Studies for the Second Womb

for tenor saxophone, violoncello, and live electronics

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Abstract

Studies for the Second Womb is a mixed piece written for tenor saxophone and violoncello with live electronics. As scientific research shows, fetuses can begin to hear sounds around 20 weeks of gestation. The conceptual idea behind this piece is to recreate the very first hearing experience of human beings, which happens inside a matrix, or more precisely the womb. To contrive this idea not only conceptually but also symbolically, some musical materials such as pitches are determined by chemical research on human amniotic fluid, via a self-made CAC (computer-assisted composition) Max patch to convert parameters from NMR spectroscopy to sound spectrum. Benefiting from the surround sound system, the live-processed sounds of two instruments with fixed media will be diffused to simulate an immersive, enclosed, acoustic space like a womb, featuring sounds of water, low pulsation, and breath.

Résumé

Études pour le second ventre est une œuvre mixte écrite pour saxophone ténor et violoncelle avec des traitement en temps réel. Comme le montrent les recherches scientifiques, les fœtus peuvent commencer à entendre des sons vers 20 semaines de gestation. L'idée conceptuelle derrière cette pièce est de recréer la toute première expérience auditive des êtres humains, qui se produit à l'intérieur d'une matrice, ou plus précisément l'utérus. Pour concrétiser cette idée non seulement conceptuellement mais aussi symboliquement, certains éléments musicaux tels que les hauteurs et les rythmes seront déterminés par des recherches chimiques sur le liquide amniotique humain, grâce à un patch Max d'aide à la musique assistée par ordinateur (MAO) auto-construit pour convertir les paramètres entre la spectroscopie RMN1 et le spectre sonore. En bénéficiant du système de son ambisonie, les sons en direct des deux instruments, le saxophone ténor et le violoncelle, ainsi que certains fichiers sonores électroniques, seront diffusés pour simuler un espace acoustique immersif et clos comme un ventre, avec des sons d'eau, de basse pulsation et d'écho.

Acknowledgement

The realization of this work owes much to several esteemed individuals I've had the privilege to encounter on this journey:

Foremost, I extend my deepest gratitude to Philippe Leroux, my supervisor and mentor. His unwavering guidance and consistent encouragement throughout my studies at McGill have been invaluable for me. I am thankful for his inspiring conversations, rigorous critiques and consisting trust in me and my music.

Sean Ferguson, my teacher of electronic music. It was under his tutelage during a seminar that I first became acquainted with the concept of CAC (computer-assisted composition). This notion significantly influenced the compositional process in this project. Moreover, the knowledge of live electronics that I learned and applied to this project is a testament to his guidance.

Audréanne Filion and Antonin Bourgault, the performers for this project, are both talented musicians and composers themselves. I collaborated extensively with them before the actual composition began, and they provided invaluable inspiration and confidence in my approach to instrumental writing.

Last but not least, my dearest family. Their unconditional love and support have been the most precious thing for me while being so far away from home. This thesis is dedicated to you.

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Introduction

Studies for the Second Womb is a mixed piece written for tenor saxophone, violoncello, and live electronics in 2023, with a duration of approximately 14 minutes. This piece stands as a pivotal milestone in my compositional journey, marking the culmination of nearly a decade's immersion in music composition and a subsequent two-year deep dive into the realm of electronic music. The primary objective of this thesis is two-fold: to elucidate the aesthetic principles underpinning my composition and to analyze the techniques employed therein.

The inspiration for this work arises from the universal auditory experience shared by humanity but often forgotten—the sounds heard by a fetus within the womb. Anchored within this profound notion of the maternal matrix, this piece facilitates a deeper exploration of themes that have perennially intrigued me, namely: the genesis of life, memory, the relationship between human and machine, and maternity.

This thesis is systematically structured. The first chapter delineates the symbiotic relationship between the poetic aspects and the musical materials deployed in the composition. Subsequent to this, the next two chapters provide a detailed exposition on three salient musical parameters in the composition: morphology, timbre, and harmony. The fourth chapter offers a panoramic view, encapsulating the overarching structure of the composition. Given the dual nature of the piece, which melds traditional instrumentation with electronic elements, the concluding chapter is dedicated exclusively to an exploration of the electronic components that contribute to the work's unique sonic world.

Chapter 1: Concept and Materials

1.1 Sounds from the inception of life

The inspiration for this project stems from a profound reflection on a universal auditory experience shared by humanity: the sounds perceived by a fetus within its maternal womb. This auditory encounter, originating from the inception of human life, is often forgotten by many. Yet, I posit that people frequently expend a lifetime seeking the primordial state of existence, as it can offer insights into life's overarching journey. The title “the second womb” carries dual symbolism: it not only alludes to the physiological womb, representing the auditory space that this composition endeavors to reconstruct musically, but also hints at the potential of an artificial womb in future societies—a concept that fuels my artistic vision of humanity’s prospective trajectory.

This project encapsulates my aesthetic inclinations and compositional preferences I’ve developed over years of compositional study. From a poetic viewpoint, my re-envisioning of this core human auditory experience aligns with my aim to break down cultural barriers through the medium of art. Grounding the composition in an experience universally shared by humanity, unconstrained by specific geographies or historical epochs, was the conceptual commencement of this work. Subsequently, the dual interpretation of the “womb” serves to bring in my prognostications regarding the trajectory of human life. Furthermore, this thematic exploration resonates with my feminist convictions.

From a musical perspective, I aim to contrive this concept not only conceptually but also morphologically and symbolically in composition. Despite the pitch- and rhythm-oriented composition, I’ve adopted a morphological approach in this piece. Benefiting from the setting of live electronics, I shaped my musical materials to perceptually mirror the form of a fetus, or more specifically an “embryo.” Additionally, with the assistance of Computer-Assisted Composition (CAC) tools, I derived pitch materials from the interplay between scientific research data and musical parameters.

A short disclaimer should be made here: Although the majority of musical materials will be covered in this thesis, one aspect of the music will not be touched upon: rhythms. The reason is that this aspect of the music, as opposed to pitch and morphology, were not conceived and used systematically, but rather intuitively. Nevertheless, a general aesthetic principles was kept while dealing with the rhythmic material of the work, and it will be covered as part of the temporal structure in Chapter 4.

1.2 Morphological approach

In the initial stage of the compositional process, I chose to engage with my musical materials from a morphological perspective, with the imagery of the human embryo serving as a visual stimulus (see Figure 1 as one example). I approached the womb from two standpoints: firstly, by examining the fetus from an external viewpoint, and secondly, by reconstructing the immersive auditory environment experienced by a fetus. These bifurcated perspectives underpin the overarching structure of this piece, culminating in two distinct sections on a macro scale.

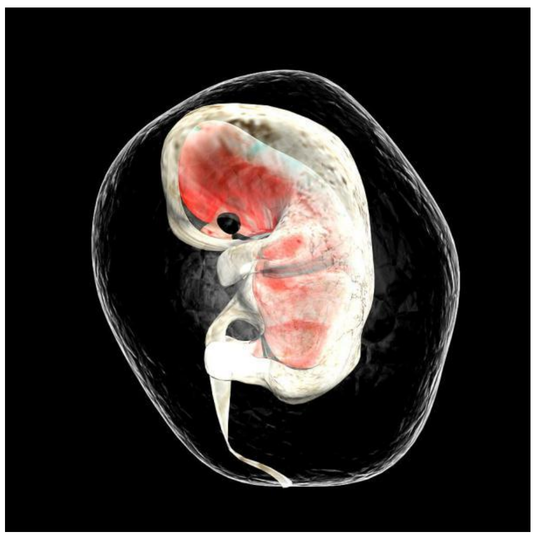

Figure 1: Human Embryo, computer artwork by Christian Darkin

The first section, spanning from measure 1 to 66, is dedicated to the external observation of an "embryo." Here, a composite hybrid sound object[1] serves as the foundational "embryo" material. As this material undergoes variations and expands, the "embryo" evolves. The second section, from measure 67 to 162, seeks to reconstruct the immersive auditory journey experienced by a fetus within the womb, as scientific

[1] The concept of "sound object" (French: "objet sonore"), developed by Pierre Schaeffer, emphasizes the intrinsic qualities of sounds over traditional musical structures. This approach promotes acousmatic listening and innovative sound manipulation.

research shows fetuses can begin to hear sounds around 24 weeks of gestation[2]. Fundamental components of the “embryo” material are dissected and developed concurrently on various planes, aiming to craft an enveloping environment characterized by watery textures, low pulsations, and faint external vocal utterances. The transition between the two sections is seamlessly facilitated by fixed media, ensuring a smooth shift in perspectives with morphological coherence. A comprehensive exploration of the morphological approach will be addressed in Chapter 2.

1.3 CAC (computer-assisted composition) approach

Regarding the foundational musical parameter, namely pitch, I endeavored to derive it from scientific research on amniotic fluid, thus interlinking the artistic and scientific dimensions of the parameters. After delving into the study of human amniotic fluid, I selected an NMR[3] spectrum from a representative sample of human amniotic fluid as the foundational graphic representation. Based on the visual congruence with the sound spectrum, I constructed a Max patch primarily utilizing bach and cage Max libraries[4] to transform the spectrum. The outcome provided the foundational pitch materials. A more detailed discussion of the pitch organization will be presented in Chapter 3.

1.4 The axis

From a historical perspective, the evolution and interplay between humans and machines have emerged as salient concerns. This dynamic not only poses challenges but also invites artists to contemplate the integration of these questions within their artistic endeavors. A primary criterion to distinguish between the human and machine is the consideration of their existence in nature: humans being associated with attributes like artistry and intuition, and machines characterized by systematic approaches, artificial intelligence, and generative capabilities.

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[2] Birnholz, J C, and B R Benacerraf. “The Development of Human Fetal Hearing.” *Science (New York, N.y.)* 222, no. 4623 (1983): 516–18.

[3] Nuclear magnetic resonance (NMR) spectroscopy is a spectroscopic technique to observe local magnetic fields around atomic nuclei. Due to its powerful ability for monitoring drug toxicity effects and disease, it has been used in the study of human body fluids for many years.

[4] The bach library is a suite of Max objects and abstractions for computer-assisted composition. The cage library is a suite of high-level abstractions based on bach library for real-time computer-assisted composition.

In the realm of music, I endeavored to attribute characteristics of these entities to three fundamental musical parameters in this composition: timbre, pitch and rhythm. When these parameters are accentuated to their extremes, they veer towards the mechanical domain (see Figure 2, towards the white outer circle). Conversely, when they remain moderate, they resonate more with human attributes (see Figure 2, towards the blue inner circle).

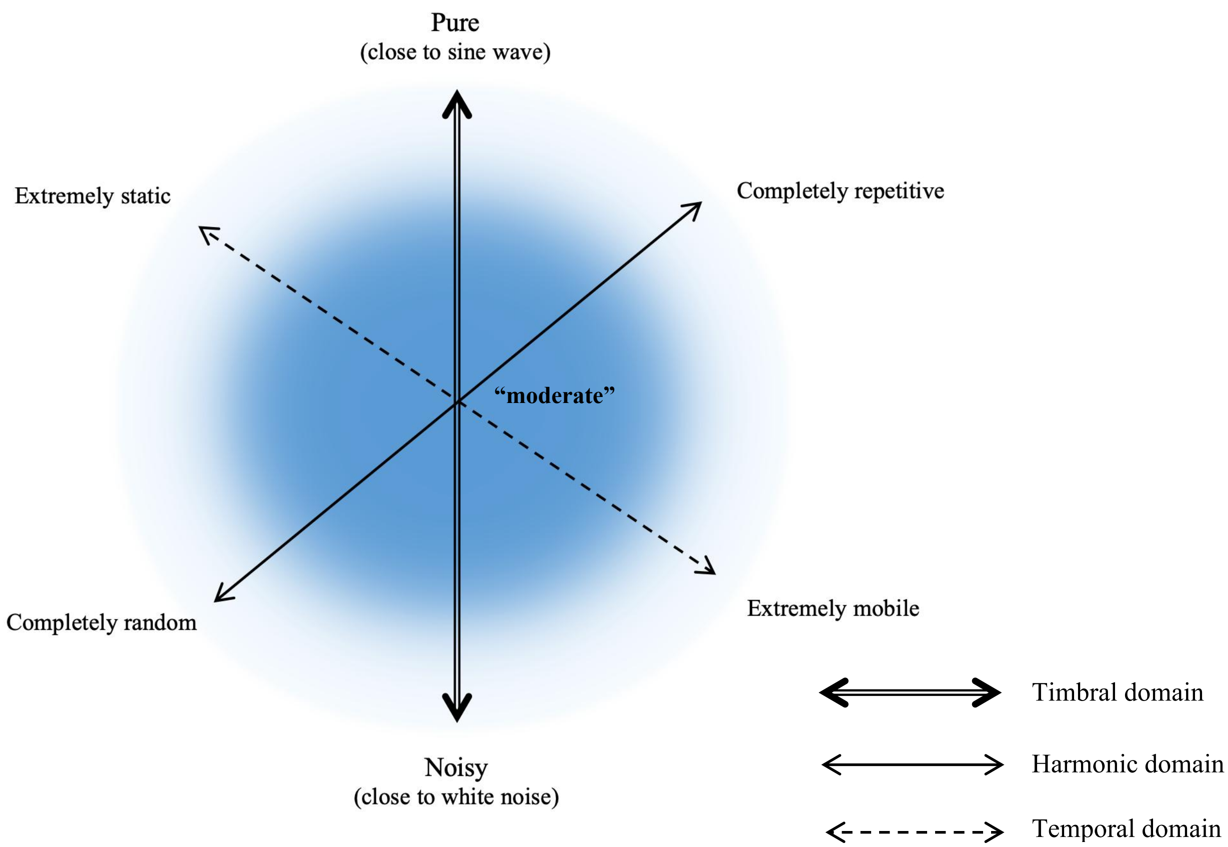


Figure 2: The axis in timbral, harmonic, and temporal domain

The pivotal area on this spectrum, marked as blue, is termed "moderate" range in this axis. However, its exact definition varies across different sections and domains. This spectrum serves to guide the materials, orchestration, and overarching trajectory of the piece. The nuances of how this axis influences the timbre and pitch direction at a detailed level will be explored in Chapter 2 and Chapter 3 respectively, and the temporal trajectory from a broader perspective in the Chapter 4.

Chapter 2: Morphology and Timbre

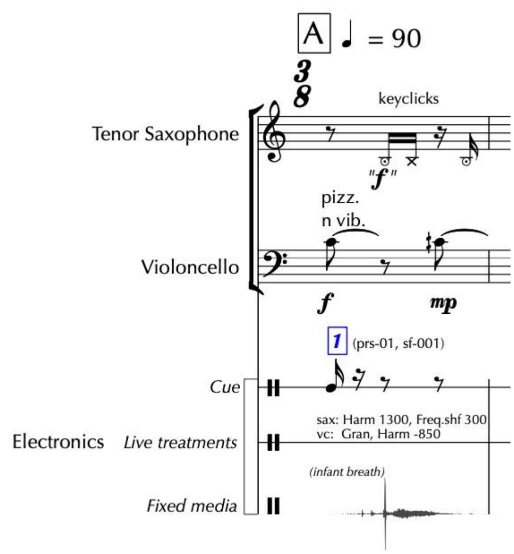
In this composition, I approached mixed music from two methodologies, aiming to acquire a comprehensive range of sound spectromorphologies[5] (see Figure 3). The first methodology is to obtain live-processing sounds or prerecorded sound files derived from original instrumental performance, subsequently facilitating interaction between the instrument and the electronics. The second one involves enabling the instrument to interact with external electronic materials not inherently generated by the instrumental part in the score. These methodologies are strategically adopted to circumvent the singular interaction observed between an instrument and live electronics, where the electronic component solely operates as a live effect of the instrumental performance.

1) Instrument (original) —> Electronics (live/fixed) —> Instrument (new)
2) Electronics (external) —> Instrument (new)

Figure 3: Two methodologies of composing for mixed music in this piece

2.1 The "embryo" material

The primary material, which is of paramount significance and permeates the entire piece, is a hybrid sound object that I conceptualize as an "embryo" presented at measure 1 (see Score 1). When represented morphologically (see Figure 4), as designed and drawn by myself, it becomes evident that this material encompasses five core constituents (see Table 1).



Score 1: The "embryo" material

[5] The concept and terminology of spectromorphology, developed by Denis Smalley, is a tool for describing and analysing listening experience. The two parts of the term refer to the interaction between sound spectra (spectro-) and the ways they change and are shaped through time (-morphology). Smalley, Denis. "Spectromorphology: Explaining Sound-Shapes." *Organised Sound* 2, no. 2 (1997): 107–26.

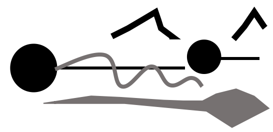


Figure 4: Spectromorphological representation of the “embryo” material

No.	Sound sources	Description of sounds	Spectro-morphology types	Spectro-morphological representations	Timbral quality
1	Violoncello	Pizzicato	Grain		Round; moderate
2	Violoncello	Resonance of pizzicato	Continuum		Resonant; pure
3	Tenor saxophone	Keyclicks	Click		Metallic; noisy
4	Live-processing	Granulation of cello	Wave		Round; moderate
5	Soundfiles	Baby breath sound	Divergence / Convergence (when reversed		Breathy; noisy

Table 1: The five core constituents in “embryo” material

The “embryo” material is a sound object amalgamated with original instrumental sounds, live-processing sounds, and external sound files. This integration offers considerable potential for the evolution of mixed music, in alignment with the two methodologies previously discussed. The timbral design of this “embryo” sound object serves as the anchor of the timbre axis, constituting a blend of noise and pure sound, with a slight predilection towards the noise spectrum, as depicted in Figure 5.

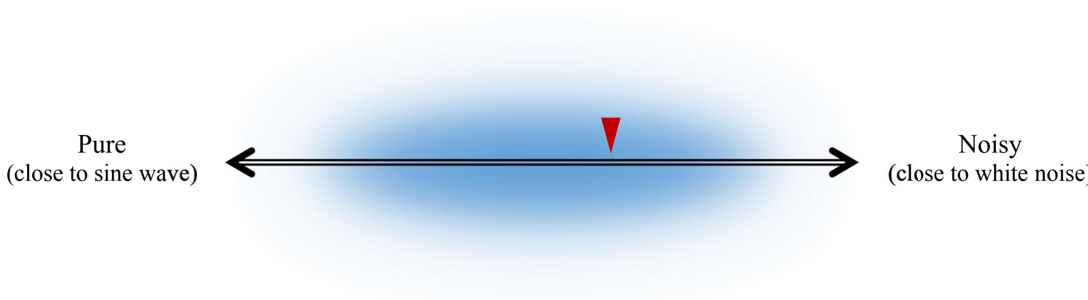
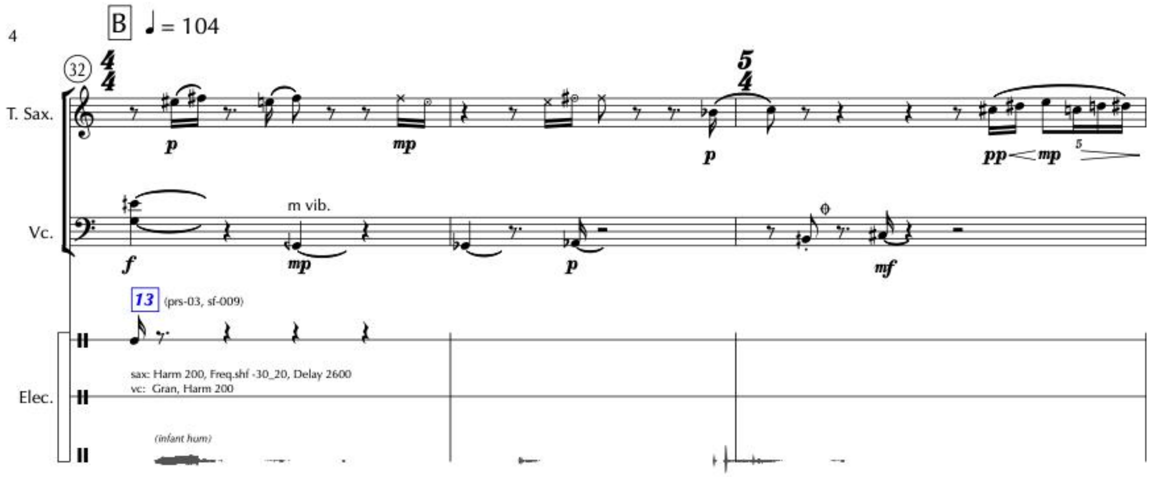


Figure 5: The timbral axis of “embryo” material

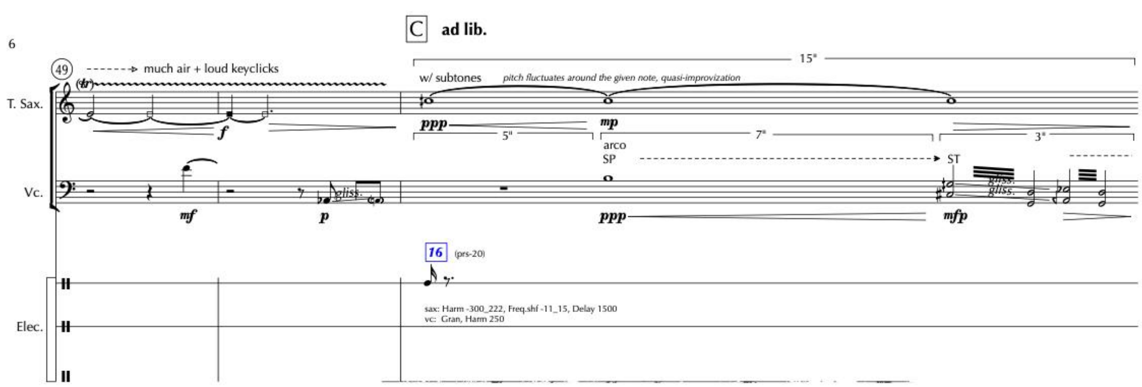
2.2 Evolution of the “embryo”

Within the two sections, the “embryo” material undergoes different developments, stemming from its evolution perceived from two distinct standpoints: an external observation of its progression and an auditory experience akin to perceiving from within a womb.

In the first section, subsequent to the material’s presentation from measure 1 to 31, the tenor saxophone commences mirroring the live-processing effects of the violoncello, (see Score 2). Then, the violoncello segment aligns with the saxophone’s, resulting in an intertwined texture that metamorphoses into a novel material, as illustrated in Score 3.



Score 2: measure 32-34



Score 3: measure 49-51

Thus, the progression of music within the first section adheres to the aforementioned primary methodology of material development: Instrument (original) → Electronics (live) → Instrument (new). The interaction, as manifested in its morphological representation, is delineated as follows (see Figure 6):

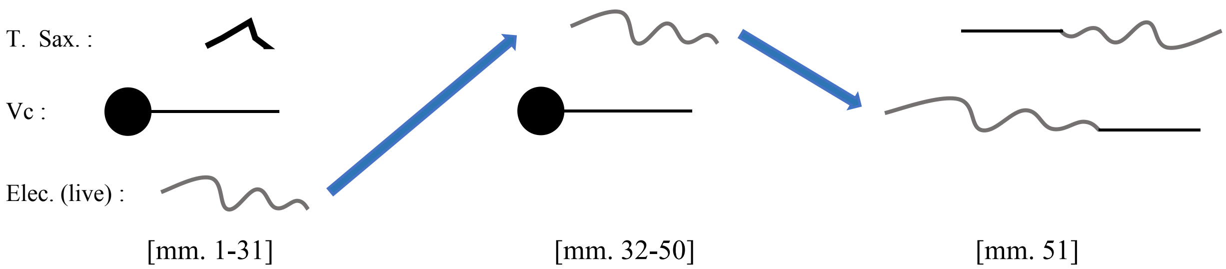
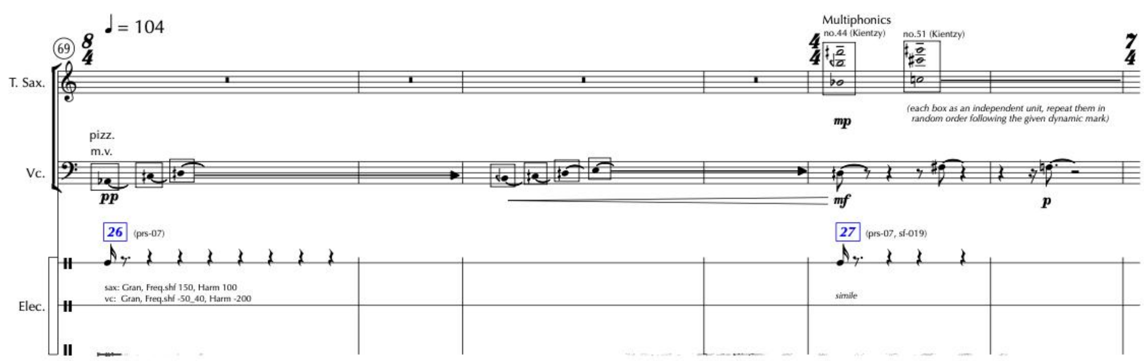


Figure 6: The evolution of the "embryo" material in spectromorphological representation

In the second section, the five foundational components of the "embryo" evolve simultaneously within three distinct layers, reminiscent of polyphonic structures (see Score 4 and Figure 7). Contrasting sharply with the first section, the compound materials are segregated and interpolated to fabricate a novel texture, culminating in an immersive section.



Score 4: measure 69-74

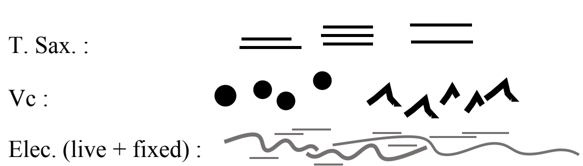


Figure 7: Spectromorphological representation of the second section

2.3 Transitional materials

Regarding the transition between the two sections, an external sound file was employed as a bridging mechanism. This approach aligns with the second methodology of composing fixed music: Electronics (external) → Instrument (new).

Starting from cue 14, the sound file was initially triggered. Its genesis lies in an improvisational recording session with the cellist, marked by a predominant use of random pizzicato in the lower register. This recording subsequently underwent significant stretching and processing, as its final spectrum illustrated in Figure 8. The elongated sound file exudes an elastic quality and is juxtaposed with the latter half of the first section.

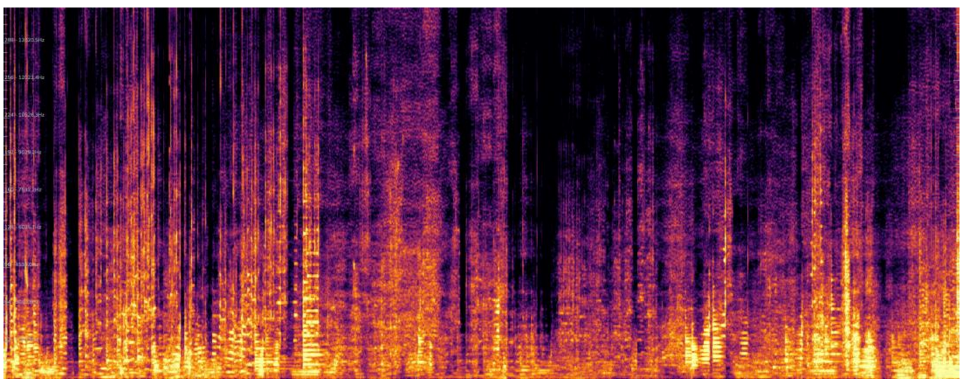


Figure 8: Spectrogram of the transitional material in sound file 010

(X-axis: 0~38s, Y-axis: 20~20kHz)

As the composition unfolds, the stretched sound file gradually condenses in a series of stages triggered by cue 14, 17, 18, and 20. This compressive evolution spans the initial segment of the second section, imbuing the composition with continuity across both sections and also endowing it with a dynamic force (see Figure 9).

	First Section					Second Section		Coda
Timeline:	0:00	~2:25				~6:10		~12:00
Cue no. :		14	17	18	20	27	30	39
Sound file no. :		010	011	012	013	019	020	024
Temporal quality of the sound file (fixed):		Extremely stretched—>		Normal—>		Condensed —>		Extremely condensed
Instrumental part:		Elongated texture (Vc. + T.Sax.)		Fast tremolo (Vc.)				Recap "embryo" material (Vc. + T.Sax.)

Figure 9: The transitional materials in sound files and instrumental part

2.4 Trajectory of timbre

In terms of the timbral trajectory, broadly speaking, the musical progression begins in a human state, characterized by a moderate timbral quality, and culminates in a mechanical state, encompassing two distinct sections.

Figure 10: The trajectory of human-machine axis at macro level

Within each section, the timbral changes follow their respective trajectories. In the first section, as the musical material unfolds, the timbre transforms gradually from a moderate quality towards a noise-dominated state. Subsequently, in the second section, the timbre undergoes a sequence of transformations: starting from a moderate state, it progresses towards a pure timbral quality, then oscillates between purity and noisiness, and ultimately concludes the second section in a state of complete noisiness. There is an additional coda recapitulating the musical journey with the original "embryo" material, thereby providing a sense of closure and unity to the overall composition, as well as a personal attitude of backing to humanity (see Figure 11).

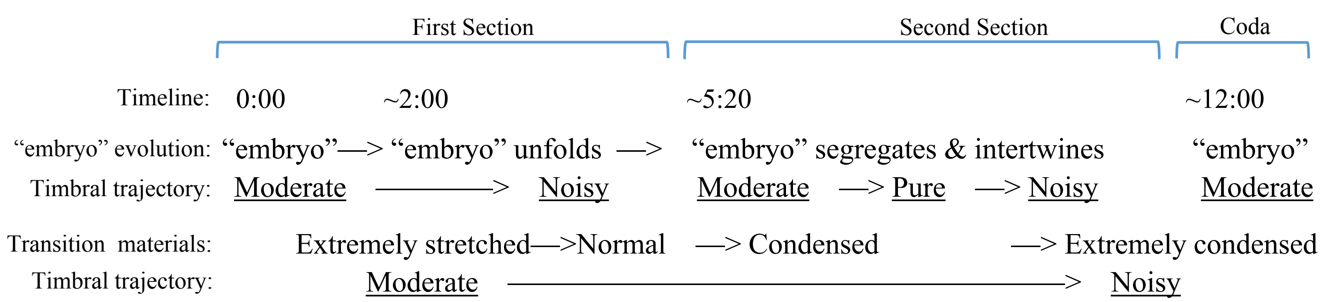


Figure 11: Trajectory of timbre for the "embryo" material and transitional materials

Chapter 3: Harmony

3.1 Conversion via CAC

In terms of harmony, one of the most potent symbolic parameters, I tried to build it upon a connection between artistic creation and scientific research. According to the similarity between sound spectrum analysis and fluid spectroscopy analysis, I decided to generate the initial pitch materials based on a study of human body fluid related to gestation. Upon delving into the study of human amniotic fluid, I found that the study of human body fluids by nuclear magnetic resonance (NMR) spectroscopy, a spectroscopic technique to observe local magnetic fields around atomic nuclei, has been recognized as a powerful tool for the monitoring of drug toxicity effects and disease for many years[6]. Thus, I chose a NMR spectra of a typical sample of human amniotic fluid (see Figure 12[7]) as the original graphics, sourced from a study that employed NMR spectroscopy on samples procured from 16 healthy pregnant women during their 16-22 weeks of gestation.

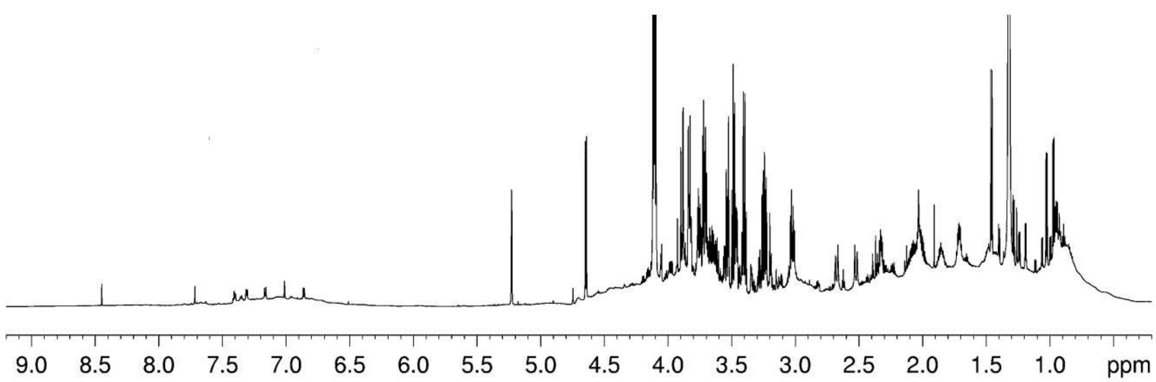


Figure 12: NMR spectra of a typical sample of human amniotic fluid

In the NMR spectroscopy of human amniotic fluid, I identified twelve prominent peaks (see Figure 13, highlighted as red nodes) and initially transformed them into a graphic representation with 12 nodes (see Figure 14). Subsequently, this graphic was

[6] Graça, Gonçalo, Iola F Duarte, Brian J Goodfellow, António S Barros, Isabel M Carreira, Ana Bela Couceiro, Manfred Spraul, and Ana M Gil. "Potential of Nmr Spectroscopy for the Study of Human Amniotic Fluid." *Analytical Chemistry* 79, no. 21 (2007): 8367–75.

[7] Graça, Gonçalo, Iola F Duarte, Brian J Goodfellow, António S Barros, Isabel M Carreira, Ana Bela Couceiro, Manfred Spraul, and Ana M Gil. "Potential of Nmr Spectroscopy for the Study of Human Amniotic Fluid." *Analytical Chemistry* 79, no. 21 (2007): 8367–75. Figure 1 (a).

integrated into a Max patch, primarily utilizing objects from the bach and cage Max library. I designated the spectrum range between 65 Hz and 880 Hz, aligning with the feasible performance range of the violoncello. The data corresponding to each peak, on both the X axis and Y axis, was methodically programmed for conversion into the frequency and amplitude domains, respectively. This process culminated in the formulation of a 12-note core chord (see Score 4), designated as the foundational pitch materials for this piece. The gradation of color in the score denotes dynamic levels: darker shades correspond to heightened volume. Such gradation will guide both the sequence and extent of pitch transpositions in the composition (to be discussed in the following section).

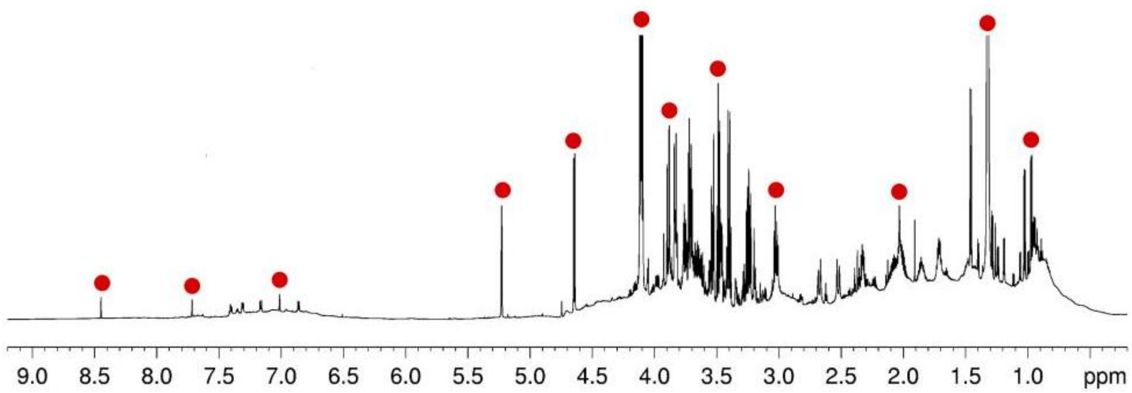
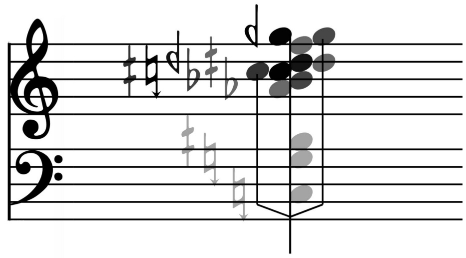


Figure 13: NMR spectra of a typical sample of human amniotic fluid with selected 12 peaks

Figure 14: 12-node graphics extracted from the NMR spectra (Figure 13)



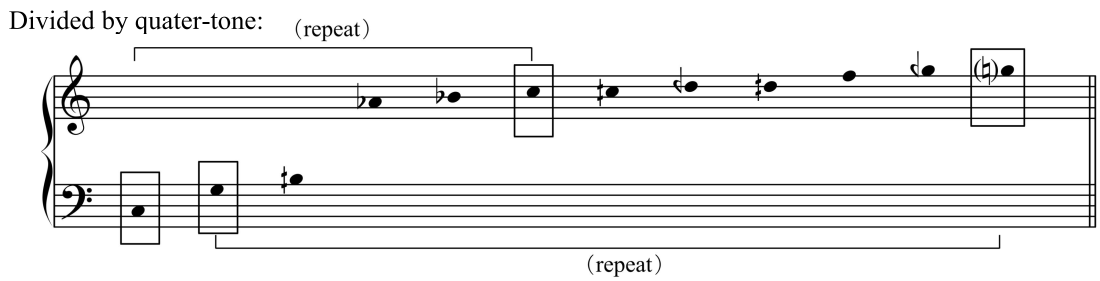
Score 5: Core chord

3.2 Pitch organization

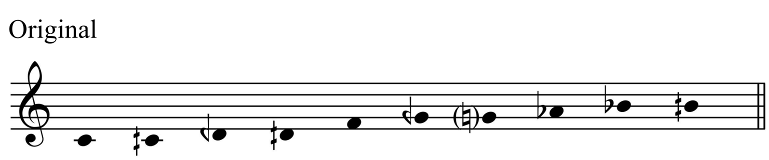
The 12-note chord, derived from the NMR spectrum, is principally employed in two modalities: as an independent sequence and as part of a harmonic series.

3.2.1- as a sequence

Initially, the set of twelve notes is quantized to quarter-tones to for the convenience of performance. After eliminating the repetitive notes (with two notes recurring in disparate octaves, as illustrated in Score 6) and transposing all notes to fall within a singular octave, a sequence of 10 notes is established as the foundational note sequence (see Score 7).



Score 6: 12 notes in core chord divided by quater-tone



Score 7: 10-note sequence (original)

Based on the amplitude of each note in the 12-note graphic representation, I selected the four most prominent notes to commence the transposed sequences (see Figure 15 and Score 8), then transposed the original sequence accordingly. The relative intervals between adjacent notes within each sequence are meticulously preserved, mirroring the original sequence (see Score 9).

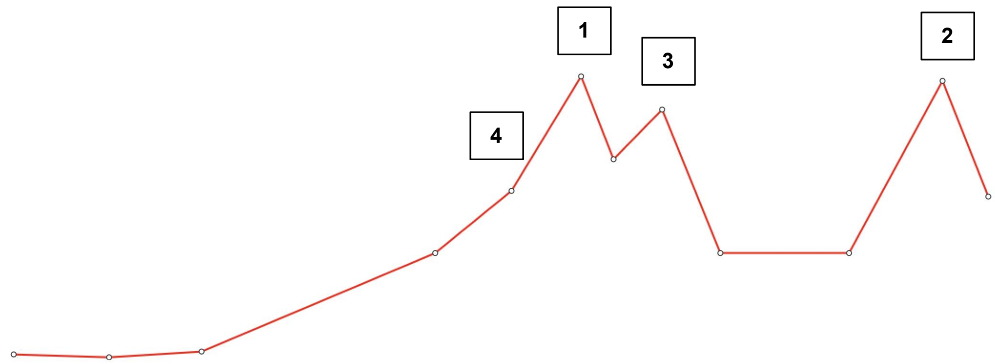
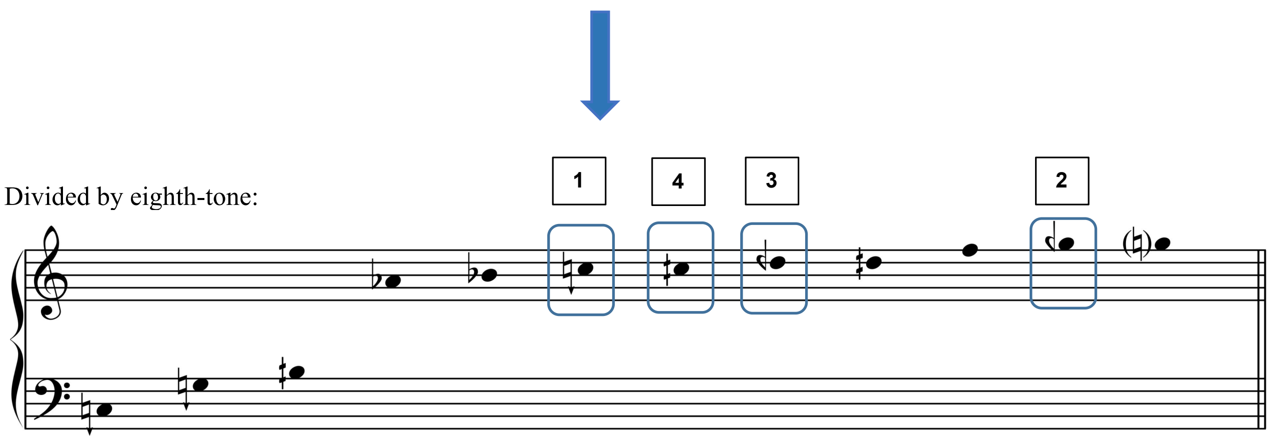


Figure 15: 12-nod graphics with the first four loudest peaks



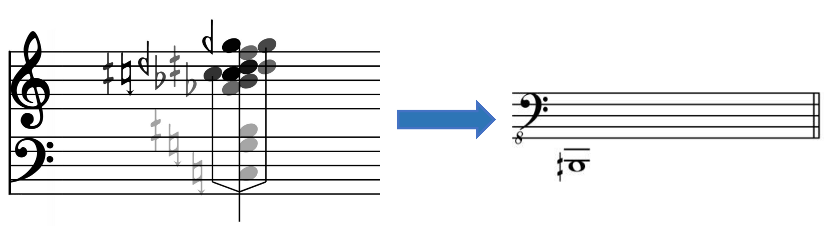
Score 8: The four notes corresponding the first four loudest peaks

Score 9: Four sequences

These sequences serve as the primary pitch materials in the first section. They are predominantly articulated in the cello part, introducing the thematic "embryo" material. A more detailed discussion on variations and transitions to succeeding segments will be addressed in Section 3.3 "Trajectory of Harmony".

3.2.2- as part of a harmonic series

In the second section, the core chord is primarily considered within the context of a harmonic series. The manipulation of this harmonic series assumes greater significance than the sequence on its own. I conducted an analysis of the virtual fundamental pertaining to this 12-note chord, identified as B$_0$ 1/4 sharp (see Score 10), utilizing the cage.virtfund object in Max.



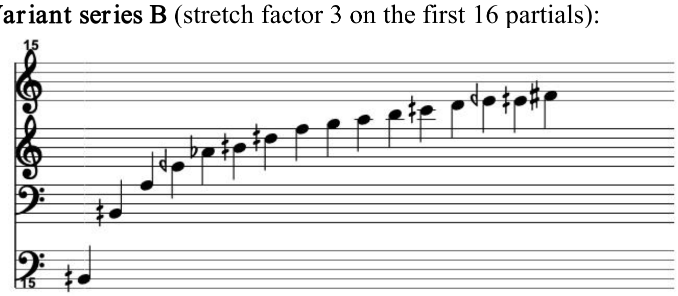
Score 10: The virtual fundamental of the core chord

Upon determining the virtual fundamental, the inherent harmonic series up to the 51st partial assumes a significant role in pitch organization within the first section (see Score 11). In the second section, variations of the harmonic series emerge as the predominant harmonic content. I employed the cage.harmser object in Max to generate and elaborate upon the first 16 partials of the harmonic series. The stretch mode is configured to 0, corresponding to the frequency domain. Subsequently, the stretch factor is allocated values of 2 and 3, leading to the two variant series of notes (see Score 12). A comprehensive outline of the harmonic trajectory will be elucidated in the following section.

Score 11: The harmonic series on B0 1/4 sharp (up to partial no. 51)

Variant series A (stretch factor 2 on the first 16 partials):

Variant series B (stretch factor 3 on the first 16 partials):



Score 12: Two stretched harmonic series

3.3 Trajectory of harmony

In the first section, two tiers of harmonic content unfold concurrently. The primary tier comprises the transposed sequence, accompanying the presentation of the "embryo" material. The secondary tier, on the other hand, features the original harmonic series aligned with the evolution of the "embryo." The harmonic series commences with the higher partials, progressing towards the lower ones, and ultimately culminates with the fundamental of the harmonic series by the close of the first section (see Figure 16). In the second section, the harmonic series begins to broaden within the frequency domain. The shifted harmonic series emerges as the primary harmonic content, while the transposed sequence diminishes during this phase (see Figure 17).

First Section

Rehearsal letter:	**A**		**B**		**C**			**D**	
Measure number:	1-13	14-31	32-42	43-50	51-			52-56	58-66
No. of sequence used:	1	2	1&2	3&2&1	n/a			1	1&3
No. of partials used (on original harmonic series):	25-51	—	n/a	35&37	25-51	17-39	7-29	3-9	1-7
Trajectory of partials used:	High partials →								Low partials
Trajectory of sequence used:	Original →								

Figure 16: The harmonic trajectory for the first section

Second Section

Rehearsal letter:	**E**				**F**	**G**		
Measure number:	67	69-74	75-79	80-85	86-106	107-132	133-147	148-158
No. of sequence used:	3	n/a	4	n/a	n/a	n/a	4&3&2	1
No. of variant series used:	n/a	A	n/a	A	—	B&A	B	n/a
Trajectory of variant series used:	Slightly stretched →						More stretched	
Trajectory of sequence used:	→					More deviant →		Original

Figure 17: The harmonic trajectory for the second section

The harmonic axis functions at a macroscopic level. To evoke a mechanistic sensibility, a specified degree of randomness is conferred upon the performer for improvisation in the second section, and the shifted harmonic series serve as the range of choices. Conversely, in the first section, the transitional material subtly integrates as a prerecorded randomized content, as the randomness was posited in the pre-compositional recording session. Across both sections, the harmonic content is constructed from both instrumental and electronic components.

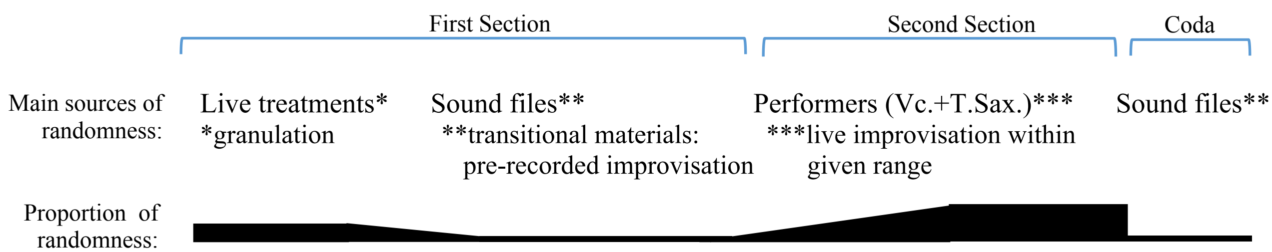


Figure 18: The harmonic axis regarding the randomness at a macro level

Chapter 4: Form

4.1 Overall formal structure

Broadly speaking, this composition can be bifurcated into two distinct sections. However, these sections seamlessly bond into a singular, cohesive journey. The intricate layers of trajectories in a macroscopic level are delineated as follows:

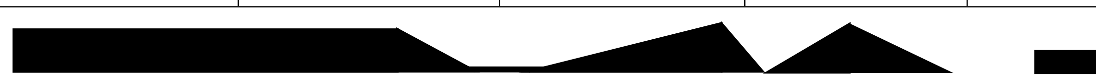
Standpoints	Observing a fetus		Listening as a fetus		
Sections	First section		Second section		Coda
Compositional Goal	Spectromorphological imitation of an "embryo" and its evolution		Recreating the immersive aural environment perceived within a womb		Recap
Music evolution	"embryo" material	"embryo" unfolds	"embryo" segregates and intertwines		"embryo"
Rehearsal letter	A	B - D	E - G		H
Measure no.	1 - 31	32 - 66	67 - 159		160-162
The axis	Human			Machine	Human
Timbral trajectory	Moderate	—> Noisy	Moderate —> Pure —> Noisy		Moderate
Harmony trajectory	Moderate (few random elements)	—> Repetitive (lasting chords)	—> Random (more random elements)		Moderate
Temporal trajectory	Moderate	—> Static	Moderate —> Mobile		Moderate
Relationships between instruments and electronics	Instruments, live electronics and fixed media all mixed as a hybrid sound object	New instrumental material (T.Sax.) generated by previous live treatments (Vc.)	Instrumental part and electronic part developing as two concurrent but independent layers	Instrumental part dissolving into electronic part (fixed) and ending solely with electronics	All mixed as one hybrid sound object again
Proportion of live treatments					
Proportion of fixed media					

Table 2: The overall structure in multiple levels

Chapter 5: Electronics

In this project, the electronic component is configured for four-channel quadrophonic surround sound. A detailed introduction to the technical setup, concert patch, real-time treatments, fixed media, and spatialization will be covered in this chapter.

5.1 Performance setup

The 4.0 surround sound system is configured in pairs, meaning channels No. 1-4 correspond to loudspeakers at the front left, front right, back left, and back right, respectively, as shown in Figure 19 (where LS stands for loudspeaker). A MIDI pedal should be assigned to the cellist to trigger the cues, while two microphones, named input No.1 and No.2, are set to capture live sounds from the violoncello and tenor saxophone, respectively. A sound engineer should be monitoring the mixer during the performance, if possible, and the composer should be overseeing the Max patch on the computer in case of any emergent issues.

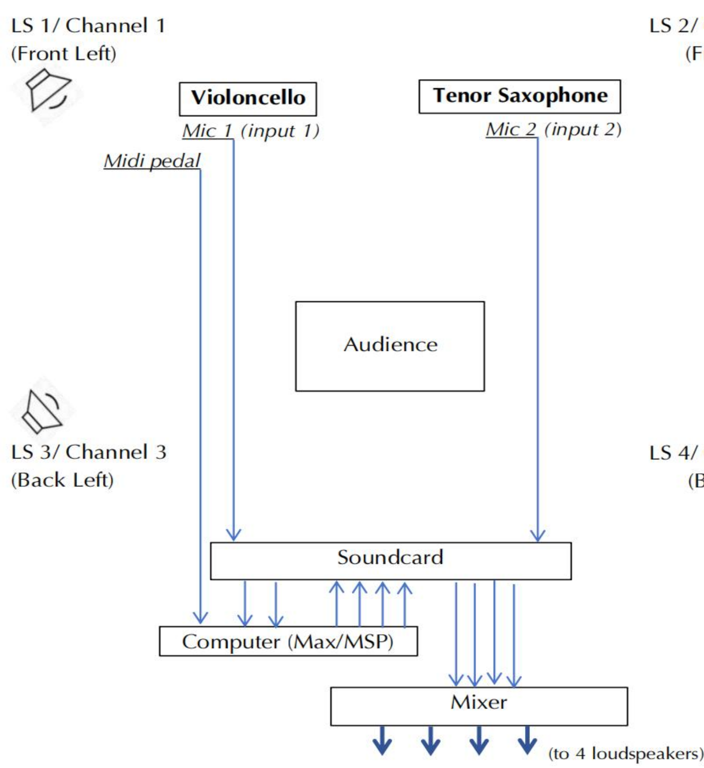


Figure 19: The technical setup

5.2 Main window of the concert patch

Figure 20 displays the main window of the Max patch. This window is also used by the composer to rehearse with instrumentalists and to monitor during the concert. The first column on the left consists of three parts: “Audio Settings,” where we can initialize the patch and manually modify the settings; “Checklist,” which should be followed before the performance starts; and “Output Levels” for monitoring the four-channel live output levels.

In the second column on the left, a dropdown menu allows us to open one of the main subpatcher windows, such as the module-window, routing-window, events-window, cues-window, and audio-io-window. Below this dropdown menu, there is a switch to toggle audio processing on and off, along with a button (or the option to hit the escape key twice rapidly) for an emergency stop, in cases of feedback, distortion, etc. The percentage of CPU usage is also displayed here in real time. The third column on the left is where we can monitor the current cue number and its content, the next cue, and the status of the MIDI pedal (the trigger button lights up when a cue is received). The toggle at the top allows the use of either the space bar or the MIDI pedal to trigger events, and this must be enabled to run the piece.

In the middle section of the two central columns, there are two identical interfaces for monitoring the inputs from two instruments. Both interfaces use the first dropdown menu to select the input for the processing matrix, which can be either a microphone or a sound file simulating a live musician’s performance. When using a sound file for simulation, the “choose soundfile” button opens a file dialog to select the audio file. Then, the pink button above the “Input-1: CELLO” interface should be used to play two sound files simultaneously. Furthermore, the “Live Input PA” interfaces allow us to monitor the live input levels sent directly to the loudspeakers, while the “Live Input to Processing Matrix” interfaces control the signals going through the signal processing matrix.

The module monitoring boxes in the right column and the lower part of the two middle columns are set to control the live output levels of the most commonly used modules.

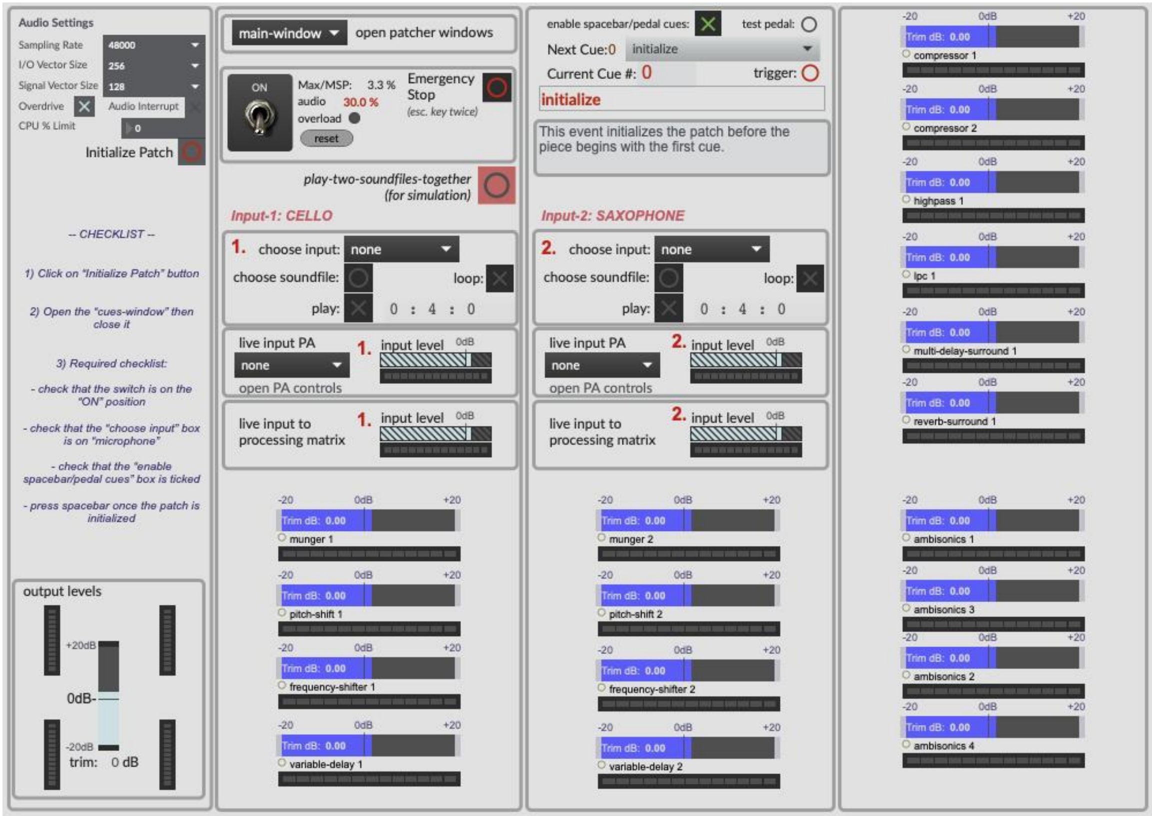


Figure 20: Main window of the patch

5.3 Real-time treatments

The live-electronic part in this project primarily serves two functions: firstly, to apply real-time sound treatments as effects, aligning with my foundational "embryo" material and its progression; and secondly, to introduce supplemental harmonic content through the pitch-shift and frequency-shift modules.

A total of 40 cues are utilized in this project, as shown in Figure 21, the interface of the "events-window". The most commonly used live treatments are the granulator, cross-synthesis, frequency shift, pitch shift, etc. Additionally, time-varying data is employed to modulate specific parameters during performance, as illustrated in Figure 22, which displays the content within the first event. A function object is used to control the Munger module via time (as shown in the graphics inside the upper right rectangle box), while the Ambisonics module is controlled by the spat interface over time (the square black boxes at the bottom right). Other non-time-varying parameters are sent by the message object.

Figure 21: The interface of “events-window”

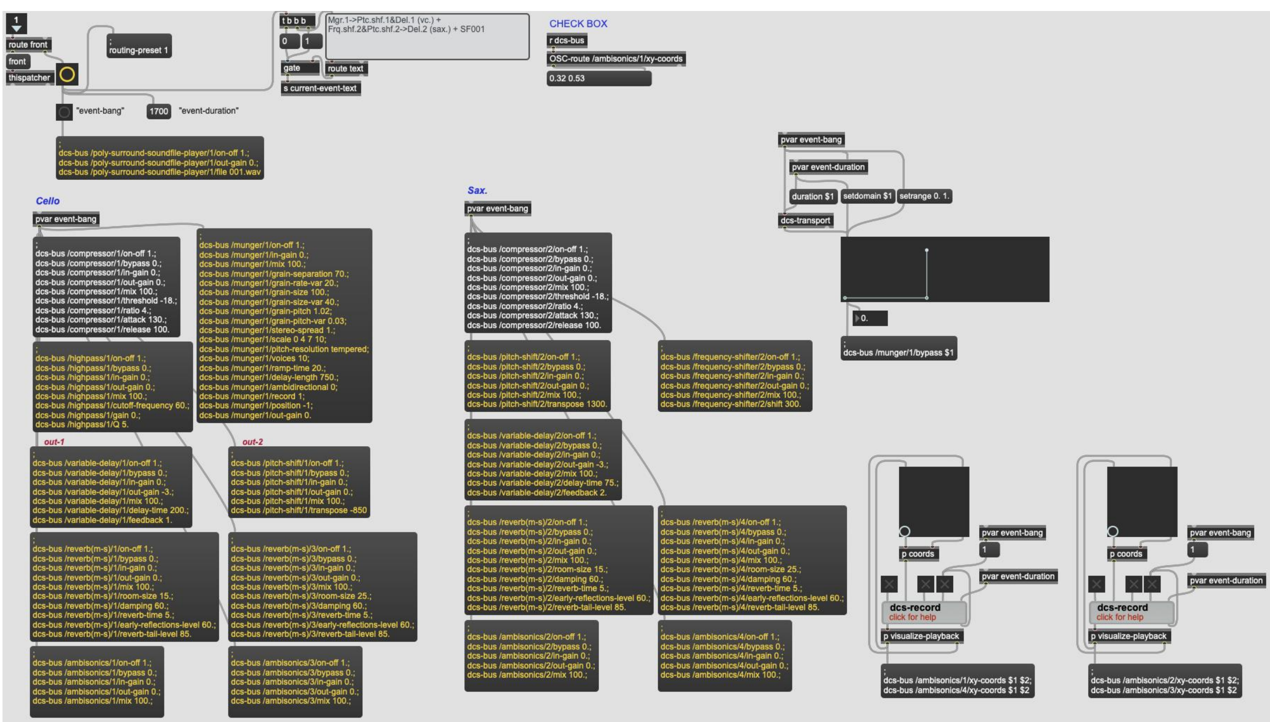


Figure 22: The content within the first event “Cue01+SF001”

5.4 Fixed media

In terms of fixed media, this project encompasses a total of 24 sound files. Analyzing the duration of these sound files reveals that they range from as brief as 1 seconds (as seen in sf-001) to as extended as 3 minutes and 30 seconds (as seen in sf-022). This span underscores the trajectory of the fixed electronics, transitioning from minimal to abundant, which parallels the axis from human to machine.

The functions of the fixed media can be delineated through three perspectives. Firstly, specific external sound elements, such as baby breathy sounds and watery sounds, necessitate the use of a tape for conveyance. Secondly, certain sound files play a pivotal role in structuring the entire composition, exemplified by the transitional material detailed in Chapter 2. Lastly, the fixed media introduces an unexpected illusion to the performance, bridging between performers' gestures and the fixed sounds: for instance, the juxtaposition of a cellist with a saxophone sound file, an effect unattainable solely through real-time treatments.

5.5 Spatialization

Both in live and fixed electronics, spatial considerations are meticulously addressed. The ambisonics[8] technique is predominantly employed to achieve spatialization in the live setting. Within the fixed media, spatialization can be categorized into three primary types:

1) Discrete and clearly sourced sounds, such as baby breaths and transitional materials (condensed), e.g. sf-001;

2) Sounds with explicit trajectory, such as transitional materials (highly elongated), e.g. sf-010 and sf-011;

3) An immersive space with implicit trajectories of sounds, where determining directions is challenging, e.g. sf-022.

[8] Ambisonics is a full-sphere surround sound technique that captures and reproduces audio in a three-dimensional space, allowing for sound sources to be placed anywhere around the listener, including above and below.

Conclusion

This project serves as an emblematic testament to my evolving aesthetics and compositional predilections. The intricate dance between art and science, and the dynamic between the human essence and machinery, has perennially piqued my artistic interests.

At the core of this work lies a profound inquiry: seeking the quintessence of what delineates our humanity. This endeavor aims to transcend the confines of geographical histories and cultural variances, focusing instead on the elemental and primal state of being human. Additionally, this piece contemplates the trajectory of humanity's potential future, juxtaposing it against our primordial roots.

It is candid for me to acknowledge here that the compositional techniques and conceptual frameworks I've employed in this piece may still be in their nascent stages. However, they undeniably offer a fertile ground from which my subsequent compositions and research can sprout. The melding of instruments and electronic components, in particular, emerges as a promising avenue that I am keen to explore further. Thus, this project, in its essence, can be perceived not merely as a reflection of my current stance but as a pivotal fulcrum for my future endeavors in composition and research.

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Yulin YAN

studies for the second womb

for tenor saxophone, violoncello, and live electronics

(2023)

Program Note

This project stems from a profound reflection on a universal auditory experience shared by humanity: the sounds perceived by a fetus within its maternal womb. The title "the second womb" carries dual symbolism: it not only alludes to the physiological womb, representing the auditory space that this composition endeavors to reconstruct musically, but also hints at the potential of an artificial womb in future societies—a concept that fuels my vision of humanity's prospective trajectory.

Duration

Approx. 14 minutes

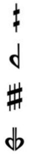
Max patch download link (w/ instructions for using the patch)

https://drive.google.com/drive/folders/1rKmr7YX8DAd_JDwPb7vMiy1pAGCeEKER?usp=sharing

Notes for Performance

For <u>all</u>

 diminuendo towards silence (or as quite as possible)



a quarter tone sharp

a quarter tone flat

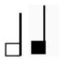
three quarter tones sharp

three quarter tones flat

 fast tremolo (always as fast as possible)

For <u>tenor saxophone</u>

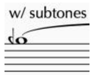
 keyclicks (the round notehead means pressing down the key, the cross-notehead means loosening the key)

 inhale or exhale, airy sound (without pitch)

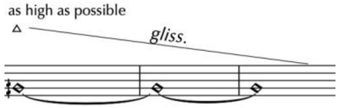
 tongue ram

slap tongue

play as hard as possible, although the actual sounding is not loud enough



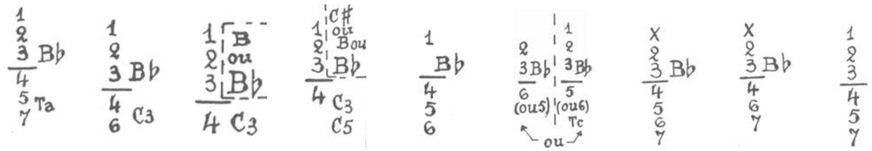
subtones



harmonic glissando (the diamond-notehead refers to the fundamental)

<u>Fingerings for multiphonics:</u> [reference: *Les sons multiples aux saxophones* by Daniel Kientzy]

no.12 no.22 no.24 no.43 no.44 no.51 no.67 no.70 no.98

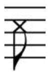


For <u>violoncello</u>

 harmonic press

 stop the resonance after playing immediately

multiphonics (the diamond-notehead refers to possible position of the harmonic nod, however, the performer is responsible to find the best position to generate the multiphonics)

 tap the fingerboard on the given notes by left hand

MST	molto sul tasto
ST	sul tasto
ord.	ordinario
SP	sul ponticello
MSP	molto sul ponticello
c.l.b.	col legno battuto
crini e legno	arco with half wood and half string
crini	arco with string only
n vib.	non vibrato
m vib.	molto vibrato

cue number: to press the MIDI pedal with right foot on the beat where the blue boxed number is indicated

* Three plastic guitar finger picks () should be prepared on the violoncello before performance, in order to add a noisy buzzing effect while playing:

Two of them hanging on the fourth string and one on the third string ---- right above the bridge.

Technical Setup

Stage Setup

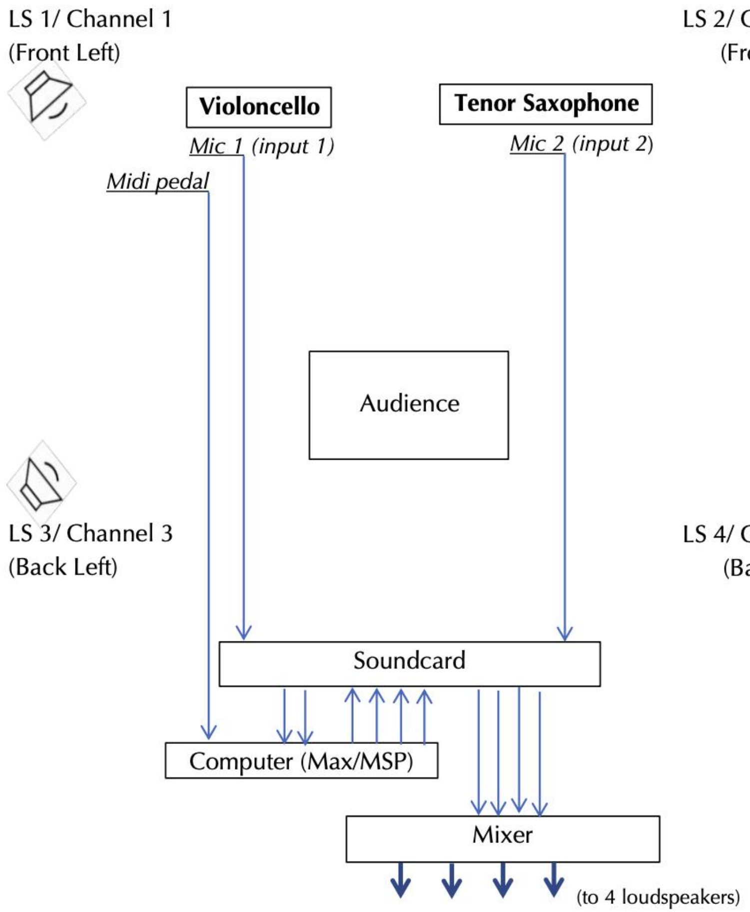
- 2 music stands

Audio Setup

- 1 4-channel audio interface (Quadrophonic surround sound in pairs: ch.1-front left, ch.2-front right, ch.3-back left, ch.4-back right)
- 2 microphones (preferred: DPA 4099)
- 2 microphone stands
- 1 MIDI pedal for the cellist
- 1 mixer
- 1 computer (laptop) with software Max/MSP
- 1 soundcard

Software Requirements

- Max/MSP 8

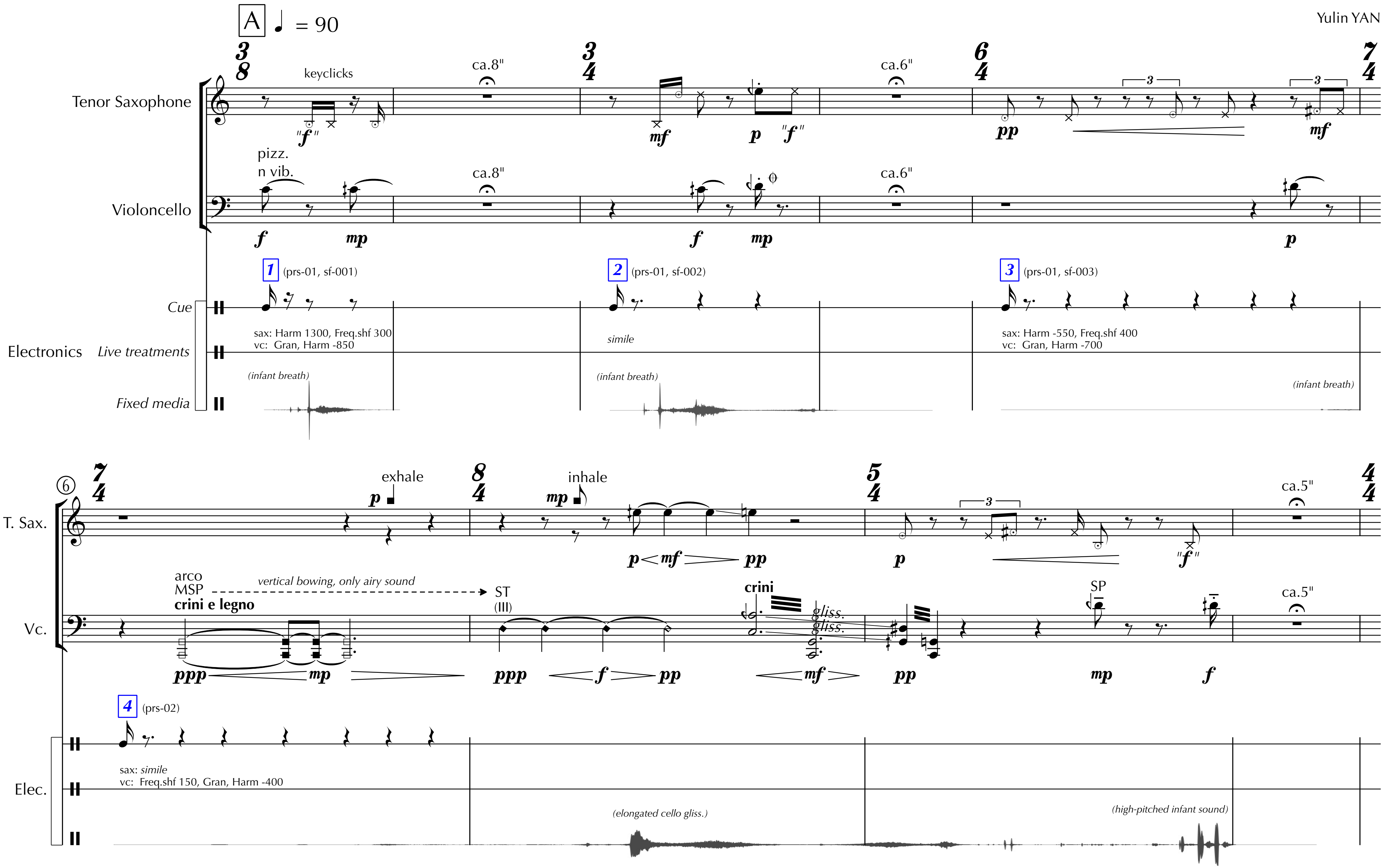


Transposed Score

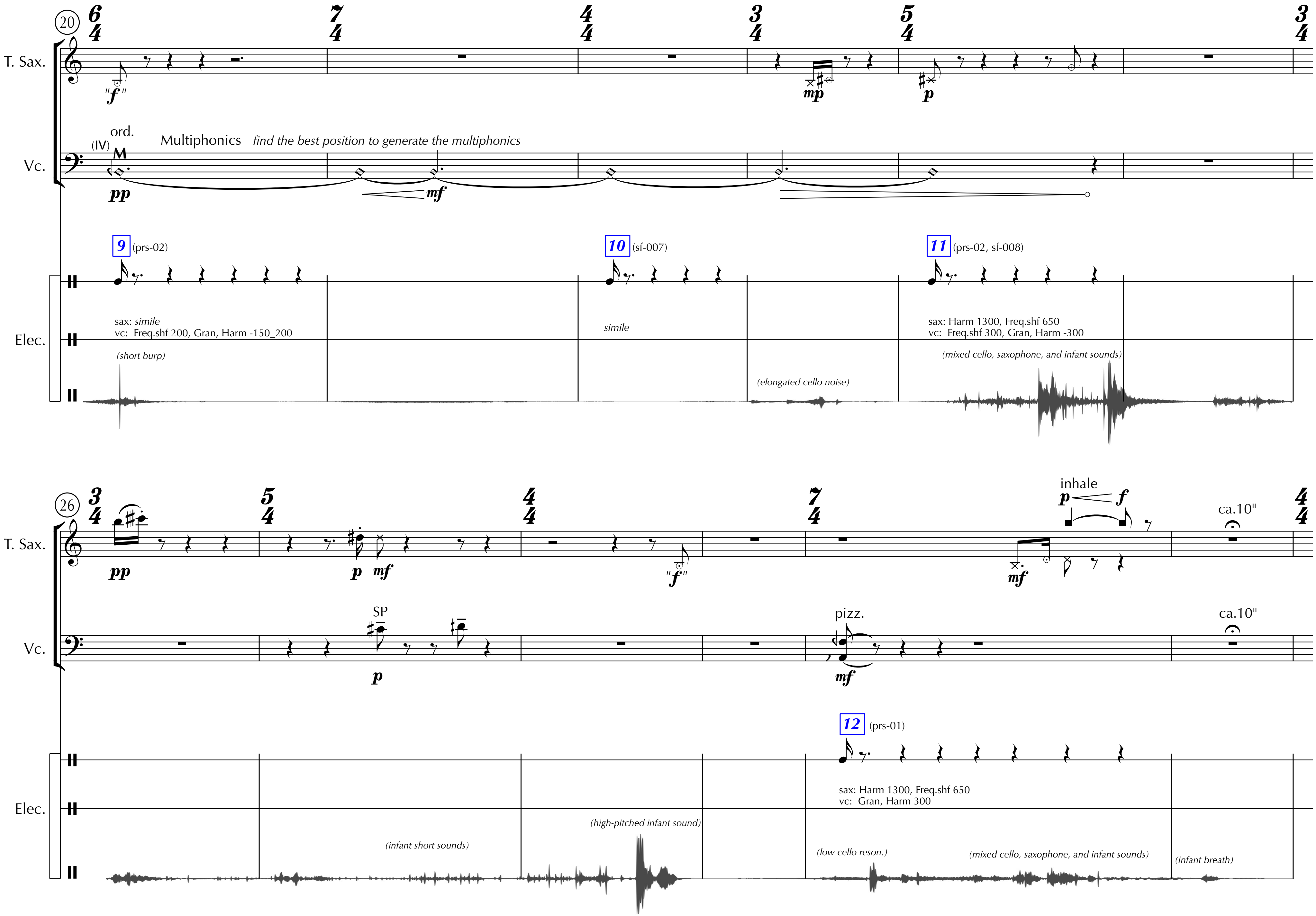
studies for the second womb

I.

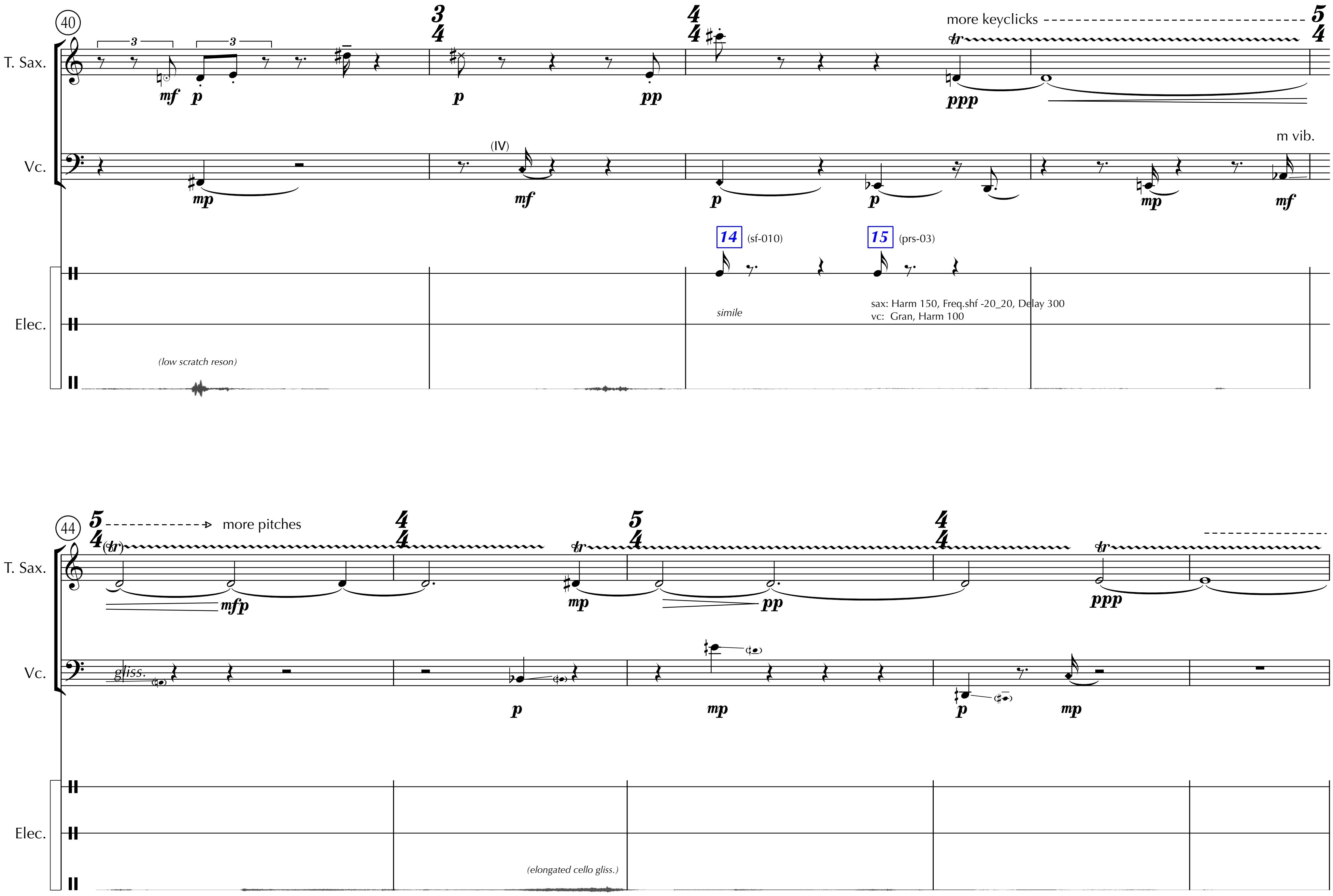
Yulin YAN

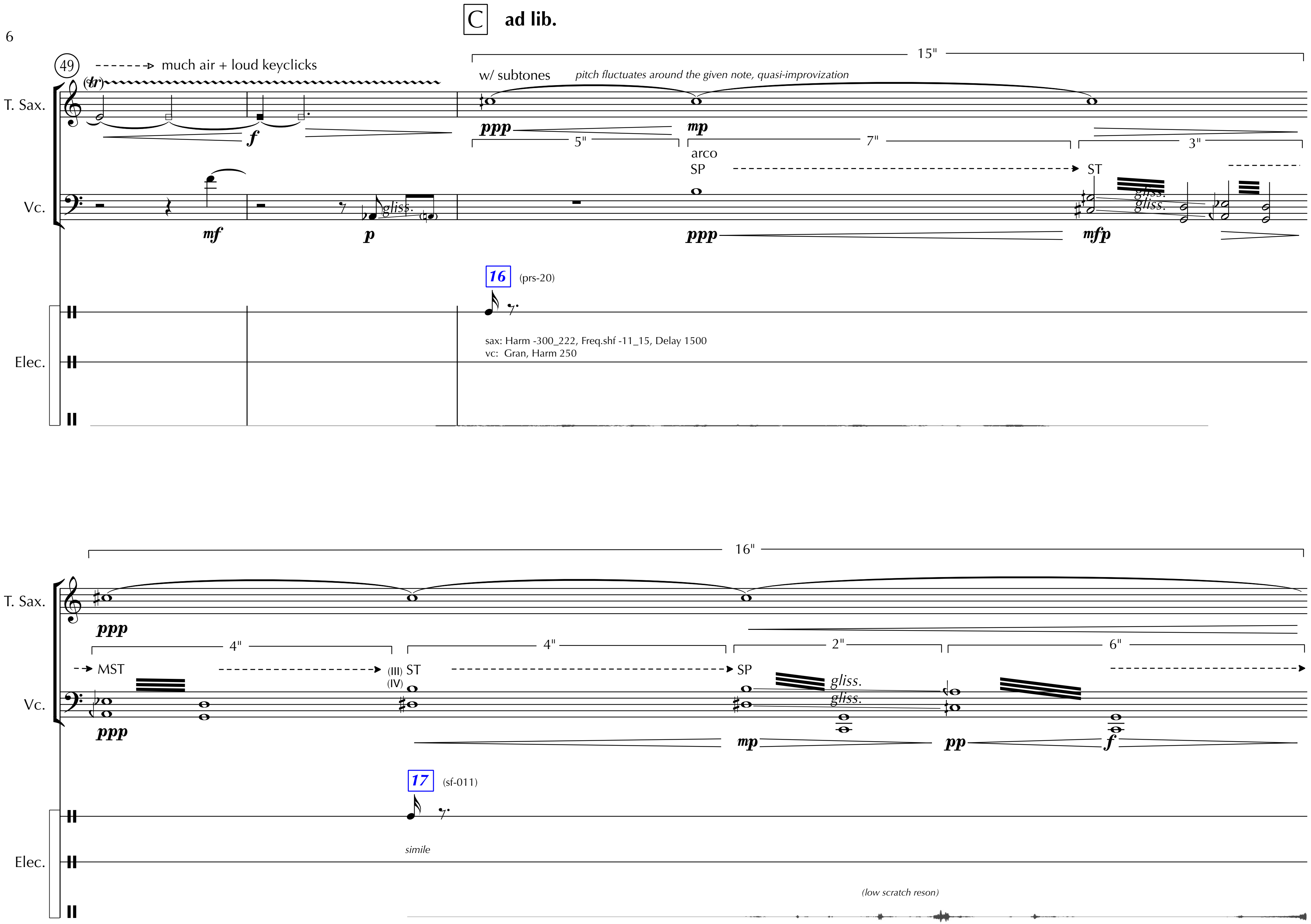


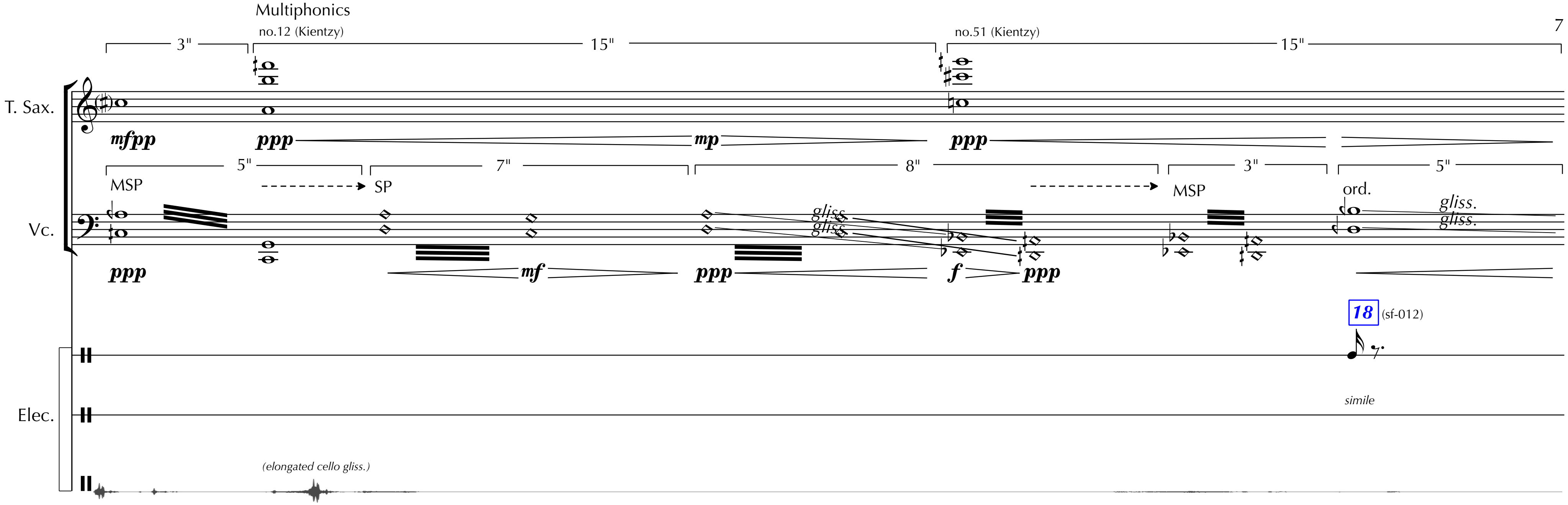

10
T. Sax.
Vc.
Elec.
tongue
ram
ff
"f"
mp
inhale
exhale
pp
p
pizz.
c.l.b.
pizz.
p
mf
f
mp
mf
mp
f
pizz.
p
mp
5
(prs-01, sf-004)
6
(prs-01, sf-005)
7
(sf-006)
sax: Harm -550, Freq.shf 400
vc: Gran, Harm -700
sax: Harm 1300, Freq.shf 600
vc: Gran, Harm 300
simile
(damped attack)
(infant hum)
(elongated cello gliss., infant sound)
15
T. Sax.
Vc.
Elec.
mp
mf
p
mp
exhale
mp
arco
ST
(III) crini e legno
crini
gliss.
gliss.
(ST)
mf
p
ppp
f
pp
mf
pp
f
8
(prs-02)
sax: simile
vc: Freq.shf 150, Gran, Harm -400
(mixed cello and saxophone)
(infant short sounds)
(elongated cello gliss.)
(longer elongated cello gliss.)

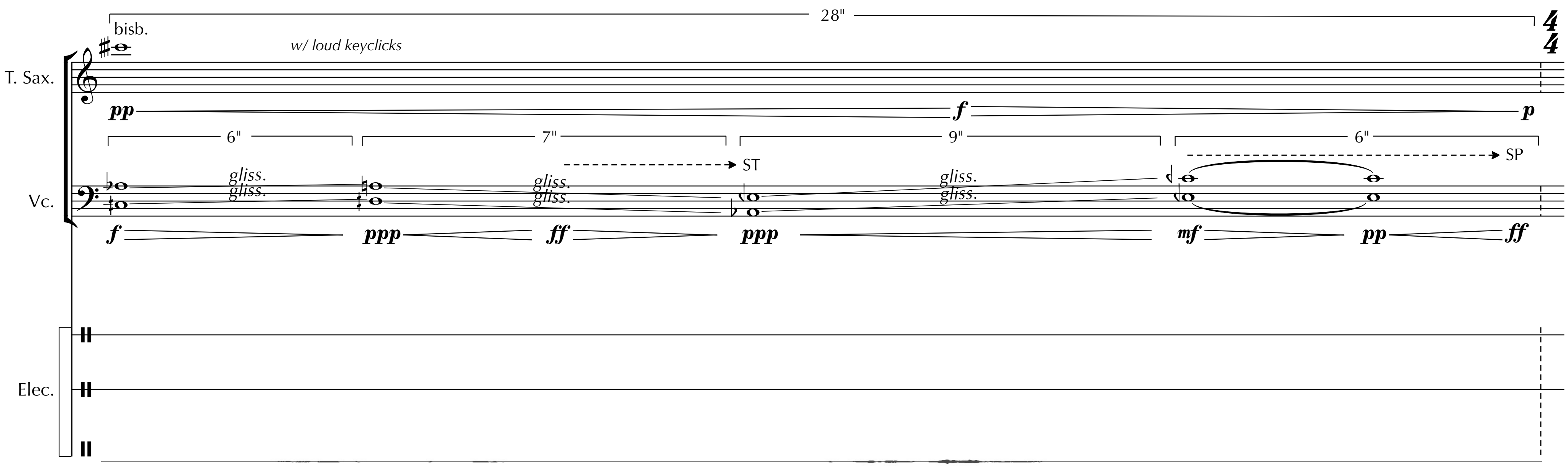

20
T. Sax.
Vc.
Elec.
"f"
mp
p
ord.
(IV)
Multiphonics
find the best position to generate the multiphonics
pp
mf
9 (prs-02)
10 (sf-007)
11 (prs-02, sf-008)
sax: simile
vc: Freq.shf 200, Gran, Harm -150_200
simile
sax: Harm 1300, Freq.shf 650
vc: Freq.shf 300, Gran, Harm -300
(short burp)
(elongated cello noise)
(mixed cello, saxophone, and infant sounds)
26
inhale
p
f
ca.10"
SP
pizz.
12 (prs-01)
sax: Harm 1300, Freq.shf 650
vc: Gran, Harm 300
(infant short sounds)
(high-pitched infant sound)
(low cello reson.)
(mixed cello, saxophone, and infant sounds)
(infant breath)

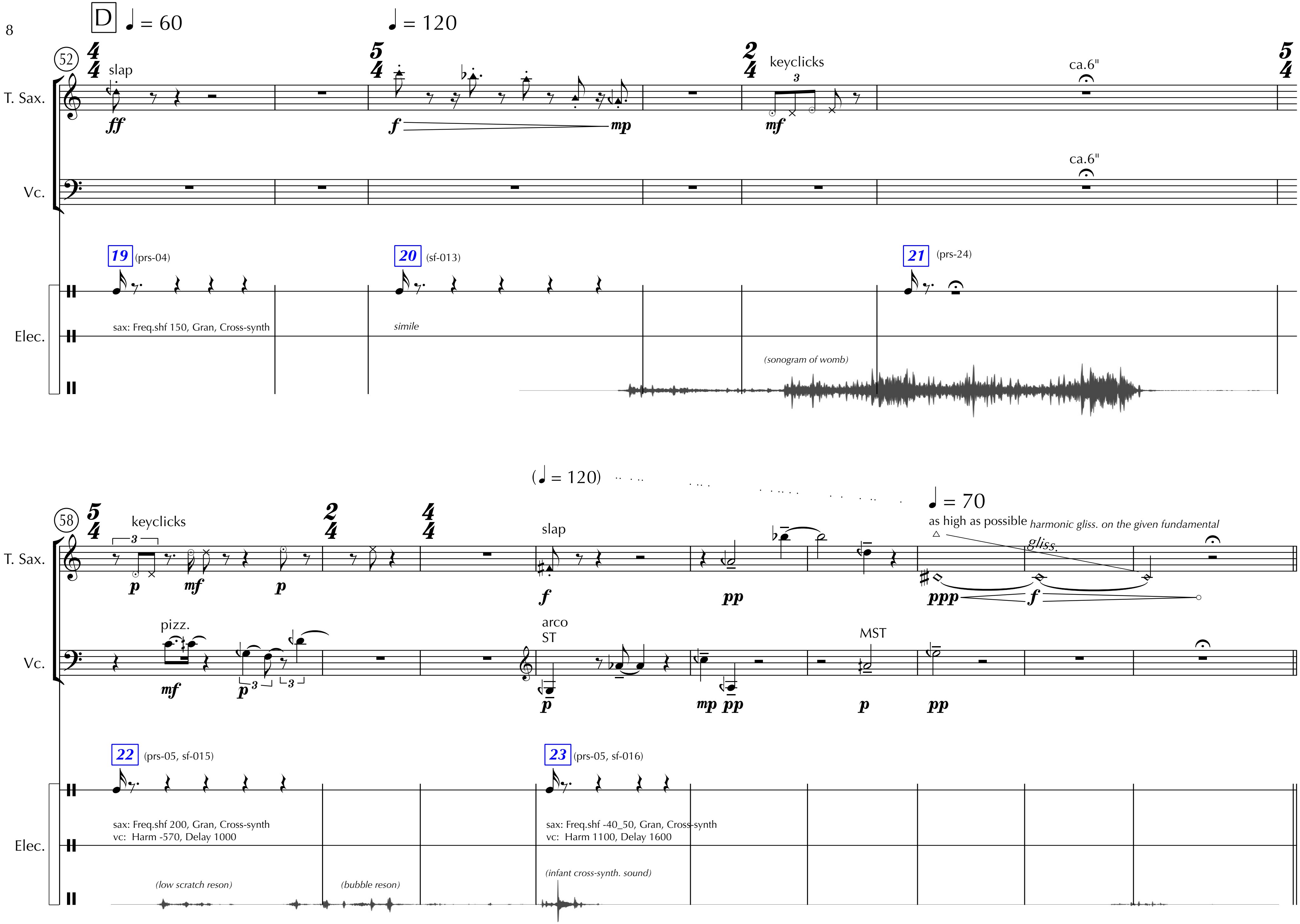

B
♩ = 104
32
T. Sax.
Vc.
m vib.
13
(prs-03, sf-009)
sax: Harm 200, Freq.shf -30_20, Delay 2600
vc: Gran, Harm 200
(infant hum)
Elec.
36
T. Sax.
Vc.
Elec.


40
T. Sax.
Vc.
Elec.
more keyclicks
m vib.
(IV)
14 (sf-010)
15 (prs-03)
simile
sax: Harm 150, Freq.shf -20_20, Delay 300
vc: Gran, Harm 100
(low scratch reson)
44
more pitches
gliss.
(elongated cello gliss.)

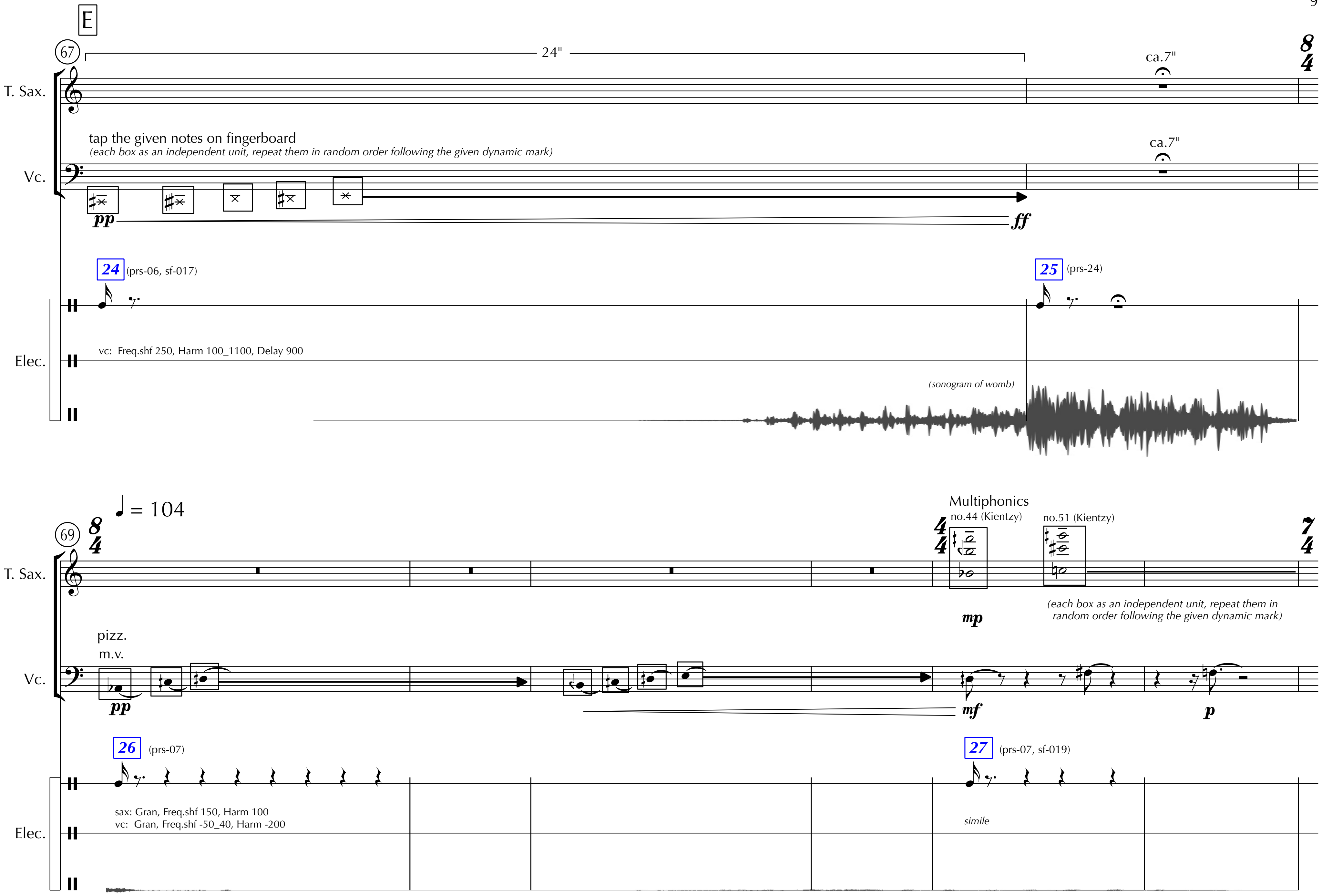

C
ad lib.
49
much air + loud keyclicks
15"
w/ subtones
pitch fluctuates around the given note, quasi-improvization
T. Sax.
(tr)
f
ppp
mp
5"
7"
3"
arco
SP
ST
Vc.
gliss.
mf
p
ppp
mfp
16
(prs-20)
sax: Harm -300_222, Freq.shf -11_15, Delay 1500
vc: Gran, Harm 250
Elec.
16"
T. Sax.
ppp
4"
4"
2"
6"
MST
(III) ST
(IV)
SP
gliss.
gliss.
Vc.
ppp
mp
pp
f
17
(sf-011)
simile
Elec.
(low scratch reson)

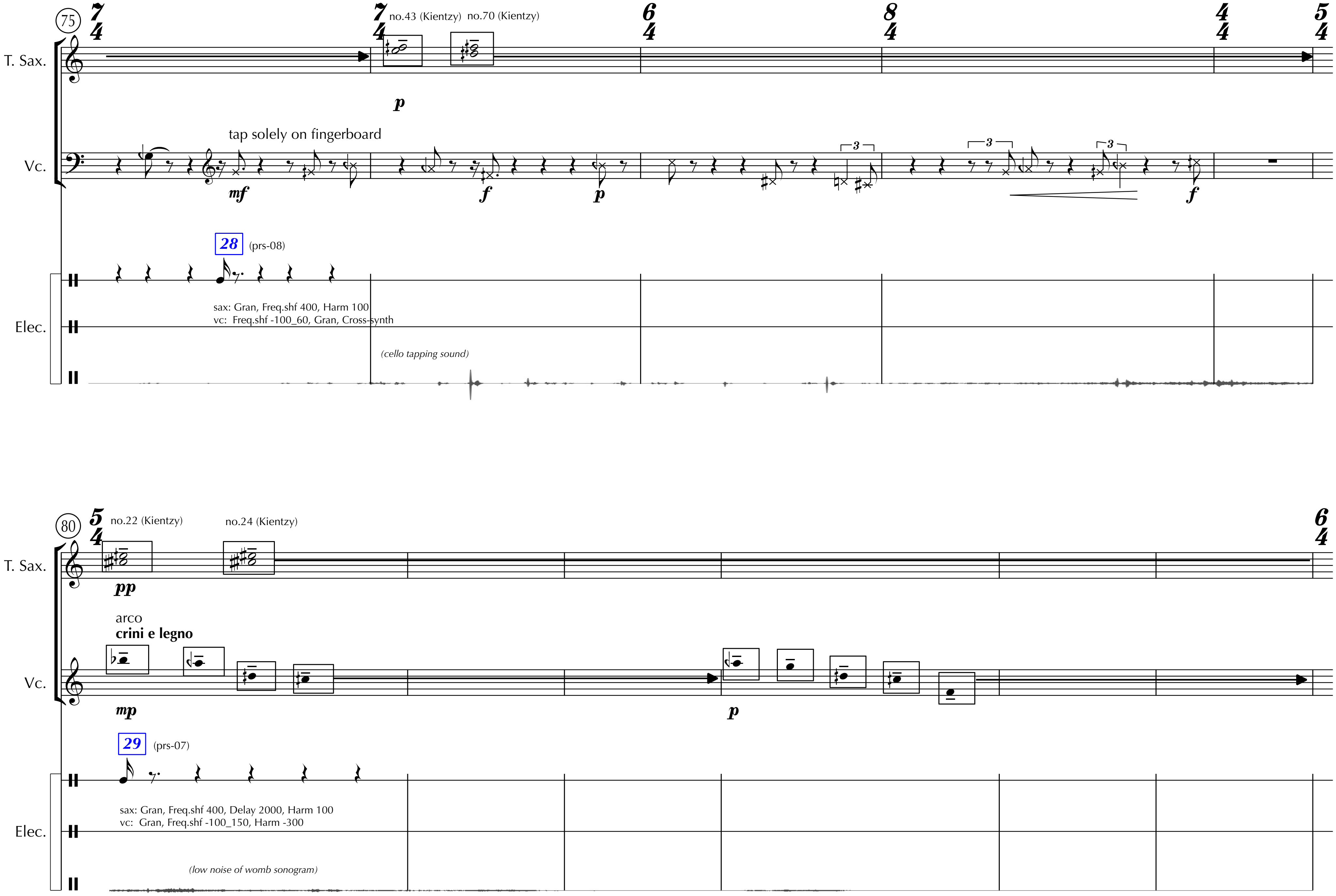

Multiphonics
no.12 (Kientzy)
no.51 (Kientzy)
3"
15"
15"
T. Sax.
mfpp
ppp
mp
ppp
5"
7"
8"
3"
5"
MSP
SP
MSP
ord.
gliss.
gliss.
gliss.
gliss.
Vc.
ppp
mf
ppp
f
ppp
18
(sf-012)
simile
Elec.
(elongated cello gliss.)


28"
bisb.
w/ loud keyclicks
4
4
T. Sax.
pp
f
p
6"
7"
9"
6"
ST
SP
gliss.
gliss.
gliss.
gliss.
gliss.
gliss.
Vc.
f
ppp
ff
ppp
mf
pp
ff
Elec.

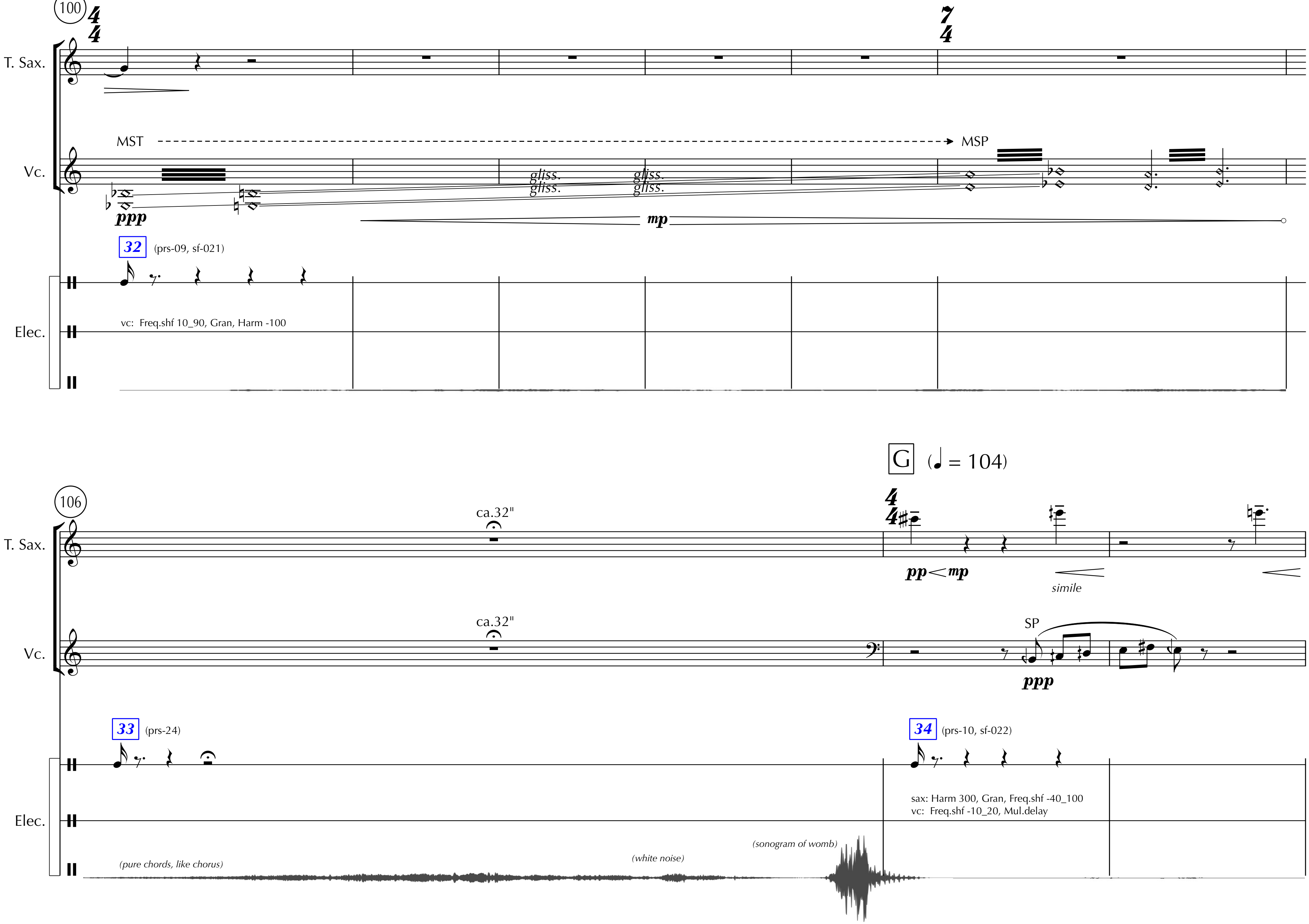

D
= 60
= 120
52
slap
keyclicks
ca.6"
T. Sax.
Vc.
19 (prs-04)
20 (sf-013)
21 (prs-24)
Elec.
sax: Freq.shf 150, Gran, Cross-synth
simile
(sonogram of womb)
(= 120)
= 70
58
as high as possible
harmonic gliss. on the given fundamental
gliss.
pizz.
arco
ST
MST
22 (prs-05, sf-015)
23 (prs-05, sf-016)
sax: Freq.shf 200, Gran, Cross-synth
vc: Harm -570, Delay 1000
sax: Freq.shf -40_50, Gran, Cross-synth
vc: Harm 1100, Delay 1600
(low scratch reson)
(bubble reson)
(infant cross-synth. sound)

II.

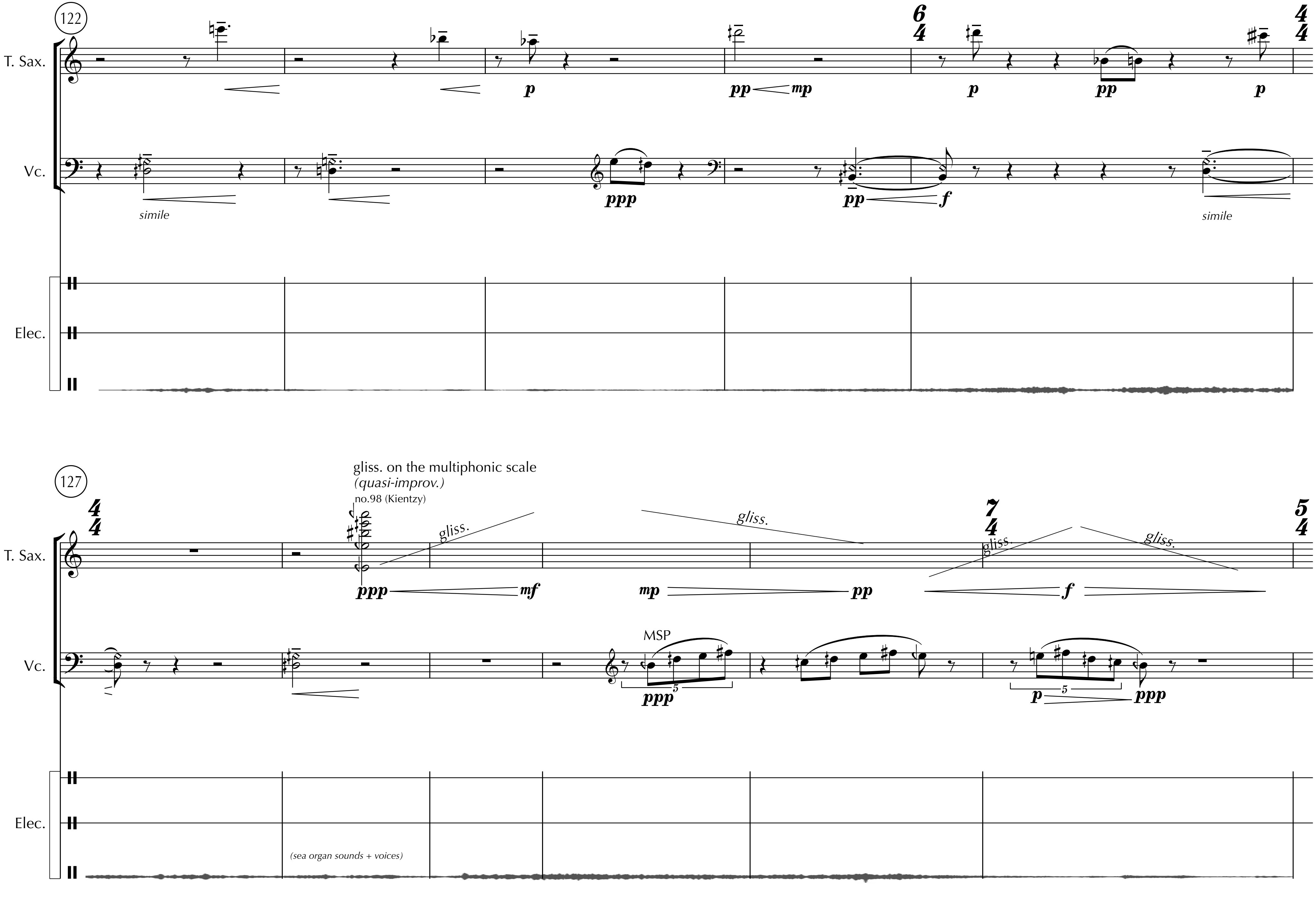

E
67
24"
ca.7"
T. Sax.
Vc.
Elec.
tap the given notes on fingerboard
(each box as an independent unit, repeat them in random order following the given dynamic mark)
pp
ff
24 (prs-06, sf-017)
25 (prs-24)
vc: Freq.shf 250, Harm 100_1100, Delay 900
(sonogram of womb)
69
♩ = 104
Multiphonics
no.44 (Kientzy)
no.51 (Kientzy)
mp
(each box as an independent unit, repeat them in random order following the given dynamic mark)
pizz.
m.v.
pp
mf
p
26 (prs-07)
27 (prs-07, sf-019)
sax: Gran, Freq.shf 150, Harm 100
vc: Gran, Freq.shf -50_40, Harm -200
simile

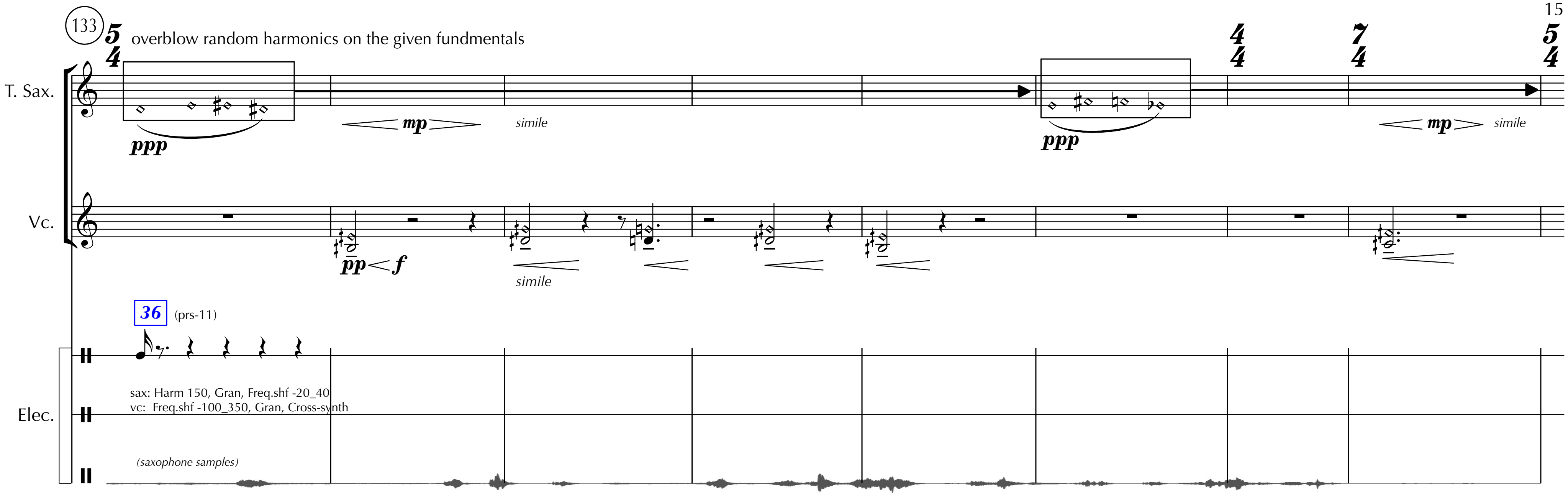

75
T. Sax.
Vc.
Elec.
no.43 (Kientzy)
no.70 (Kientzy)
tap solely on fingerboard
28
(prs-08)
sax: Gran, Freq.shf 400, Harm 100
vc: Freq.shf -100_60, Gran, Cross-synth
(cello tapping sound)
80
no.22 (Kientzy)
no.24 (Kientzy)
arco
crini e legno
29
(prs-07)
sax: Gran, Freq.shf 400, Delay 2000, Harm 100
vc: Gran, Freq.shf -100_150, Harm -300
(low noise of womb sonogram)

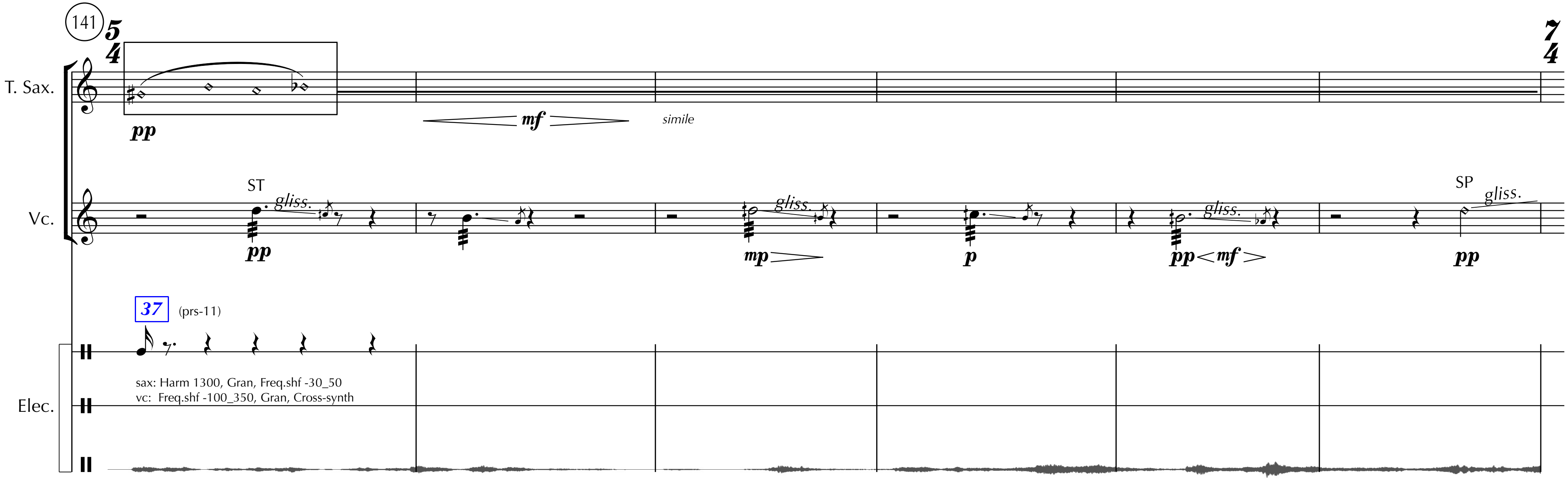

F
86
T. Sax.
Vc.
Elec.
SP
p
inhale
mp
w/ air
p
inhale
w/ air
pp
p
mp
30 (prs-07, sf-020)
sax: simile
vc: Gran, Freq.shf -100_550, Harm -500
31 (prs-07)
sax: simile
vc: Gran, Freq.shf -100_100, Harm -500
93
T. Sax.
Vc.
Elec.
inhale
mp
pp
pp
mf
gliss.
p
inhale
mf
gliss.
mp
pp
w/ air
p
w/ air
mp
pp

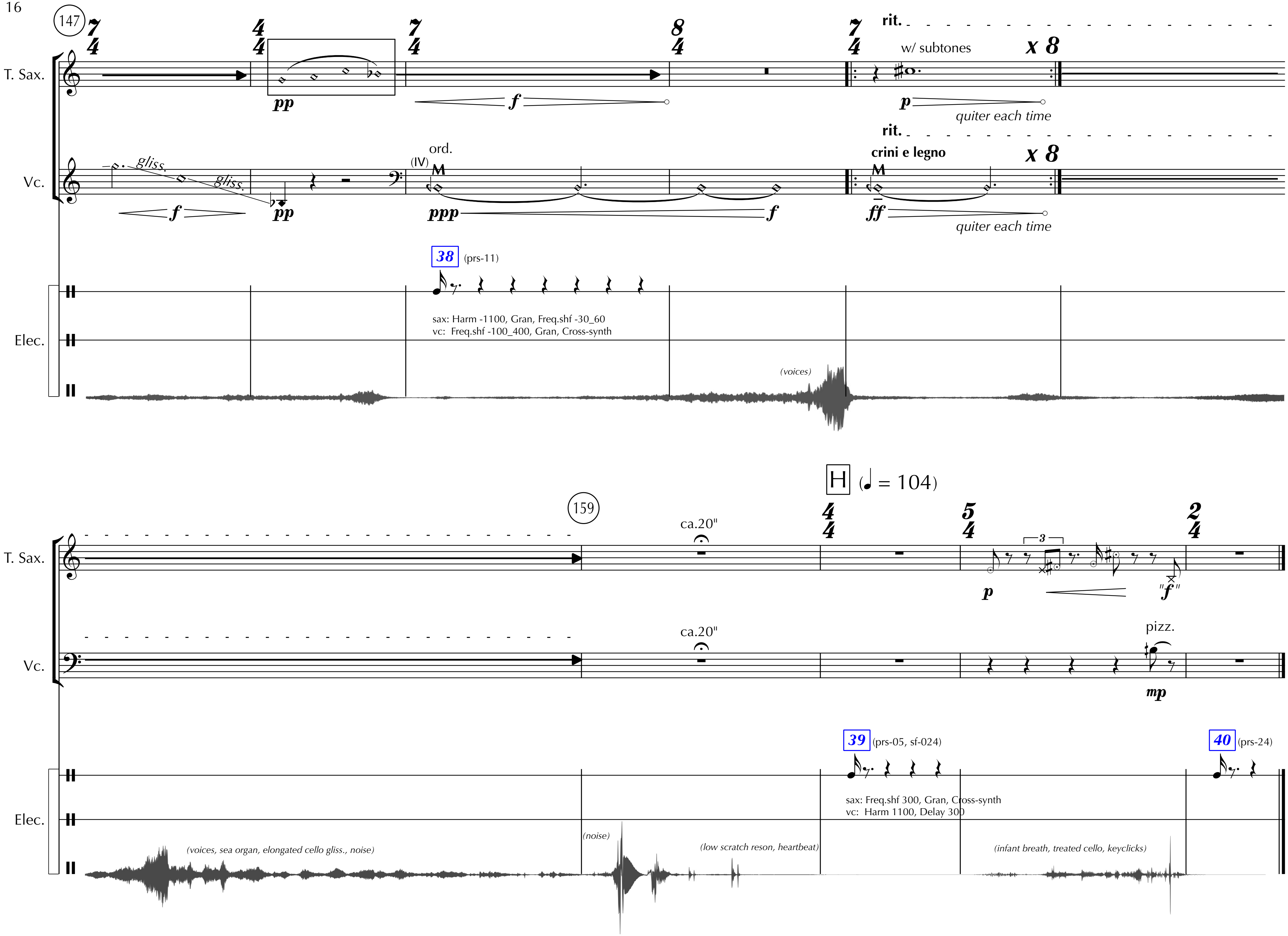

100
T. Sax.
Vc.
Elec.
MST
MSP
gliss.
ppp
mp
32
(prs-09, sf-021)
vc: Freq.shf 10_90, Gran, Harm -100
106
G
(♩ = 104)
ca.32"
pp
simile
SP
33
(prs-24)
34
(prs-10, sf-022)
sax: Harm 300, Gran, Freq.shf -40_100
vc: Freq.shf -10_20, Mul.delay
(pure chords, like chorus)
(white noise)
(sonogram of womb)


109
T. Sax.
Vc.
Elec.
MSP
(sea organ sounds)
115
simile
SP
crini e legno
gliss.
gliss.
(II)
(III)
crini
gliss.
gliss.
35
(prs-11)
sax: simile
vc: Freq.shf -20_35, Gran, Cross-synth
(sea organ sounds)


122
T. Sax.
Vc.
Elec.
simile
simile
127
gliss. on the multiphonic scale
(quasi-improv.)
no.98 (Kientzy)
gliss.
gliss.
gliss.
gliss.
MSP
(sea organ sounds + voices)


133
overblow random harmonics on the given fundmentals
T. Sax.
ppp
mp
simile
ppp
mp
simile
Vc.
pp
f
simile
36
(prs-11)
sax: Harm 150, Gran, Freq.shf -20_40
vc: Freq.shf -100_350, Gran, Cross-synth
Elec.
(saxophone samples)


141
T. Sax.
pp
mf
simile
Vc.
ST
gliss.
pp
gliss.
mp
p
gliss.
pp
mf
SP
gliss.
pp
37
(prs-11)
sax: Harm 1300, Gran, Freq.shf -30_50
vc: Freq.shf -100_350, Gran, Cross-synth
Elec.


147
T. Sax.
Vc.
Elec.
rit.
w/ subtones
x 8
quiter each time
gliss.
ord.
(IV)
crini e legno
38 (prs-11)
sax: Harm -1100, Gran, Freq.shf -30_60
vc: Freq.shf -100_400, Gran, Cross-synth
(voices)
H (♩ = 104)
159
ca.20"
pizz.
39 (prs-05, sf-024)
40 (prs-24)
sax: Freq.shf 300, Gran, Cross-synth
vc: Harm 1100, Delay 300
(voices, sea organ, elongated cello gliss., noise)
(noise)
(low scratch reson, heartbeat)
(infant breath, treated cello, keyclicks)