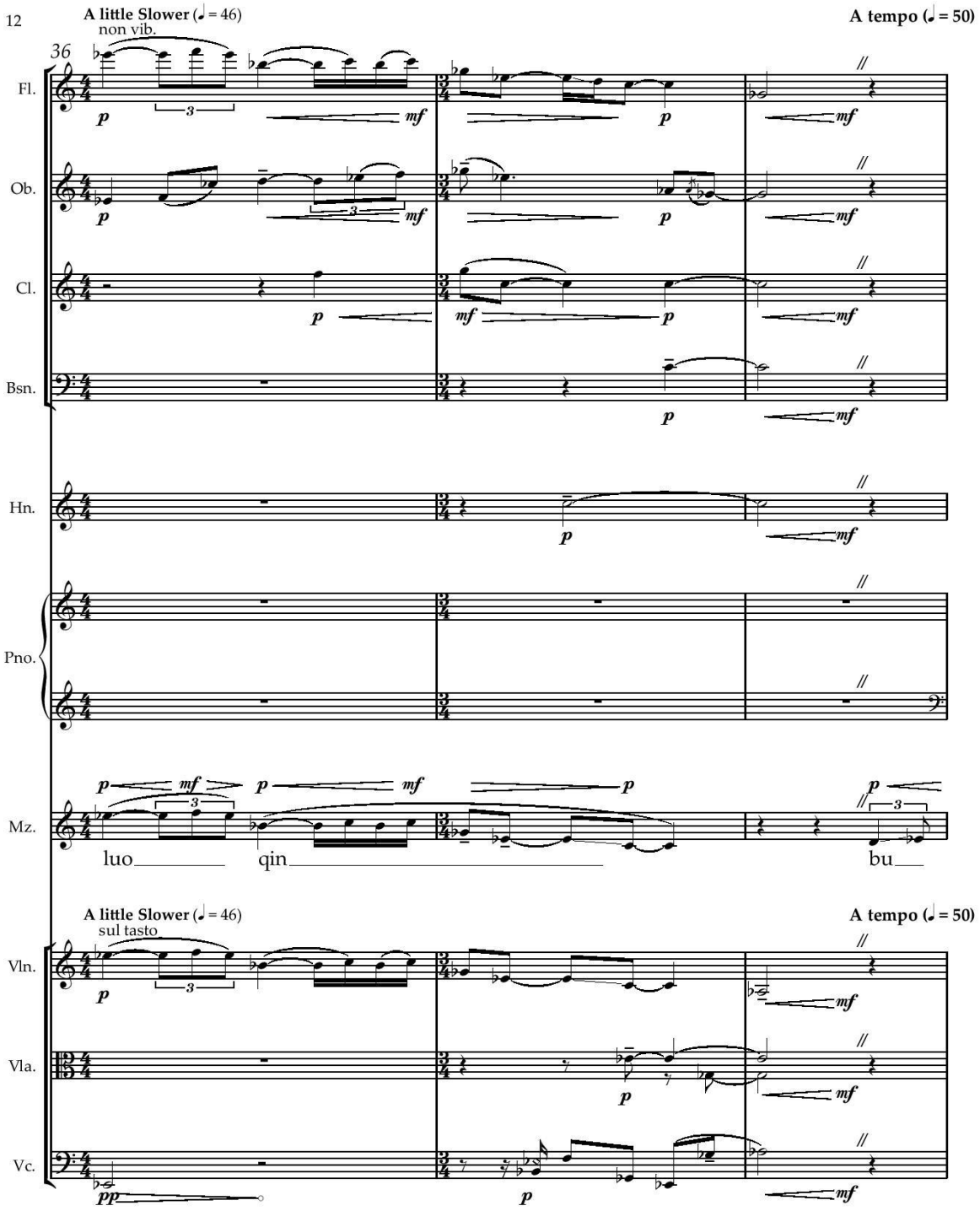
Pno.
Mz.
Vln.
Vla.
Vc.
ord.
2"
mf
f
fp
ff
p

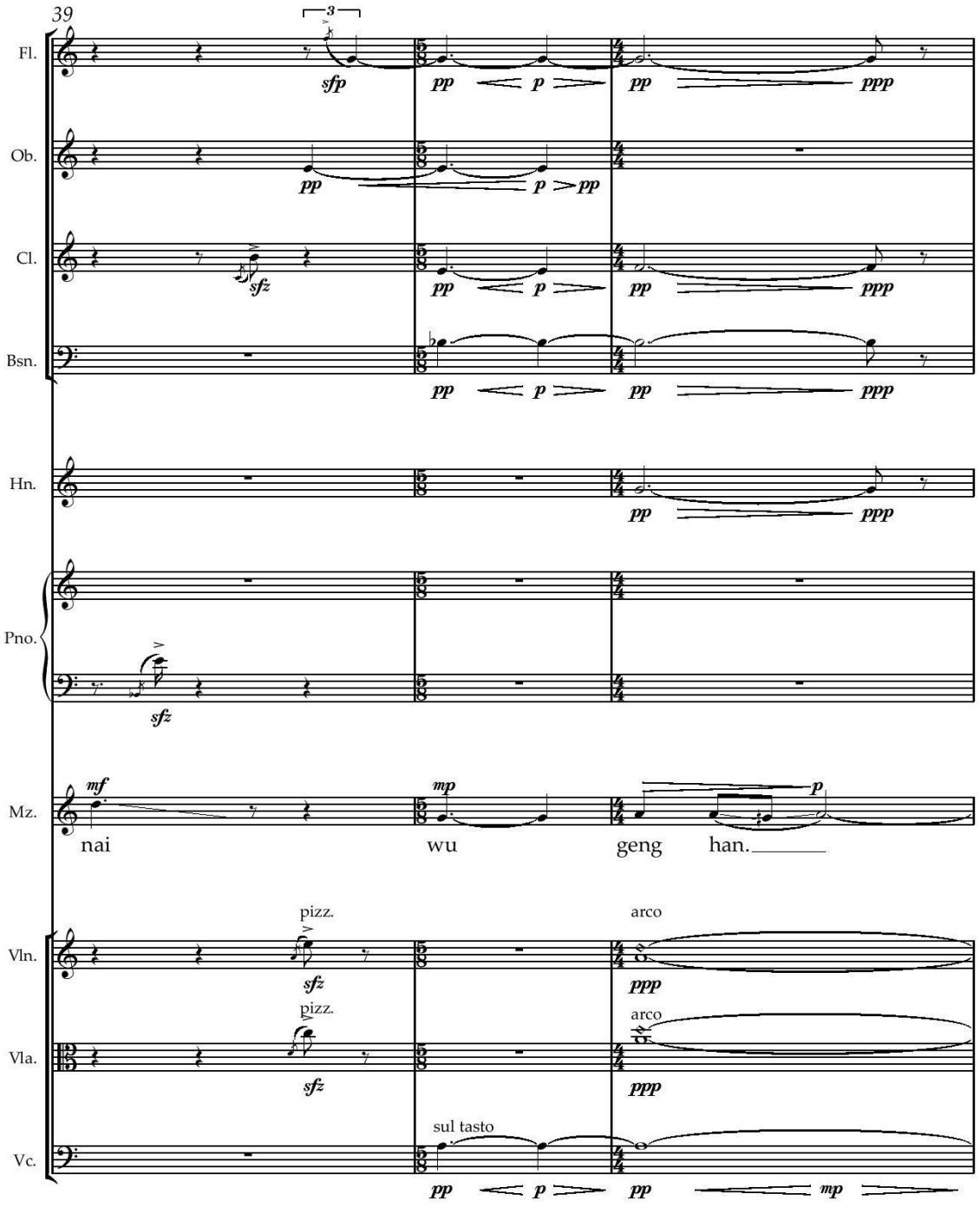

8
24
B
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
smfp
mp
p
pp
mf
smfz
sing into the mask
wistful, sentimental
gliss.
lian_ wai__ yü__ chan__ chan,

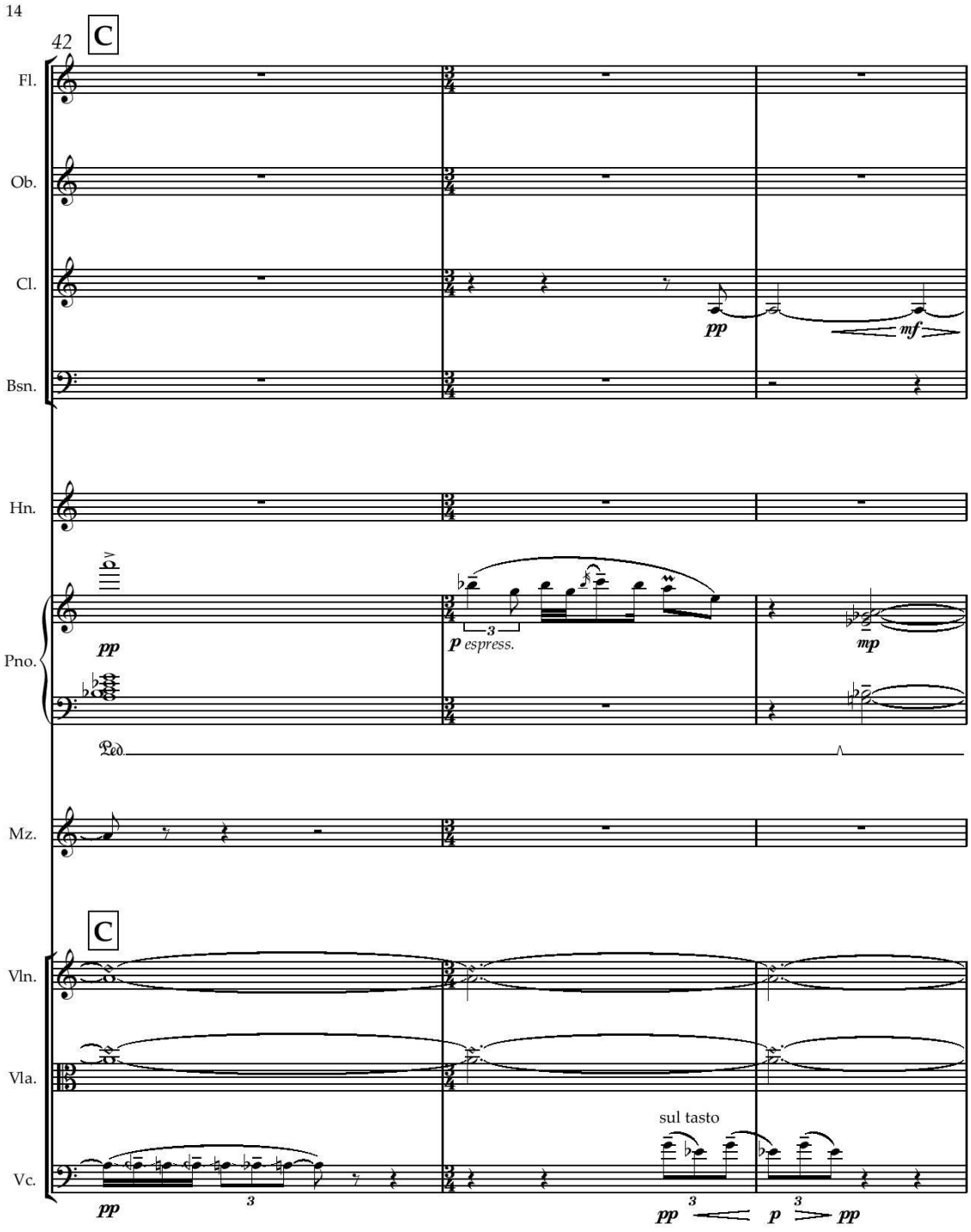

27
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
mp
sffz
pp
ppp
espress.
p
Ped.
mf
chun
yi
arco
sfp
ff
pizz.

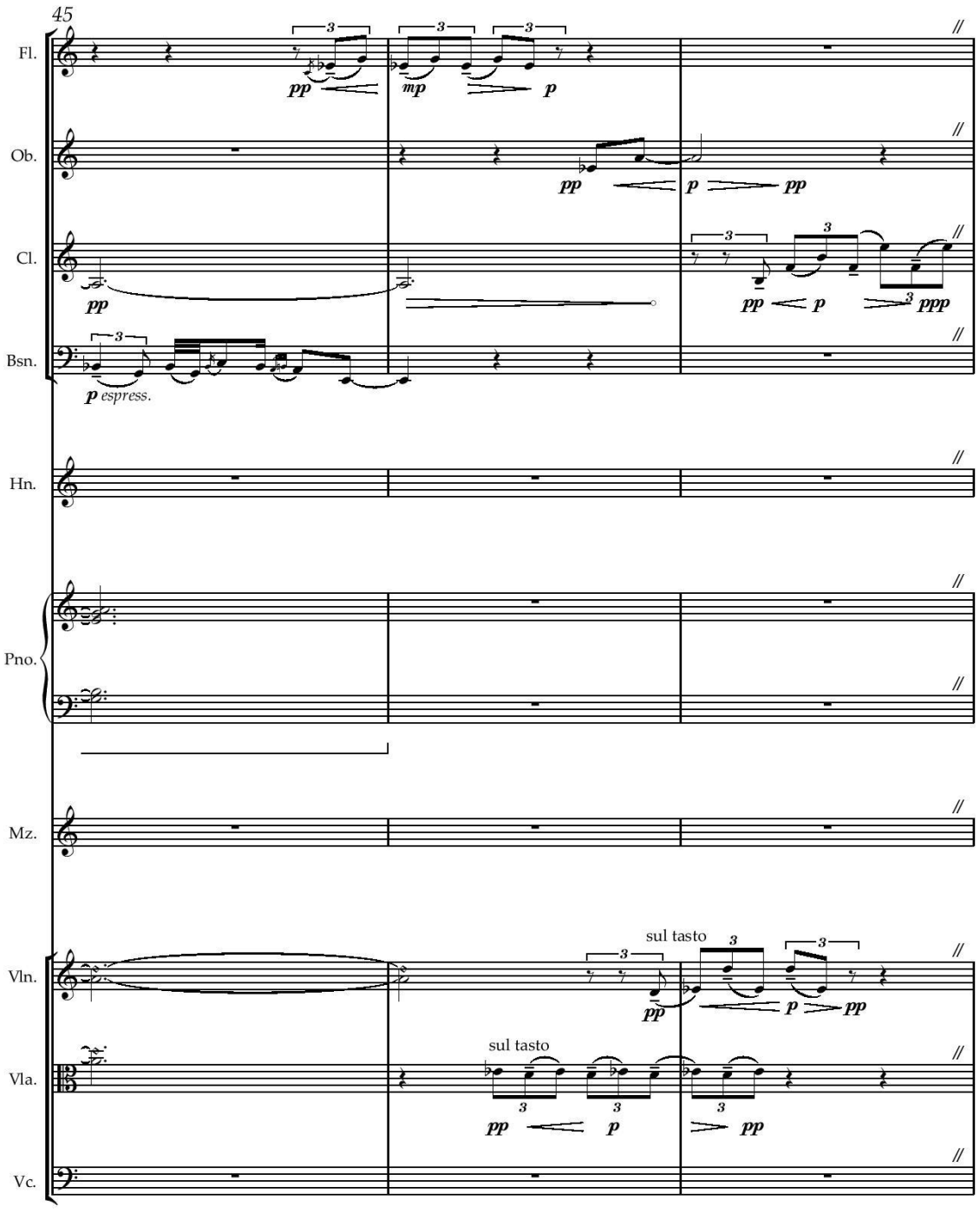

10
30
Fl.
Ob.
Cl.
Bsn.
Hn.
broadly
Pno.
Ped
Mz.
Vln.
Vla.
Vc.
pizz.
arco
pizz
arco

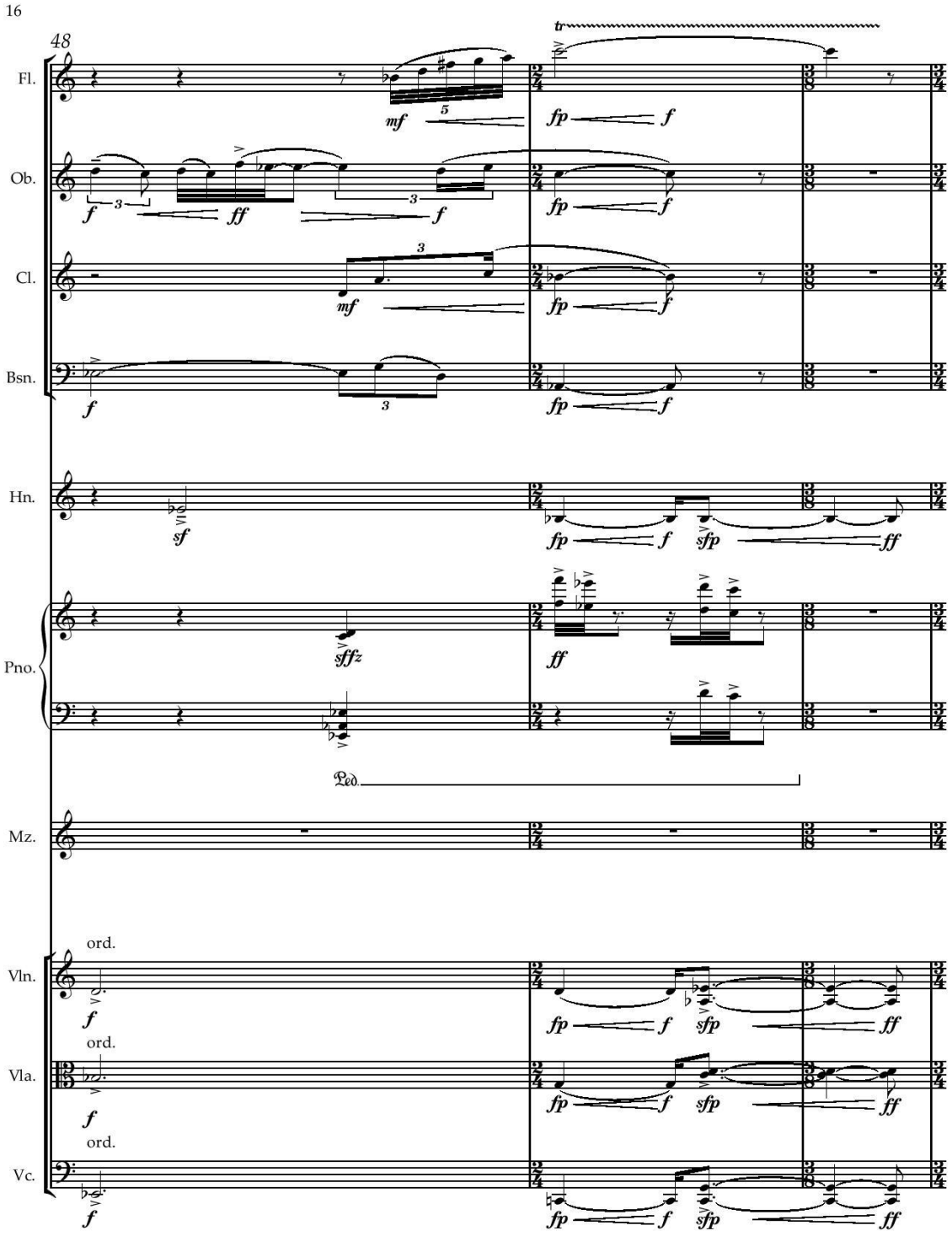

33
poco rit.
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
lan shan,
poco rit.
Vln.
Vla.
Vc.

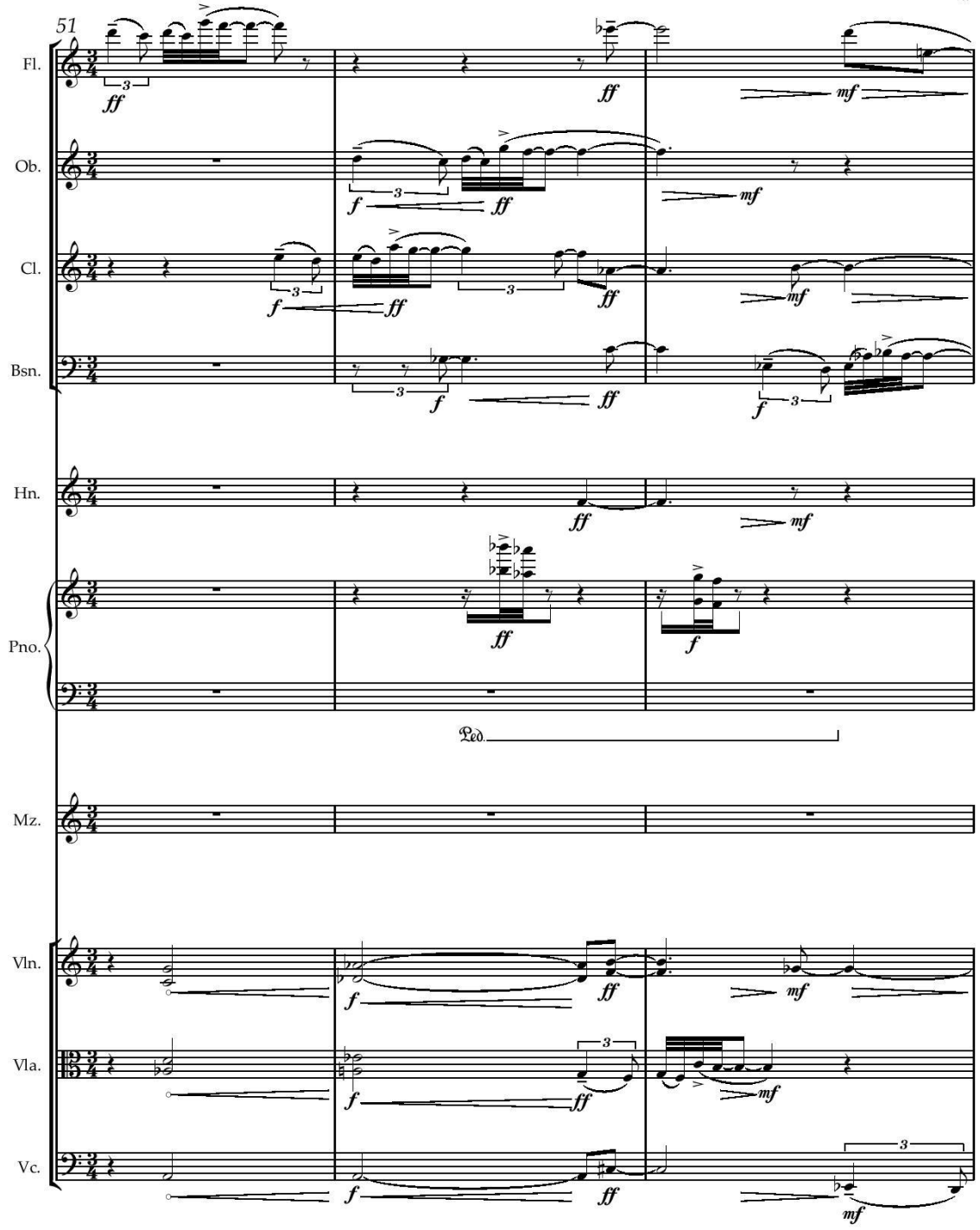

12
A little Slower (♩= 46)
non vib.
A tempo (♩= 50)
36
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
luo
qin
bu
A little Slower (♩= 46)
sul tasto
A tempo (♩= 50)
Vln.
Vla.
Vc.

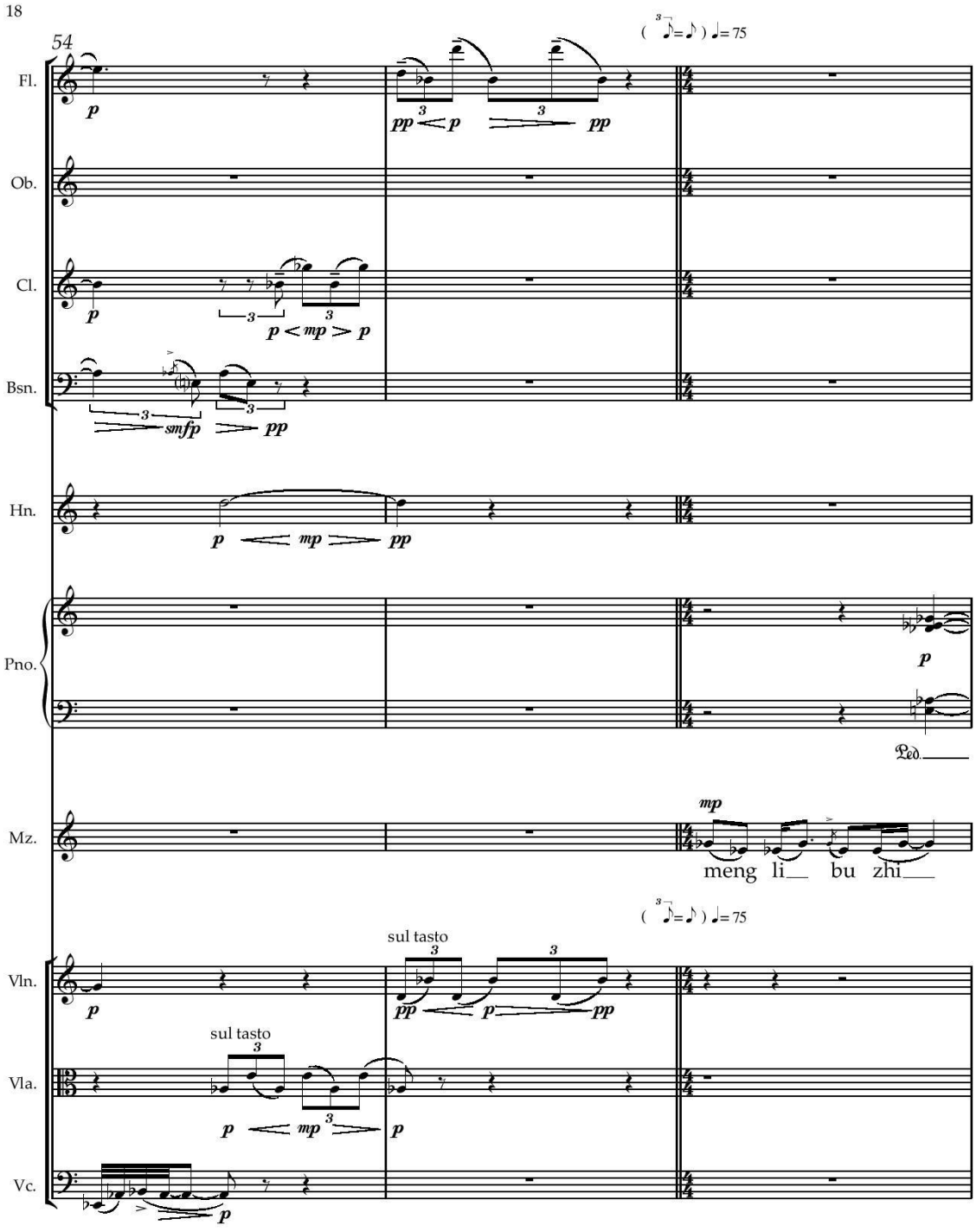

39
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
sfp
pp
p
ppp
sfz
mf
mp
nai
wu
geng
han.
pizz.
arco
sul tasto

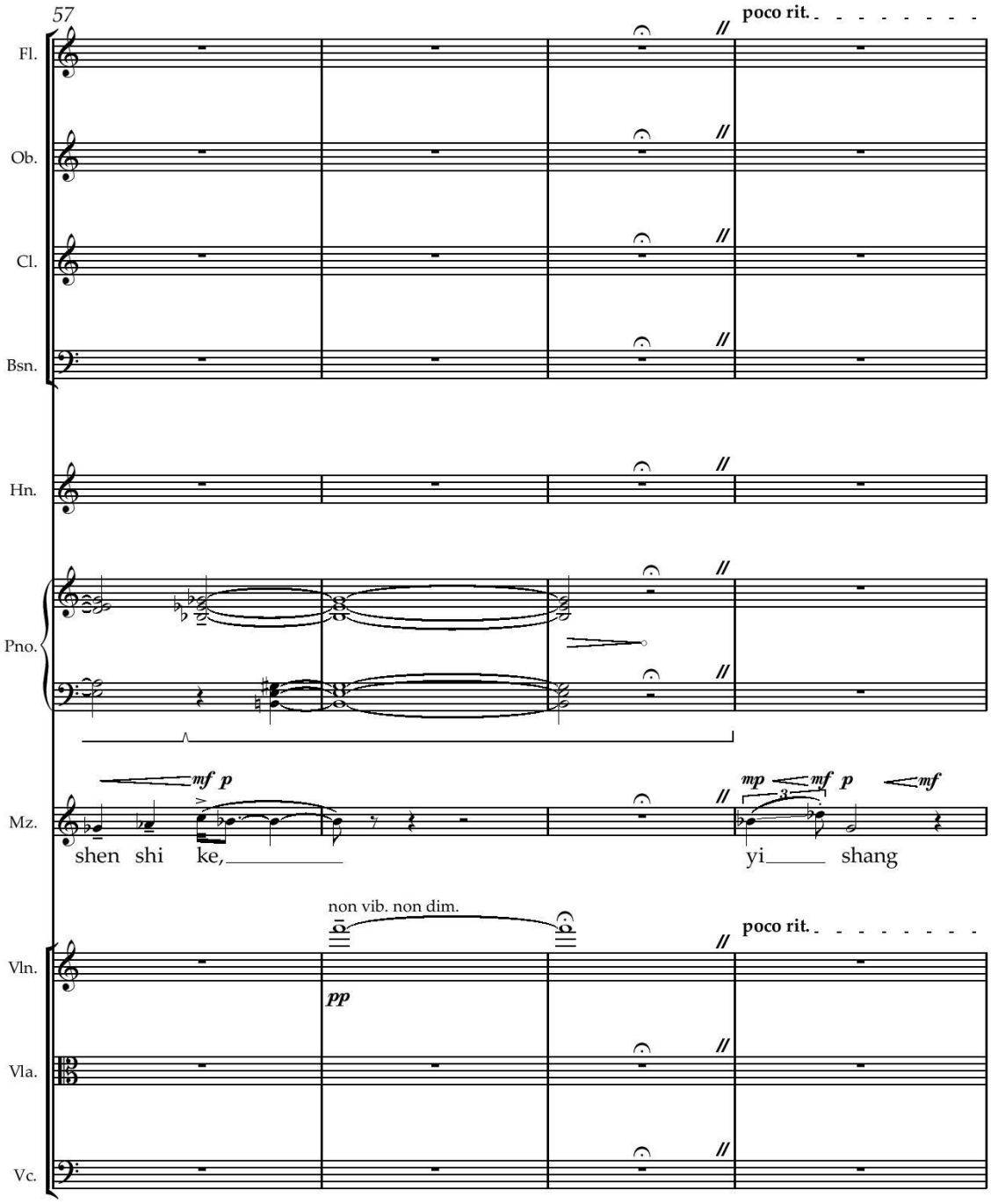

14
42
C
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
C
Vln.
Vla.
Vc.
pp
mf
p espress.
mp
sul tasto
pp
p
pp

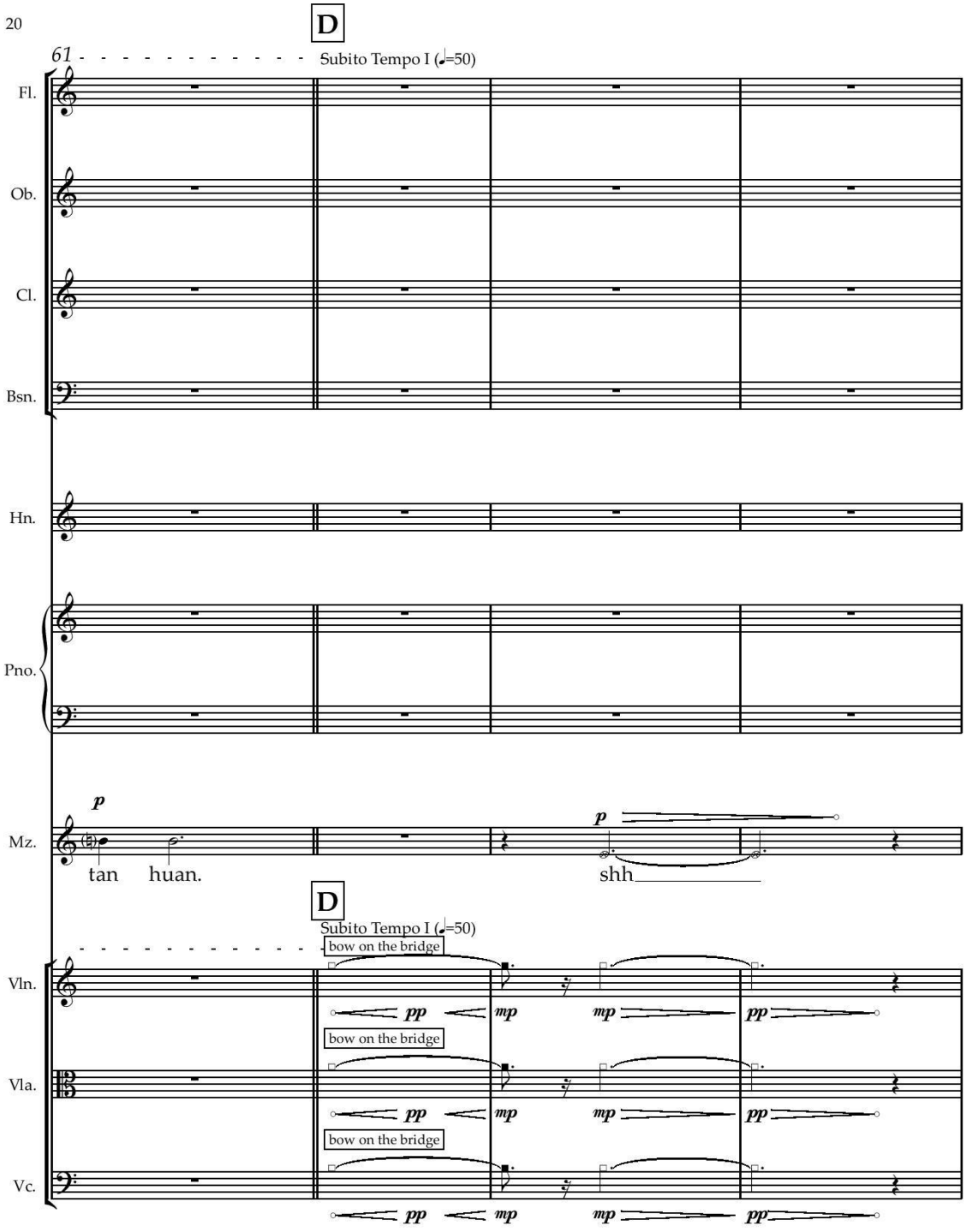

45
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
pp
mp
p
espress.
ppp
sul tasto

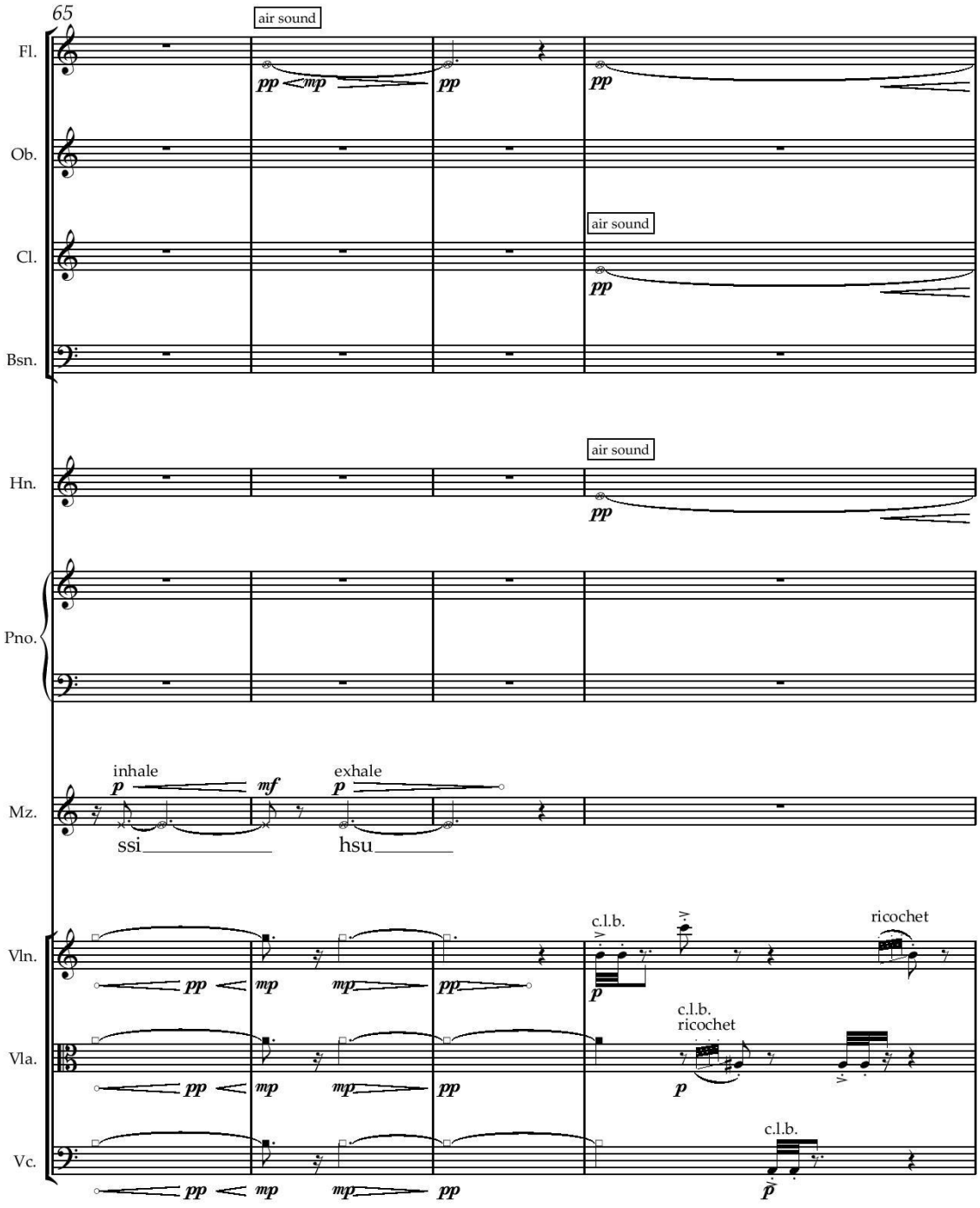

16
48
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
ord.
tr
Ped.

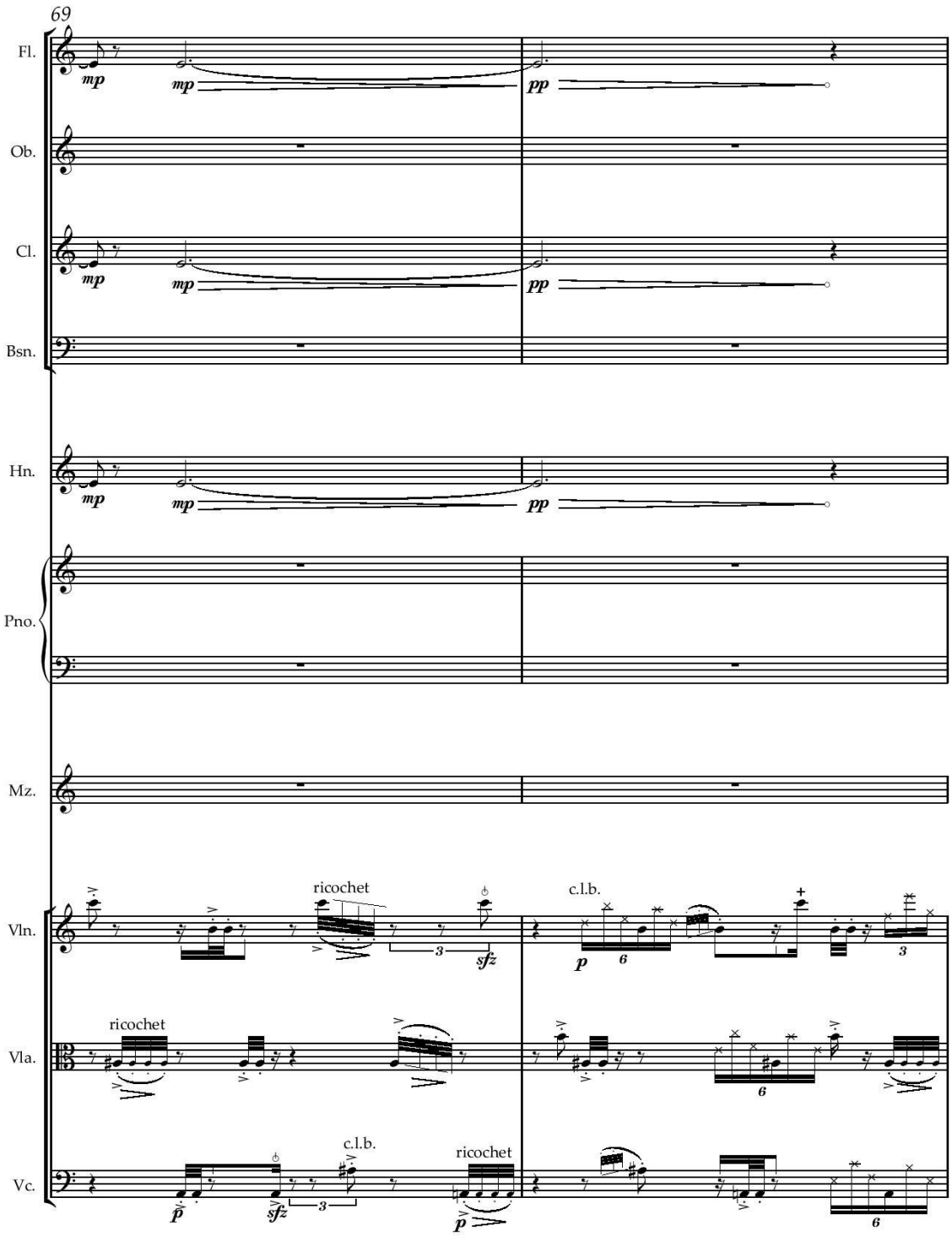

51
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
Ped.

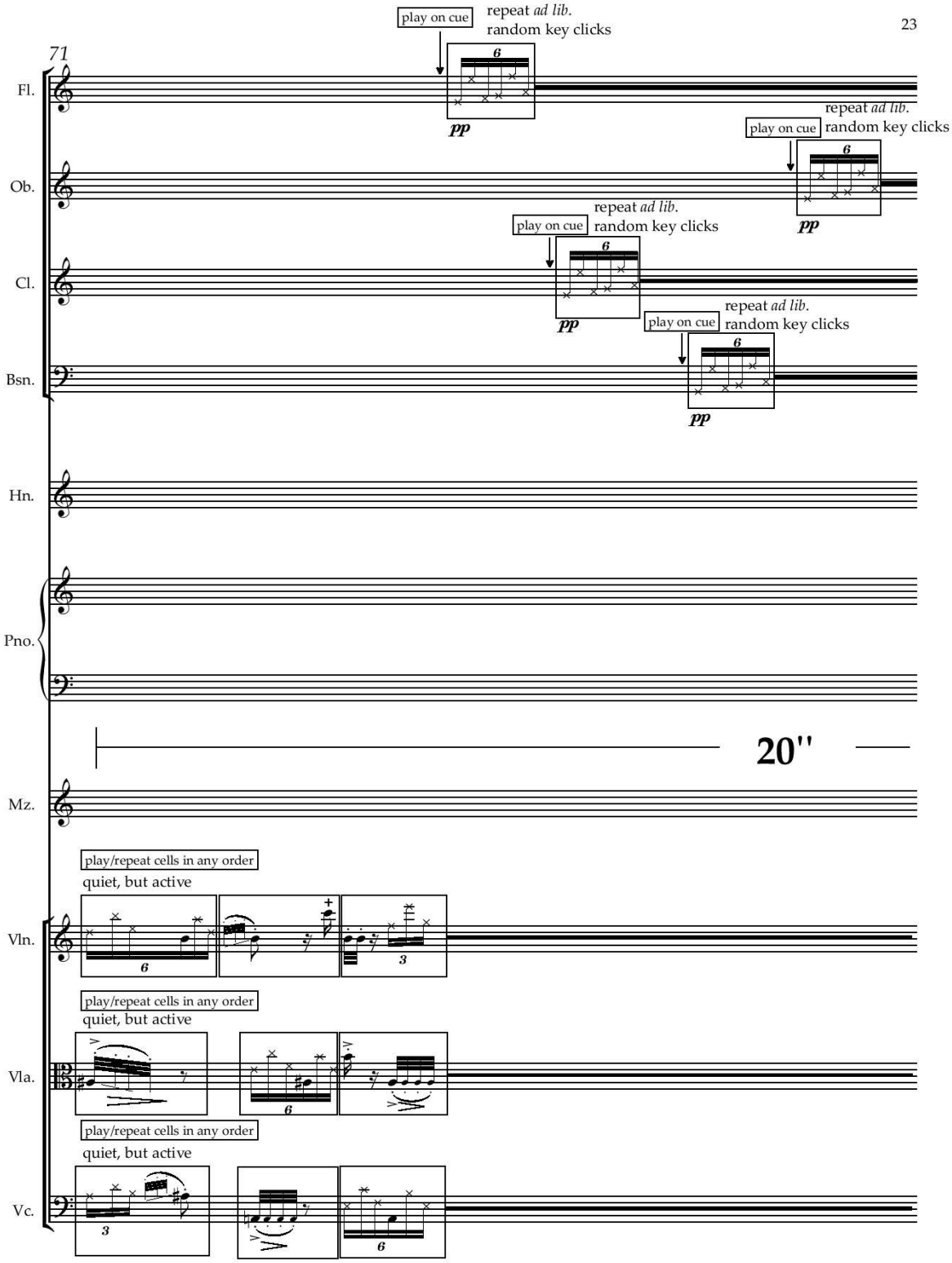

54
(♪= ♪) ♩= 75
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
meng li bu zhi
(♪= ♪) ♩= 75
sul tasto
sul tasto
Vln.
Vla.
Vc.


57
poco rit.
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
mf p
mp mf p mf
shen shi ke,
yi shang
non vib. non dim.
poco rit.
Vln.
pp
Vla.
Vc.

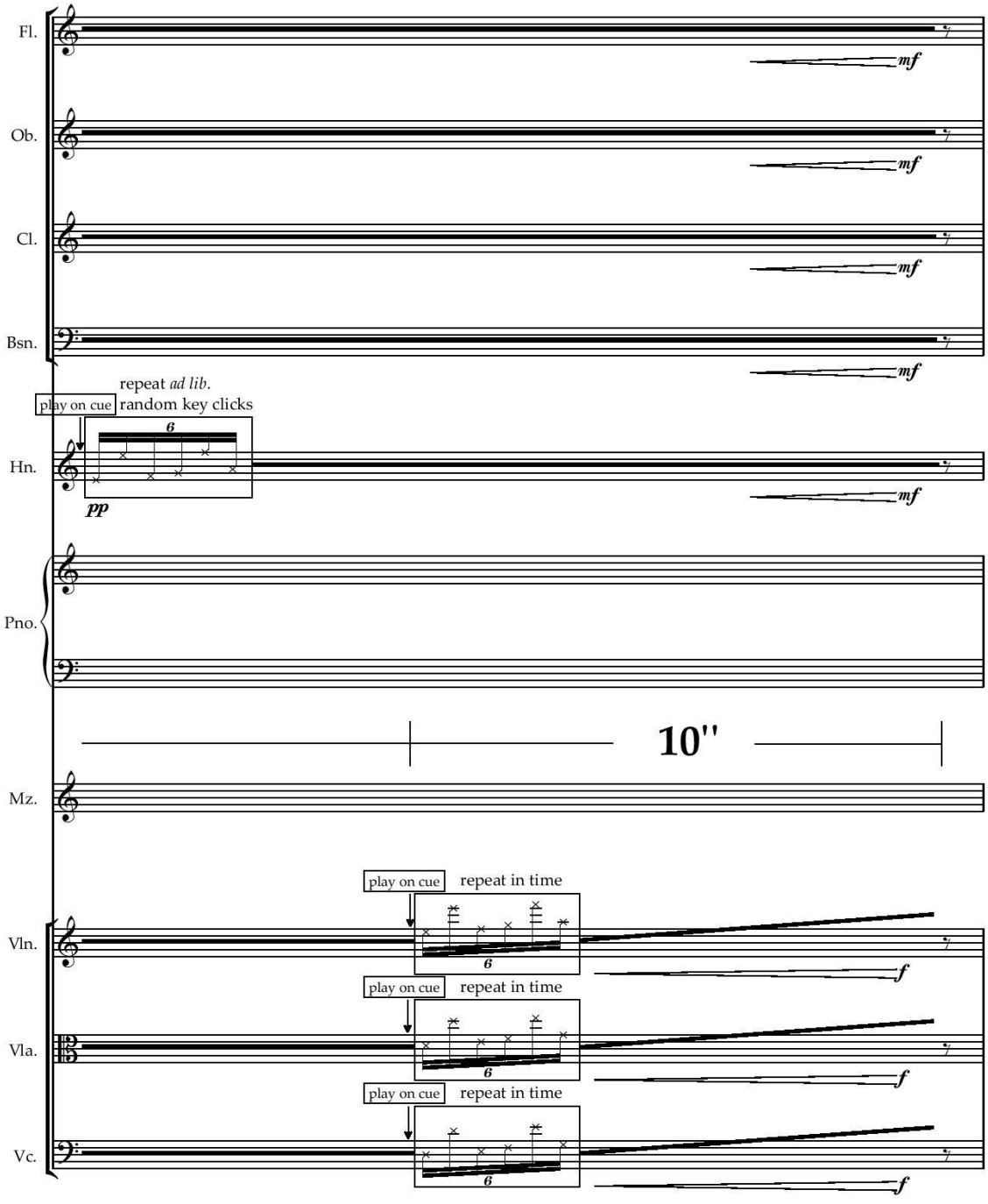

20
D
61
Subito Tempo I (♩=50)
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
p
tan huan.
p
shh
D
Subito Tempo I (♩=50)
bow on the bridge
Vln.
pp mp mp pp
bow on the bridge
Vla.
pp mp mp pp
bow on the bridge
Vc.
pp mp mp pp

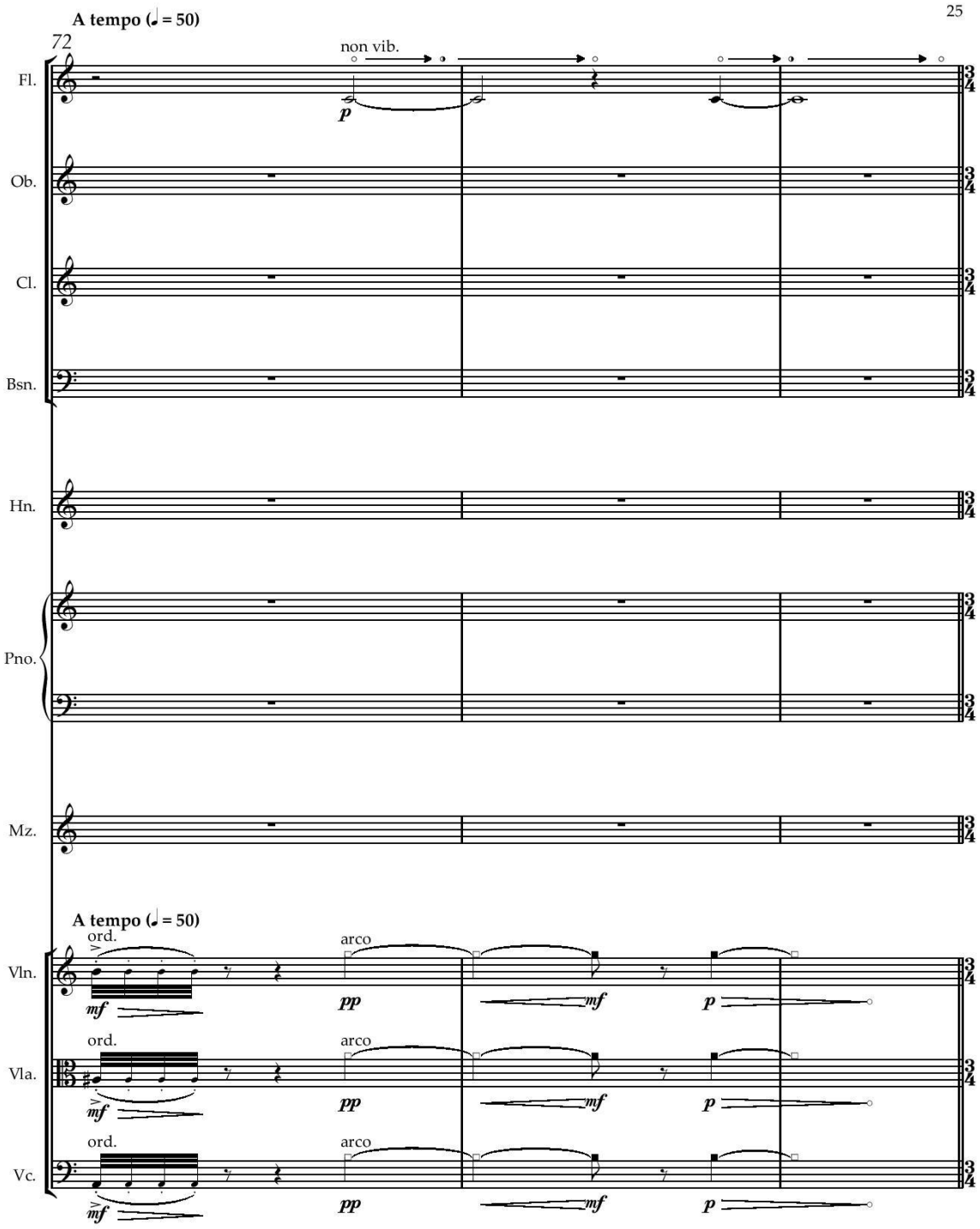

65
air sound
Fl.
Ob.
Cl.
Bsn.
air sound
Hn.
air sound
Pno.
Mz.
inhale
exhale
ssi
hsu
Vln.
Vla.
Vc.
c.l.b.
ricochet
c.l.b.
ricochet
c.l.b.

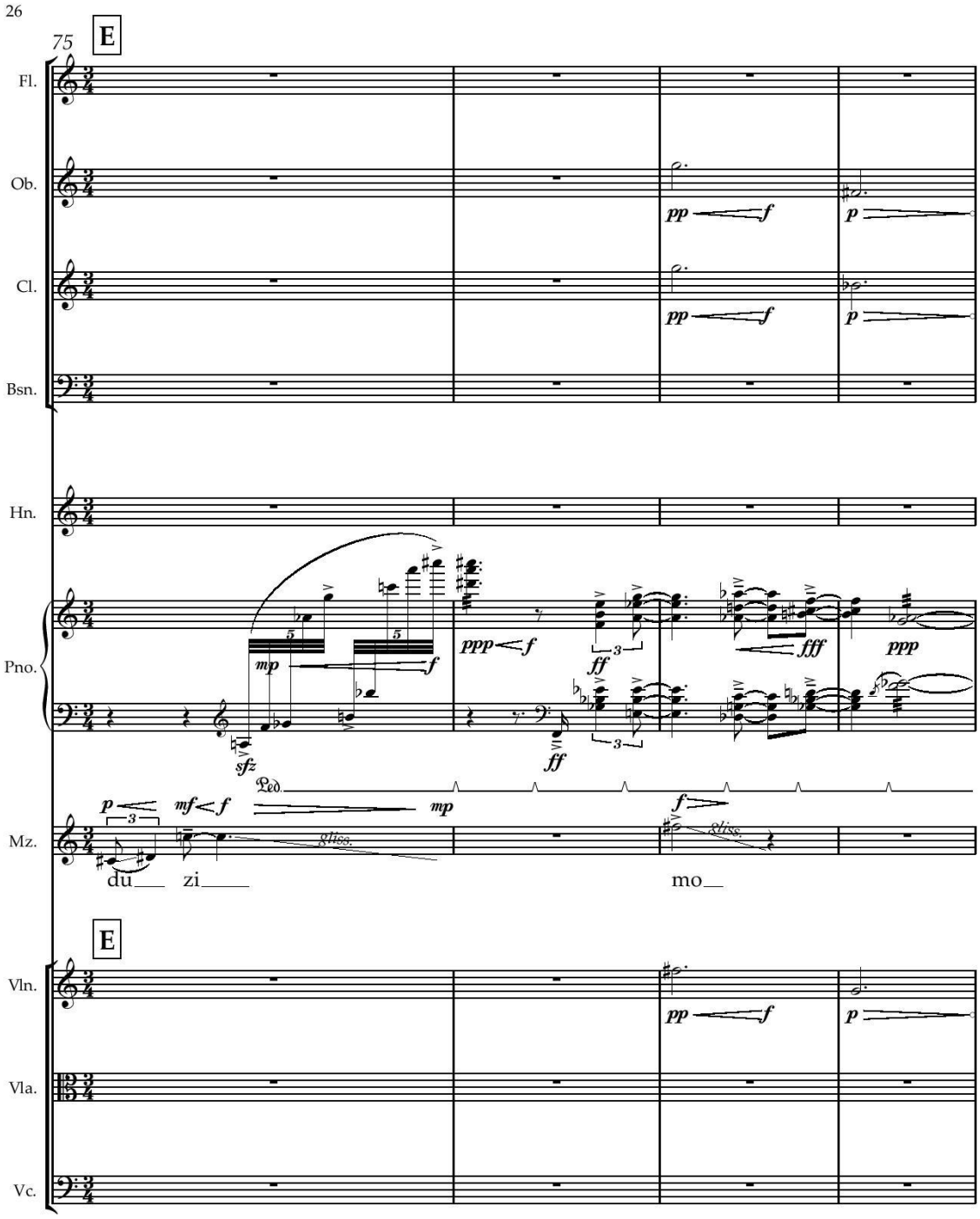

69
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
mp
pp
ricochet
c.l.b.
sfz
p

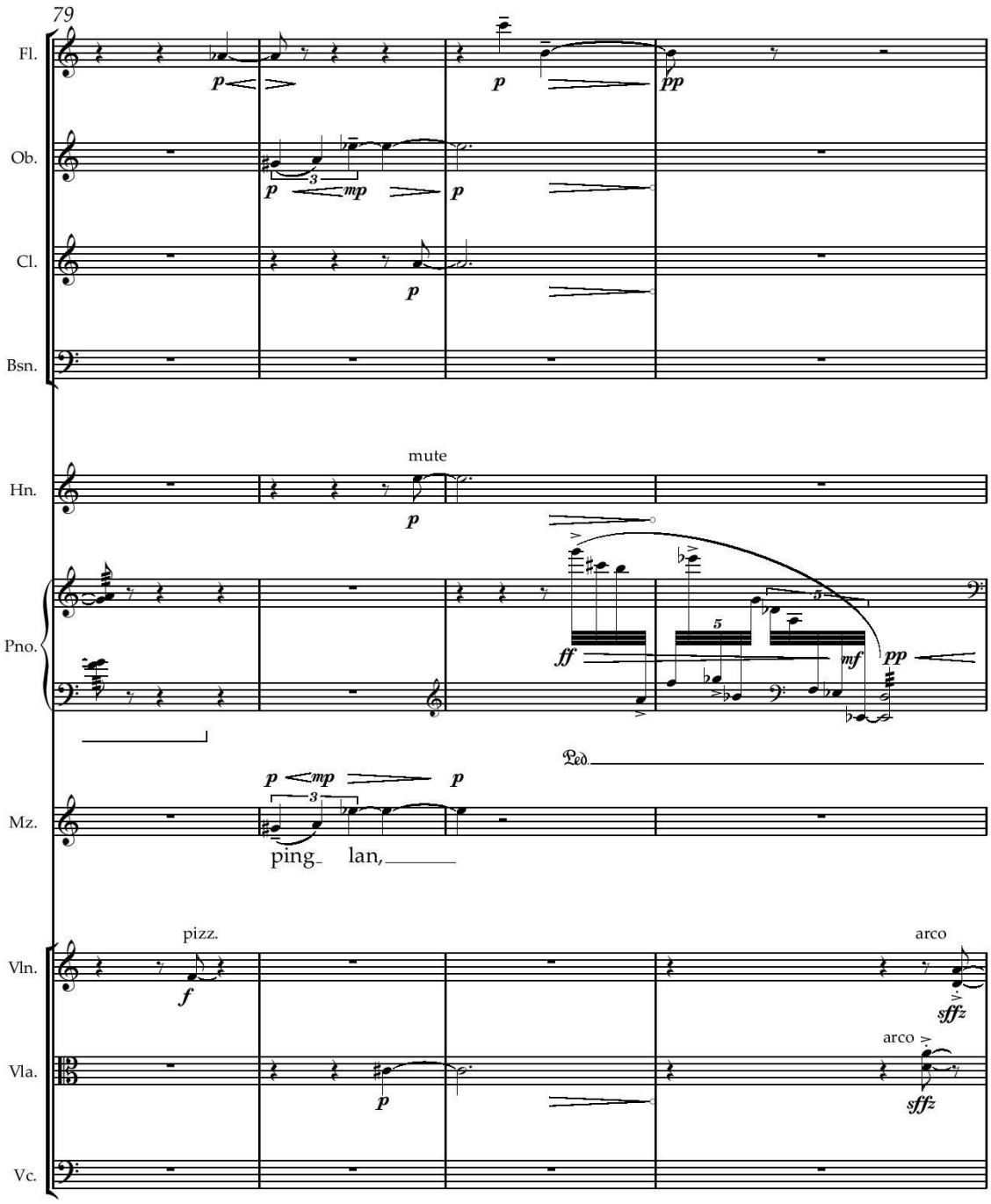

71
Fl.
play on cue
repeat ad lib.
random key clicks
pp
Ob.
play on cue
repeat ad lib.
random key clicks
pp
Cl.
play on cue
repeat ad lib.
random key clicks
pp
Bsn.
play on cue
repeat ad lib.
random key clicks
pp
Hn.
Pno.
20''
Mz.
play/repeat cells in any order
quiet, but active
Vln.
play/repeat cells in any order
quiet, but active
Vla.
play/repeat cells in any order
quiet, but active
Vc.

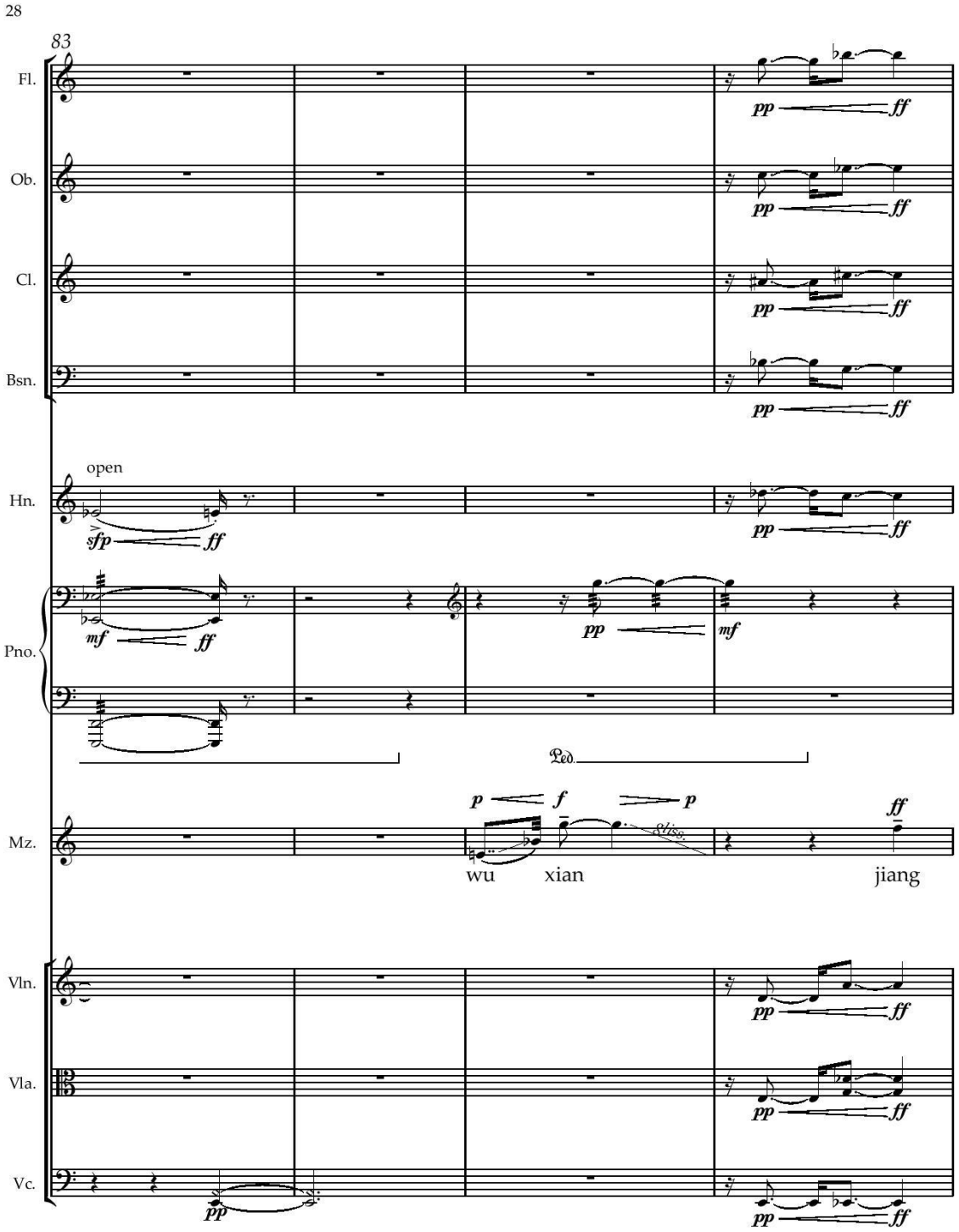
24

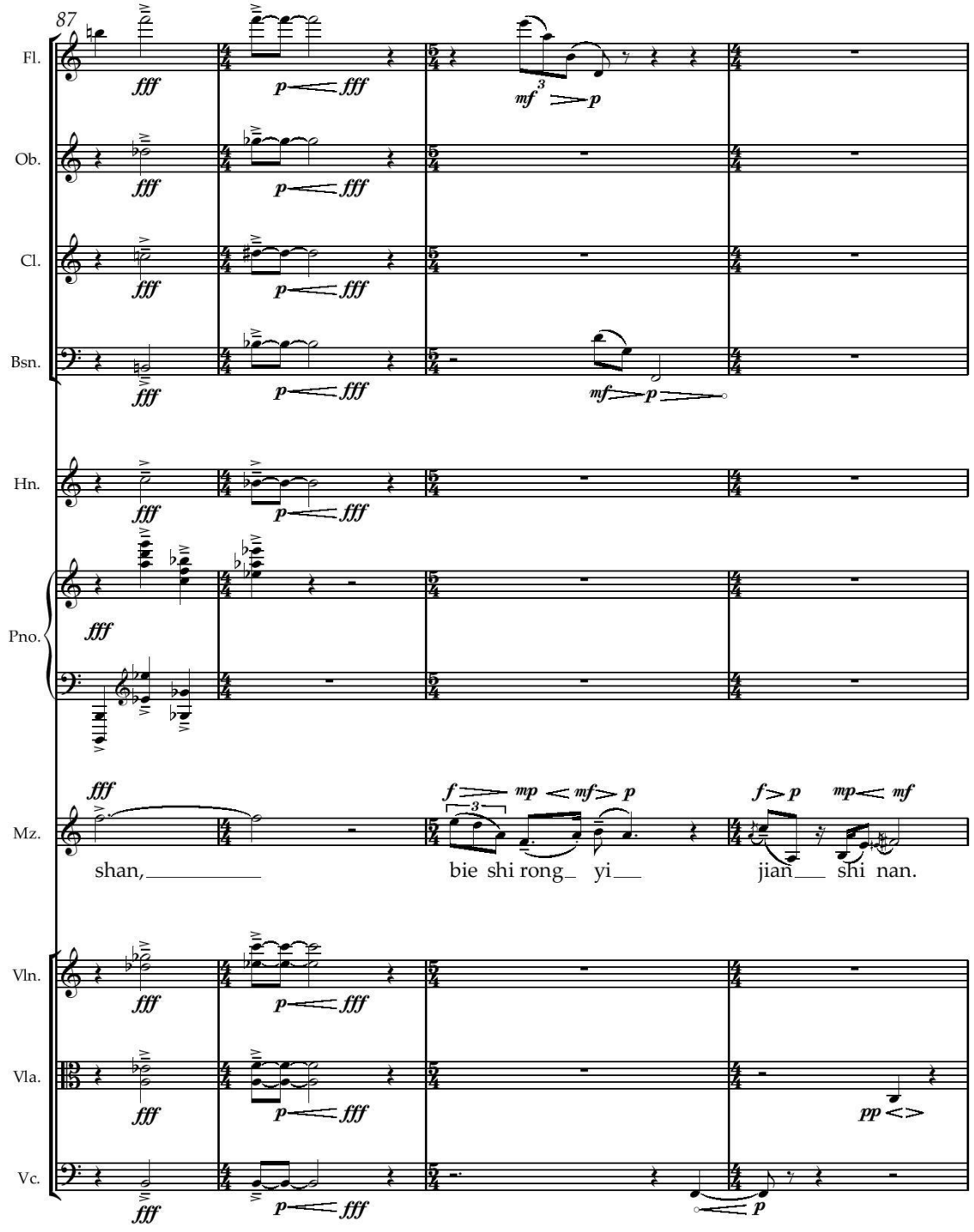

Fl.
Ob.
Cl.
Bsn.
mf
repeat ad lib.
play on cue
random key clicks
Hn.
pp
Pno.
10"
Mz.
play on cue
repeat in time
Vln.
f
Vla.
Vc.

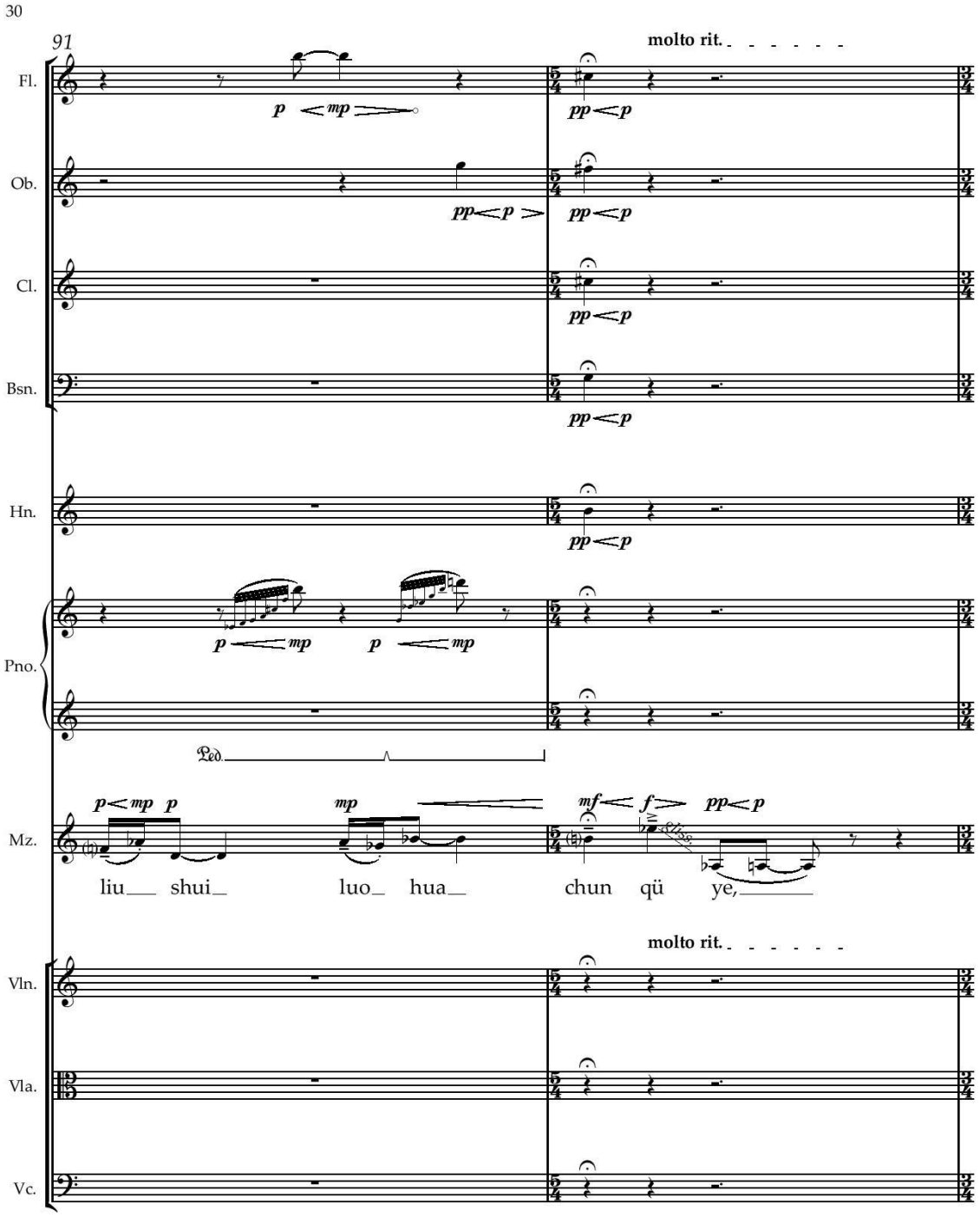

A tempo (♩ = 50)
72
non vib.
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
A tempo (♩ = 50)
ord.
arco
Vln.
Vla.
Vc.
mf
pp
mf
p

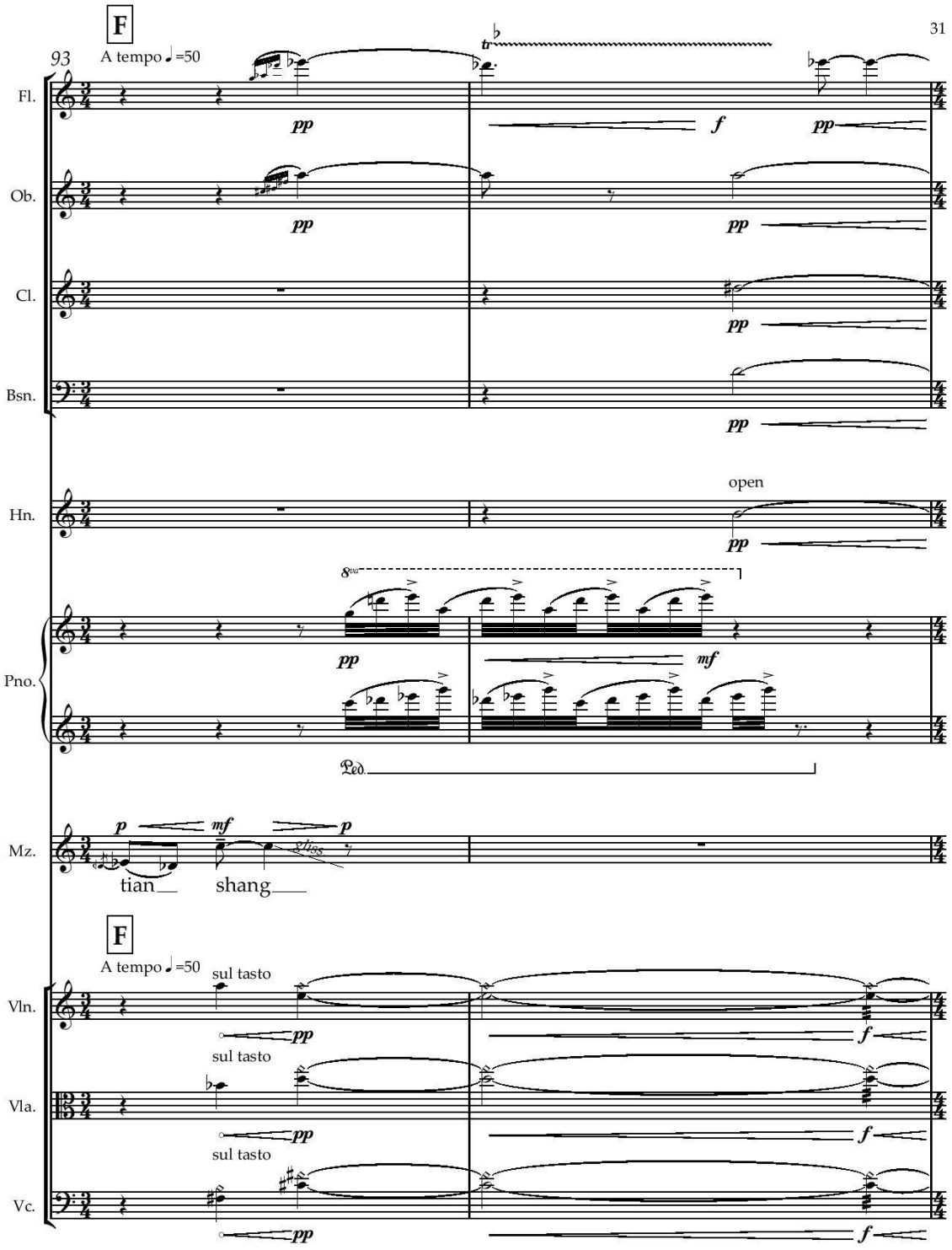

26
75
E
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
pp
f
p
ppp
ff
fff
mp
sfz
mf
gliss.
du
zi
mo

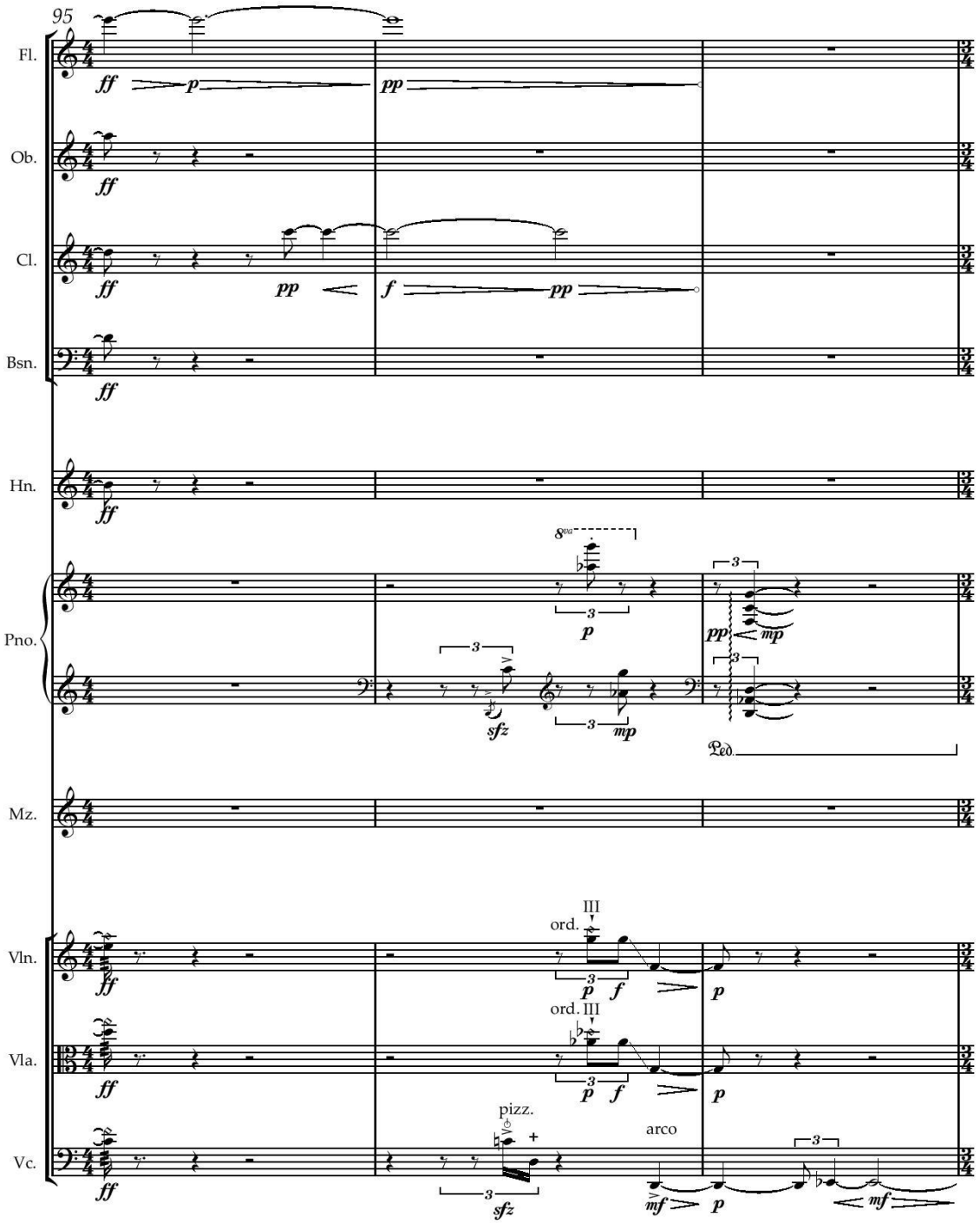

79
Fl.
Ob.
Cl.
Bsn.
Hn.
mute
Pno.
Mz.
ping_ lan,
Vln.
pizz.
arco
Vla.
arco
Vc.

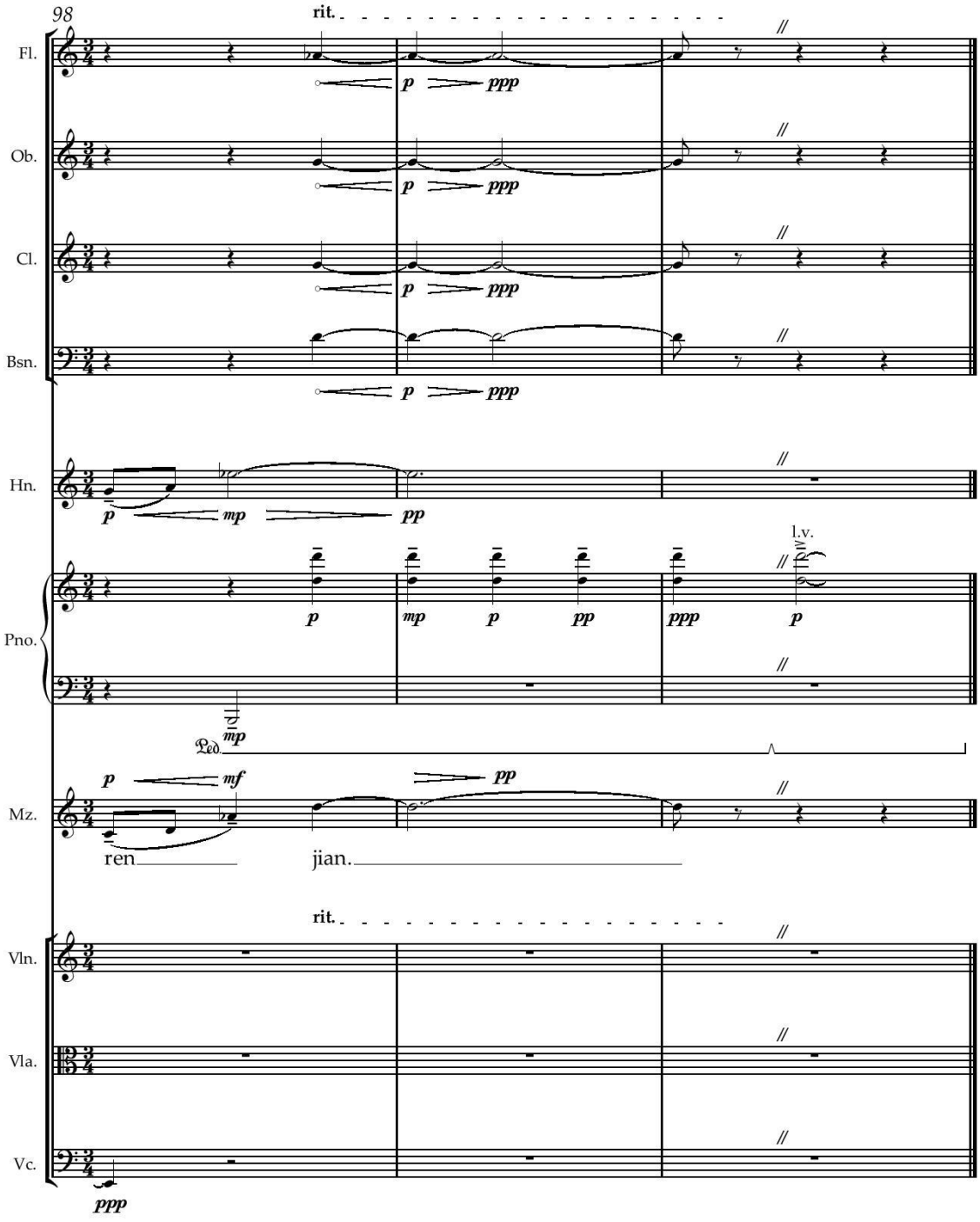

28
83
Fl.
Ob.
Cl.
Bsn.
Hn.
open
Pno.
Mz.
wu
xian
jiang
Vln.
Vla.
Vc.


87
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
fff
p
mf
pp
f
mp
shan,
bie shi rong yi
jian shi nan.


30
91
molto rit.
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
liu shui luo hua chun qü ye,
molto rit.
Vln.
Vla.
Vc.


F
93
A tempo ♩=50
31
Fl.
Ob.
Cl.
Bsn.
Hn.
open
Pno.
Ped.
Mz.
tian
shang
F
A tempo ♩=50
Vln.
Vla.
Vc.
sul tasto


95
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
Mz.
Vln.
Vla.
Vc.
ff
p
pp
f
mp
sfz
mf
ord.
III
pizz.
arco
Ped.


98
rit.
Fl.
Ob.
Cl.
Bsn.
Hn.
Pno.
l.v.
Mz.
ren
jian.
rit.
Vln.
Vla.
Vc.