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Technology and Composition — An autoethnography on the influence of electronics on orchestration practice

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"Often, we notate very carefully and play to the orchestra some crazy patches. I sit with the orchestra and say, 'Okay, how can you guys 'synthesize' this out of woodwinds, basses, and cellos – imitating the electronics and come up with a sound that nobody's heard before?' It's sort of intellectual patching within the orchestra."[1]

Hans Zimmer

Author declaration

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[1] Bjørn, Meyer, and Nagle, *Patch & Tweak*, 35.

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1. Abstract

This research explores novel methods of orchestration, focusing on the influence of electronics on my own orchestration practice. By drawing upon electronic music composition techniques and timbral-shaping tools, this project addresses the boundaries of orchestration and examines processes that inform orchestration decisions. Through the resulting portfolio, I explore timbral blend, spatialization and acoustics, real-time orchestration, computer-aided/assisted orchestration, and the extension of the timbral palette by rethinking the ideals of spectral composition. These methods aim to create unique sound worlds and audience experiences while situating my distinctive approach in relation to other existing practices. Furthermore, a supporting commentary illuminates the deep pre-compositional research that informs my orchestration practice by identifying the techniques and evaluating their application.

To explore such concepts, it is vital to conduct practice-led autoethnographic research. This allows for full, creative exploration and application of site-specific and acoustic/electronic tools. Through recognizing the impact of electronics on my approach to orchestration, I have made exciting discoveries in this field by integrating electronic and non-electronic systems, forming what I regard as my orchestration discourse.

The radical overhaul of my orchestration approach has served to highlight just how much more work there is to be made in the realm of human-machine creative collaboration and that sound has many more lessons to teach me. This research marks a ‘checkpoint’ of life-long research as contemporary arts and science work hand in hand. We cannot disregard the fact that the gap between the world of instrumental music and electronic music is still too unexplored in the timbral-based orchestration domain.

Keywords: autoethnography; technology; electronics; timbre; orchestration.

2. Acknowledgments

To my grandfather, Agostinho de Oliveira Pinto who proudly insisted on calling me a Doctor.

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To Kate Simko, Jane Chapman, Dr. Ichiro Fujinaga, Michael Ladoucer, Roger Reynolds, Tim Watts, and Tania Lisboa for the mentorship.

To all the funding artists, ensembles, festivals, and institutions, with whom I had the opportunity to work: Academia de Música de Óbidos; Anna Kim; Banda Sinfónica Portuguesa; Braga '27; Braga Media Arts; Calouste Gulbenkian Orchestra; Cat's Cradle Collective; Embassy of Portugal in the United Kingdom; Festival ECOS Urbanos; Festival Internacional de Órgão de Braga; Festival Música Viva; Frederic Cardoso; Fundação da Juventude; Fundação para a Ciência e a Tecnologia; Fundação Portuguesa das Comunicações; GNRATION; Jan Wierzba; José Eduardo Gomes; Julien Gaillac; Leões de Portugal; Museu Nacional da Música; Música Viva Festival; Nexso Festival; Orquestra Clássica do Centro; Portuguese Republic — Ministry of Culture; Prémio Jovens Músicos; RE:FLUX '16 Festival de Musique et d'Art Sonore; Ricardo Pires; Royal College of Music London; Royal Music Association; Rowan Jones; SONIC MATTER: PLATFORM FOR EXPERIMENTAL MUSIC Festival; Theatro Circo; The ACTOR Project; The Hermes Experiment; Union Chapel; University of Évora; University of Greenwich and University of Plymouth.

Finally, I am dedicated to my art, and my art is dedicated to all of you, *the audience.*

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© Permission to reproduce this excerpt has been granted by Carmine-Emanuele Cella.

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4. Portfolio

These works are listed chronologically. Over the course of the portfolio, there is an overarching shift away from intuition and 'classical' notation, moving through the traditional spectral ideals, ending with the most recent practice that engages with newer computer-aided/assisted techniques and technologies.

1. ***Moving Sources***, for chamber orchestra (2019)
    - Honourable Mention at the *III Prémio de Composição Francisco Martins 2019* by Orquestra Clássica do Centro.

2. ***Flux***, for two Iberian organs (2019~2020)
    - Honourable Mention at the *Prémio Internacional de Composição Pedro de Araújo 2ª Edição* by Festival de Órgão de Braga.

3. ***Impasto***, for wind orchestra (2020)
    - 1st Prize in the IX Concurso Nacional de Composicão Banda Sinfónica Portuguesa (PT)

4. ***Point of Departure (A&B)***, for symphony orchestra (2019~2020)
    - 1st Prize at *Prémio de Composição SPA / Antena 2 2020 9ª Edição* (PT)
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5. ***Braga Capital Europeia da Cultura 2027 Banda Sonora***, for film (2020)
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    - Commissioned by GNRATION (PT)

13. ***Suivi***, for bass clarinet and electronics (2021~2022)
    - With funding from the Portuguese Republic — Ministry of Culture

14. ***Keep up!***, for alto saxophone and live electronics (2022)
    - Commissioned by Ricardo Pires (PT)

15. ***BLUR 2.0***, for an audio-visual installation (2022)
    - Commissioned by Braga ’27 and Braga Media Arts (PT)

16. ***Nuances***, for string quartet and live electronics (2020~2023)
    - With funding from the Royal Music Association (UK)

"Year of classical music training never actually taught me how to listen to sound as my practice on the Buchla [synthesizer] did. (...)

In my experience, music always comes out of a process of negotiation between the design of the technology and the human imagination, rather than a simple imposition of an idea upon passive matter."[2]

Catarina Barbieri

5. Introduction

I have been learning music since I was five years old, and specifically composition since I was thirteen. However, ever since I began to dwell in the world of technology and electronics applied to music making, I noticed a strong shift in my way of thinking about sound, and most importantly the way I was acknowledging and 'hearing' sound. It seemed to me that the strongly enrooted, traditional, and 'classical' ideas of 'musical score', 'pentagram', 'pitch', 'musical instrument', and 'notation', had all but their meanings blurred from my newly developed perspective.

Initially, my compositional and orchestration practice was mostly based on intuition. I was not using a pre-compositional schema as can be often used in spectral music to form the basis of 'a composition' according to a given spectra. Even though my creative process has evolved since then, I still believe intuition to be a key element of one's creativity or 'original voice' as it is often referred to.

Thus, I spent the following years producing works with/without electronics and researching the multiscale technical implications of dealing with technology and electronics in music-making scenarios as part of both my licentiate and master's

[2] Bjørn, Meyer, and Nagle, *Patch & Tweak*, (324).

degree.[3] To this day, as I progressively continue to deepen my knowledge of these tools, the more I notice my 'sonic awareness' shifting.

In September 2019, I enrolled at the Royal College of Music London with the will to further follow up with my previous research, deepen my knowledge and practice with tools that I have not used before, and develop new electronic-informed orchestration resources.

Hence, in this research I explore emerging methods of orchestration, focusing on the influence of technology and electronics on my orchestration practice.

5.1 Research questions

This project examines how enriching the composer's technological knowledge of and interactions with timbre can alter and enhance the process of orchestrating sound in an electronic or instrumental environment. Here, I use the term 'technology' to describe the physical properties of both acoustic and electronic instrumental ('hardware') and spatial design. On the other hand, the term 'electronics' is utilized to describe the processes of timbral blending techniques often found in electronic music composition. My research poses the following questions:

In what ways can technology and electronics influence the timbral result of my orchestration practice?

Throughout this discussion, some other secondary questions will arise and be addressed by this research, such as:

[3] [Suggested Readings] Ramos, '*De que maneira o conhecimento tecnológico do som altera a nossa perceção composicional para o instrumento acústico*'.; Ramos, '*A ELETRÓNICA COMO ELEMENTO COMUM EM OBRAS PARA FORMAÇÕES DIVERSIFICADAS: A SUA VERSATILIDADE, ESTRATÉGIAS COMPOSICIONAIS E SOLUÇÕES PERFORMATIVAS*'.

— How can sound synthesis, signal flow, and signal processing techniques influence orchestration practice?
— In what ways can techniques of electronic music composition inform orchestration and/or timbral blend?
— How might one embrace physical (i.e., acoustics) and physiological (i.e., human) constraints in the means of electronic-informed orchestration?
— In what ways does computer-aided/assisted orchestration further impact orchestration processes, and consequently, their results?
— Which sounds might optimally be addressed by instrumental synthesis?
— What notational issues and solutions arise from the above techniques?

5.2 Methodology

For this project, I have conducted practice-led research based on an autoethnographic method of my creative practice, both as a professional composer/sound artist and an electronics performer. This has allowed for in-depth exploration of techniques in practice and in-depth reflection on my compositional and orchestration process documented through work diaries and sonic experiences (i.e., workshops, recordings, remote meetings, hands-on with hardware, amongst others).

> *"As methodology for understanding culture, autoethnography explores the position and perspective of the researcher as the central subject of study, presenting the researcher's personal experiences, often through layered writing practices which generate interwoven self-narratives."*[4]

Thus, "as a method, autoethnography is both process and product."[5] I have applied intuition, as in the ability to understand and predict an outcome without the need for conscious reasoning as a result of long-standing experience and practice, and systematic approaches, as I will further describe, to electronic-informed timbral blend and nonelectronic synthesis techniques (i. e., sound synthesis that recurs solely on acoustic instruments) with and without computer-aided/assisted software in works

[4] Findlay-Walsh, '*Sonic Autoethnographies*', 122.
[5] Ellis, '*Autoethnography: An Overview*', 1.

for diverse formations with and without the use of electronics. These oriented responses to materials allow for a unique response to electronic and acoustic sound worlds in situations where blend is either an aim or something to avoid. Timbre is here used to describe the character or quality of a produced sound in its total capacity (i. e., considering individual or the sum of all sound descriptors). On the other hand, blend refers to the spectral fusion between timbres. However, this does not imply that there needs to be a high degree of blending for an orchestration to prove successful. Often, the aim of an orchestration solution can be the exact opposite as with soloistic passages.

This method of conducting research is key for a critical exploration of the challenges of systematic software approaches vs. intuitive ('ear-led') approaches. This is a major step in defining my process of orchestration since the performance medium, the number of instruments, and the respective positional layout on stage are key modulators of an orchestration approach. Thus, this research explores several ways in which electronic and instrumental domains intersect through my creative practice, from material research (i.e., pre-compositional research of materials) to performance.

5.2.1 Limitations

All the works in this portfolio are the result of commissions and/or awards. In practice this led to creating my artistic work according to some given constraints. These could range from duration; conceptual briefs (narratives); instrumentation (the available instrumental array and both the physiological and professional characteristics of its performers); social (COVID-19 pandemic and/or remote (online) rehearsals/recordings/performances); venues (physical properties of space); funding (the budget available for research, creation, and performance), and lastly, the medium (chamber, orchestral, mixed, acousmatic, live-electronics, soundtrack, film and site-specific installation. Nevertheless, these constraints did not hold me back from exploring the research questions in full.

Additionally, while some context is provided in this commentary regarding the history of computer music and computer-aided/assisted orchestration tools, the focus of this research is not to present an extended catalogue of electronic-informed orchestration techniques and/or an in-depth technical manual on all the available technologies. Rather, the aim is to examine, through reflection and analysis, the emergence of new orchestration practices.

"The industrial revolution made the production of an instrument like this [Piano] possible. Several planks of wood, six I think in this case are overlaid and pressed into shape by tremendous force for six months.

Nature is molded into shape. Many tons of force and pressure are applied, making the strings what they are. Matter taken from nature is molded by human industry, by the sum strength of civilization.

Nature is forced into shape. Interestingly, the piano requires re-tuning. We humans say it falls out of tune. But that's not exactly accurate. Matter is struggling to return to a natural state."[6]

Ryuichi Sakamoto

6. '*Technology and the Composer*'[7]

The "search for new ideas and materials"[8] has always played a special part in the role of composers throughout the evolution of music, especially during the 20th and 21st century's discoveries of new colours and timbres.

One key example of this mindset is the work of Luigi Russolo (fig. 1), who in 1913 introduced the world to one of the most important influential texts in 20th-century musical aesthetics, *L'arte dei Rumori ('The Art of Noises')*. In this Futurist manifesto, he begins by acknowledging that musical art was approaching the noise-sound domain. For him, this revolution in music was paralleled by the increasing proliferation

[6] *Ryuichi Sakamoto: CODA*.
[7] [Suggested Reading] Boulez, '*Orientations*'.
[8] Murail, '*After-Thoughts*', 269.

of machinery in human labour, where the predominance of many varied noises meant that pure musical sound with its simplicity and purity would fail to arouse any emotion.

Russolo also defined a set of six categories of noises for the futurist orchestra. This new approach to the classification of sounds based on timbral characteristics was a major step towards aligning the composer with modern technology and the new world of sounds. He further proposed a new set of ideas on how machine technology informed his compositional approach and could extend the composer's instrumental timbral palette by embracing the infinite variety of timbres found in nature.

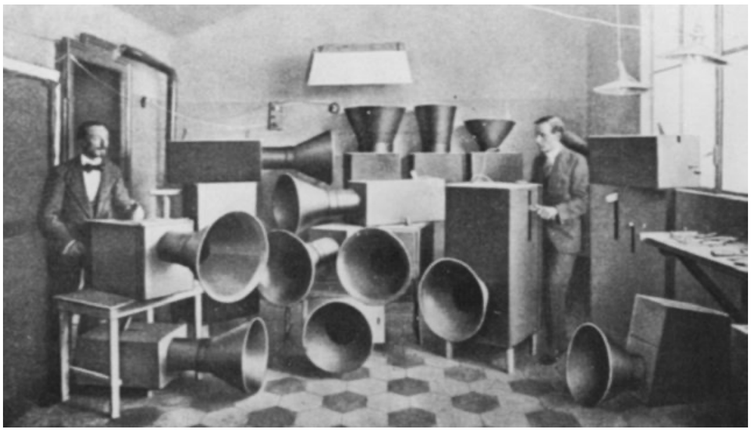

Figure 1 — Luigi Russolo [left] and Ugo Piatti [right] presenting the *Intonarumori* at Luigi Russolo's laboratory in Milan, 1914. Public domain.

Fast-forward thirty-five years and it is possible to observe the significant impact this manifesto had on composers such as Edgar Varèse (1883-1965), with the birth of avant-garde music.[9] Meanwhile, another invention was taking its first steps (from c. 1936) to become what we know today as the computer. Music influenced by technology was a fundamental pillar for the formation of new philosophies and ways of working the musical material. Therefore, this device would confirm to be one of the most important milestones of electronic music. By analysing Varèse's music, Milton Babbit states the following:

[9] [Suggested Reading] Mauceri, '*From Experimental Music to Musical Experiment*'.

> "*Such concern with and structural utilization of the timbral consequences of dynamic, registral, and durational values approach the condition of nonelectronic "synthesis," and if the presence of such procedures suggests one of the many musical dispositions that led Varèse the need for the electronic medium, then his eventual experiences with and composition for that medium seem to have "fed back" into his instrumental procedures. The synthetic separability of the attack and "steady-state" portions of the event (or, in the case of the percussive sound, the attack and decay portions) suggested the analogous construction of instrumental sounds combining constituent instruments into a resultant instrumental totality*."[10]

This exploration of the constituent components of sound was a radical step towards conceiving instrumental compositional practice as a kind of 'synthesis'. Varèse's work, *Ionisation* (1929-1931) for a percussion ensemble of thirteen players (fig. 2) is a remarkable example of this nonelectronic synthesis approach. In measure 7, Varèse's orchestration approach is informed by the technique of analogue tape splicing and editing, where the attack and decay can be found to crossfade between the 5th and 2nd percussion sets. Moreover, the use of unnatural (in this case, reversed) instrumental dynamics (see 5th percussion set), was another influence of electronic music obtained by the modulation possibilities introduced by analogue tape editing (i. e. reverse playback of a recorded sound) and the analogue mixer (i. e. amplitude modulation by altering the usual 'envelope' of sound. This helped the composer to hide, dissolve, enhance and/or shape the 'attack' of the instrument, given that "sounds blend better when they have similar attacks (…), and the timbre resulting from the blend is primarily determined by the attack of the impulsive sound and the spectral envelope of the sustained sound.[11] Applying these new 'electronic' techniques in the instrumental domain allowed for new timbral possibilities.

[10] Babbitt, '*Edgard Varèse: A Few Observations of His Music*', 20-21.
[11] McAdams and Goodchild, '*MUSICAL STRUCTURE: Sound and Timbre*', 133.

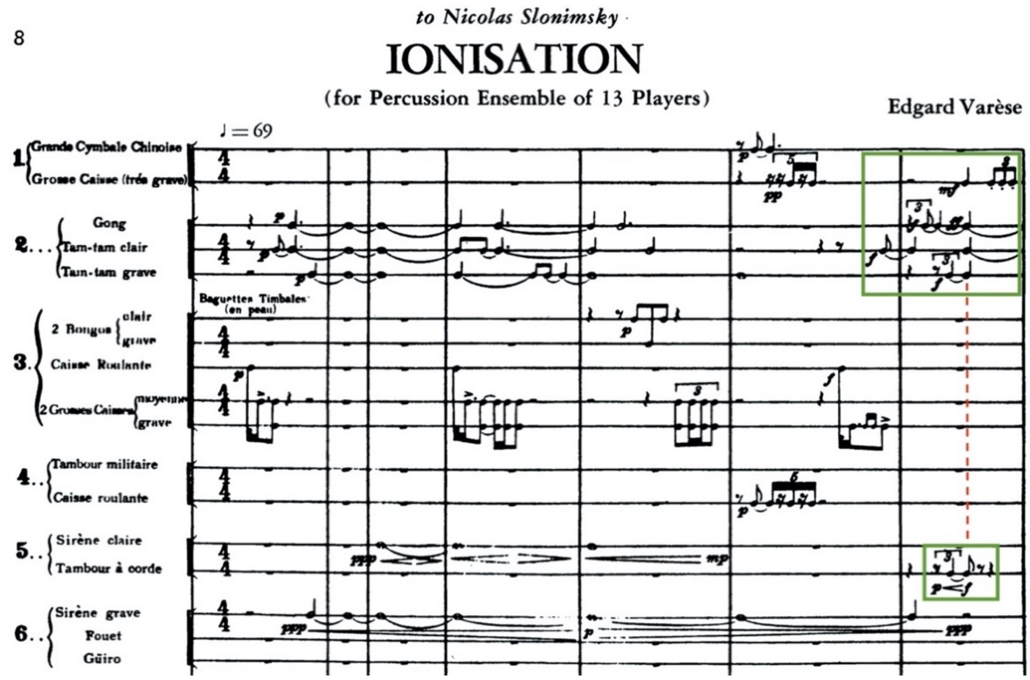

Figure 2 — An excerpt [1st page; first 6 percussion sets] of the work *Ionisation* (1929-1931) for thirteen percussionists by Edgard Varèse.

In 1948, despite the existence of some reports that indicate other previous experiences with magnetic tape recorders since 1935, Pierre Schaeffer's *Étude aux chemins de fer ('Railway Study')* was generally acknowledged to be the first example of *musique concrète*, which pioneered the intersection between modern analogue technology (i.e., magnetic tape recorder) and compositional practice. This new 'direct' approach of working with recorded sound objects ('*objects sonores*') influenced many subsequent generations of composers, including: Edgard Varèse (1883-1965), John Cage (1912-1992), Iannis Xenakis (1922-2001), György Ligeti (1923-2006), Luciano Berio (1925-2003), Jean-Claude Risset (1938-2016), Jonathan Harvey (1939-2012), Gérard Grisey (1946-1998), Tristan Murail (b. 1947), among others.

John Cage noted that the arrival of magnetic tape "has the liberating effect of allowing the composer to place a sound at any point in time at any tempo"[12] and to "invent sounds that do not exist in nature or radically transform natural sounds into new

[12] Holmes and Holmes, '*What Is Electronic Music?*', 11.

instruments."[13] Giacinto Scelsi (1905-1988) was amongst the other composers who also sought inspiration from the tape recorder.[14]

Furthermore, recording technology did more than just inform compositional practice; it facilitated the development of radically new compositional, orchestration, and performance practices. Thus, "by discussing the music in this way, I hope to acknowledge the unavoidable influence of technology on the composer,"[15] and the multi-layered role of computer in music making practice, such as:

- **The computer as an assistant**, by allowing the manipulation of "symbolic musical objects (e.g., notes, chords, rhythms, and melodies)"[16] or "sound processing, analysis, and synthesis, leading to a deeper comprehension of many aspects of sound and its perception."[17] These computer-driven analytical procedures are often associated with the field of spectral music, which generally relies on computer-aided/assisted composition and/or orchestration software[18] such as OpenMusic; PWGL; ORCHIDEA (fig. 3) and/or Max/MSP;

Figure 3 — Excerpt of some suggested orchestration solutions used in *Point of Departure* (2020). Orchidea v0.6.1 (Build date: 18 Mar 2020) using IRCAM FullSOL Orchestral Database.

[13] *Ibid*, 9.
[14] [Suggested Reading] Murail, '*Scelsi, De-Composer*'.
[15] Holmes and Holmes, '*What Is Electronic Music?*', 5.
[16] Carpentier and Bresson, '*Interacting with Symbol, Sound, and Feature Spaces in Orchidée, a Computer-Aided Orchestration Environment*', 10.
[17] [Suggested Reading] *Dahan, Brown, and Eaglestone, 'New Strategies for Computer-Assisted Composition Software: A Perspective*'.
[18] [Suggested Reading] Cella, '*Orchidea*'.

- **The computer as an instrument or a tool (as a subsection of an electronic instrument)**, given that the computer can serve as a completely new tool with no analogue predecessor. As an example, granular synthesis[19] is a digital mechanism of sound synthesis that thrived since the dawn of computer music. Thus, similarly to anything that can produce sound, any computer process can act as an instrument by itself or be part of a wider network of intertwined computer-driven processes. This not only allows the composer to develop their own electronic instruments (microscopically), but it opens the door to the realm of developing the framework where they can be performed (macroscopically) (fig. 4). Computer software is the natural successor and most often the replacement of old technology, such as the tape recorder. It is now possible to record and duplicate an endless number of lossless audio tracks with low latency;

Figure 4 — The second performance (#2) of my *solo* live-electronics work entitled *Song of Happiness #* at Festival Música Viva 2018 in Belém, Portugal. Performed by myself.
© Permission to reproduce this photo has been granted by Miso Music Portugal/O'culto da Ajuda.

[19] [Suggested Reading] Truax, '*Composing with Real-Time Granular Sound*'.

- **The computer as an extension of a 'given' instrument** as is usually found in mixed music (also known as hybrid music), where a composition uses both acoustic and electronic sound sources. However, the latter can be entirely composed of previously recorded material (often mentioned as tape, in reference to the now obsolete tape recorder); real-time processing of an acoustic instrument, even though there is always some amount of latency associated with 'real-time' generation of events, or a mixture of both. A key factor to retain is that in this case, the electronics are always dependent on an incoming audio signal. In *Keep up!* (fig. 5) the electronics are not able to synthesize anything from the get-go. The chosen devices, as seen in the bottom right corner, are meant to shape the incoming audio signal from the alto saxophone into a derivative of its timbre. Thus, in instrumental extending electronics, the processes are often used to enhance or deconstruct the incoming sound source while often keeping most of its original timbral properties. Nonetheless, this raises some questions as "to find a right balance between the amount of information or data concerning the electronic part, with respect to the traditional score writing."[20]

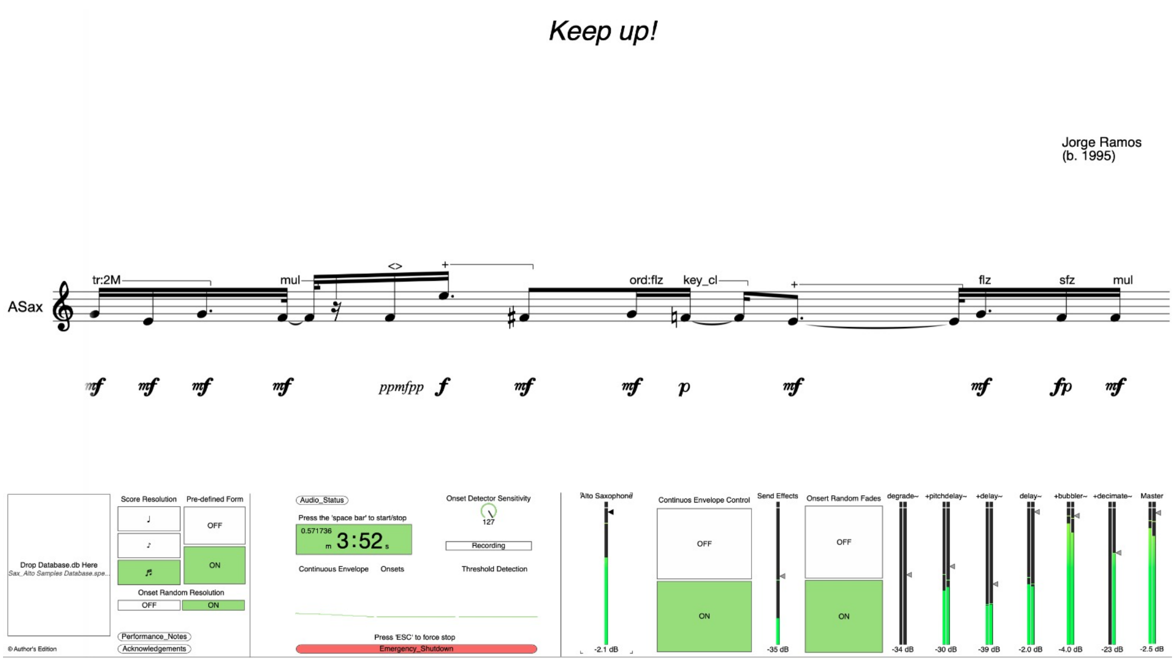

Figure 5 — Screenshot of the Cycling '74 Max/MSP Patch used for *Keep up!*

[20] Nouno, '*BUSINESS MODEL, A PIECE FOR VIOLIN, CELLO AND LIVE ELECTRONICS*', 31.

Compositional practice has been transformed by the computer, but arguably technology has led to a divergence between music that is electronic and instrumental (acoustic). For me, the possibilities of timbral processing afforded by computers has led me to widen my perception of hearing and working with sound, and consequently reimagine what I consider to be a musical instrument. I no longer see myself working under fixed traditional aspects of orchestration and instrumental/tonal timbral priorities. My approach to orchestration has shifted from being instrument-based to timbre-based. Therefore, I looked at this creative dilemma where electronic and non-electronic synthesis defines my way of orchestrating and blending timbres.

"Our musical alphabet must be enriched. We also need new instruments very badly.... (…)

Speed and synthesis are characteristics of our own epoch. We need twentieth-century instruments to help us realize them in music."[21]

Edgard Varèse

7. (Orchestra)tion as Instrumental Synthesis

As composition, orchestration is usually acknowledged as a subsection of some other wider disciplines transversal to multiple art forms. In music, orchestration is traditionally defined as "the art of selecting and arranging instrument sounds to obtain a given timbre for a musical intention"[22] by requiring "an outstanding comprehension of the complex relations between symbolic musical variables (e.g., pitches, dynamics, playing styles, ...) and the resulting timbre as a sound phenomenon."[23] In my opinion, the term 'orchestration' refers to the application of timbral shaping techniques in an orchestral setting whereas composition is a broader discipline and can be defined in music as the art of placing sound — in every shape or form — in a given time frame. Conversely, in a broader sense, timbral blend works by blending materials to obtain an intended result — that may constitute non-blended sonorities — in any medium.

Here lies one, among many, of the difficulties in formalising orchestration, the involvement of timbre, as acknowledged by many composers and researchers such as Yan Maresz[24], Kendall & Carterette[25], and Carmine-Emanuele Cella,

> *"Though there is a vast literature on the definition of timbre, it remains a difficult concept to formalise. The gap that exists between the notated*

[21] Wen-Chung, '*OPEN RATHER THAN BOUNDED*', 1.
[22] Tardieu and Rodet, '*AN INSTRUMENT TIMBRE MODEL FOR COMPUTER AIDED ORCHESTRATION*', 347.
[23] Carpentier, Assayag, and Saint-James, '*Solving the Musical Orchestration Problem Using Multiobjective Constrained Optimization with a Genetic Local Search Approach*', 682.
[24] [Suggested Reading] Maresz, '*On Computer-Assisted Orchestration*'.
[25] [Suggested Reading] Kendall and Carterette, '*Identification and Blend of Timbres as a Basis for Orchestration*'.

symbols in the score and their acoustic realisation involves many steps that are difficult to quantify and often unpredictable. Treatises on orchestration do not use a scientific approach and most of them focus on single instruments more than on the orchestra as a whole (they are, therefore, treatises on instrumentation). This is essentially the case for the reference books on orchestration that are relied heavily upon in orchestration-based pedagogy, such as (…) Piston (1955)[26], (…) and Adler (2016)[27]. The art of music orchestration is, more than other aspects of musical writing, an empirical activity essentially based on heritage. Orchestration is oftentimes taught in a manner that nurtures and develops an ***intuitive*** *and exemplar-based approach using practical recipes that are abstracted from their musical contexts, and not systematically founded upon acoustics or psychoacoustics."*[28]

Despite the endless sonic parameters available, much classical music retains predictability in its variables of orchestration. I believe this to occur due to the well-established classical music tradition, in which our auditory perception, way of teaching, notation, and performance playing techniques are highly influenced by this long-standing practice.

This raises the following question: shouldn't orchestration have progressed at a similar pace to composition and the computer and why is this still often overlooked by most instrumentation and orchestration treatises? For instance, Samuel Adler[28] chooses to solely specify twelve bibliographic references regarding computer and electronic music as an appendix, revealing that the gap between electronic music and instrumental orchestration is yet to be addressed.

Admittedly, a treatise in electronic music instrumentation and orchestration might be impossible to compile due to the endless possibility of timbres produced by electronic sound sources. However, in considering this we can unravel both the problem and its solution. If it is not practical to detail every single behaviourally property of these electronic devices, adding to the fact that the same electronic component, such as

[26] [Suggested Reading] Piston, *Orchestration*.
[27] [Suggested Reading] Adler, *THE STUDY OF ORCHESTRATION*.
[28] Cella, '*Orchidea*', 2.

filters, can result in different sounds due to the quality of its construction[29], we should then move from focusing on hardware instrumental design to focus on the timbre itself and divide those timbral possibilities into categories. In fact, as previously mentioned, this is something that Luigi Russolo began to introduce more than 100 years ago with his six categories of noises for the futurist orchestra.

"(…) though emerging technologies often encourage new practices, traditional orchestration is more concerned with the exploration of instrumental timbre than the imitation of an input sound, whether concrete or synthesized."[30] Thus, orchestration "has been relatively unexplored in the domain of computer music."[31]

The key difference between instrumental orchestration and electronic timbral blend, is that "electronic music expands our perception of tonality"[32] towards a sonic field where all sounds are equal, "just another increment on the electromagnetic spectrum,"[33] and "its sonic vistas are limitless and undefined."[34] Hence, "the composer not only creates the music but composes the very sounds themselves,"[35] which is something essential to my creative practice.

Both Luigi Russolo and Dennis Smalley are two, among other composers, that began to address this issue independently from orchestration treatises by developing and researching typologies of sound. However, this diversification approach leads to the lack of standard formalization of music terminology regarding orchestration and timbral blending in computer music. More importantly, there is inadequate recognition of the relationship between the electronic and acoustic domains as a way of conceiving the practice of contemporary orchestration. This void caused by the divergence between ways of studying instrument-based orchestration and the recent developments in sound classification and categorization[36] is unhelpful to the study and practice of contemporary orchestration techniques. This portfolio seeks to go

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[29] "*Analog circuits are rarely perfect; these imperfections – and how designers deal with them – can create unique sounds.*" In Bjørn, Meyer, and Nagle, *Patch & Tweak*, 101.

[30]Carpentier, Assayag, and Saint-James, '*Solving the Musical Orchestration Problem Using Multiobjective Constrained Optimization with a Genetic Local Search Approach*', 711.

[31] Antoine and Miranda, '*Towards Intelligent Orchestration Systems*', 2.

[32] Holmes and Holmes, '*What Is Electronic Music?*', 9.

[33] *Ibid*, 10.

[34] *Ibid*, 9.

[35] *Ibid*.

[36] [Suggested Reading] Peeters, '*A Large Set of Audio Features for Sound Description (Similarity and Classification) in the CUIDADO Project*'.

some way to addressing this gap, as discussed in the following analysis of the works.

7.1 In Practice: Intuition in *Flux*, *Impasto*, *Plug-in*, *Layers,* and *Cache*

All works in this chapter were strongly informed by my intuition, which is informed by my long-standing experience working in the electronic and mixed music domain. Hence, most of the techniques here described are analogy-based. Nonetheless, the following works were written by prioritising intuition over scientific experiments and/or schemas as these will soon follow.

7.1.1 *Flux*.

Flux was written for the two historical Iberian organs located at the top of the main entrance of the overly reverberant Sé Catedral de Braga in Portugal (fig. 6).

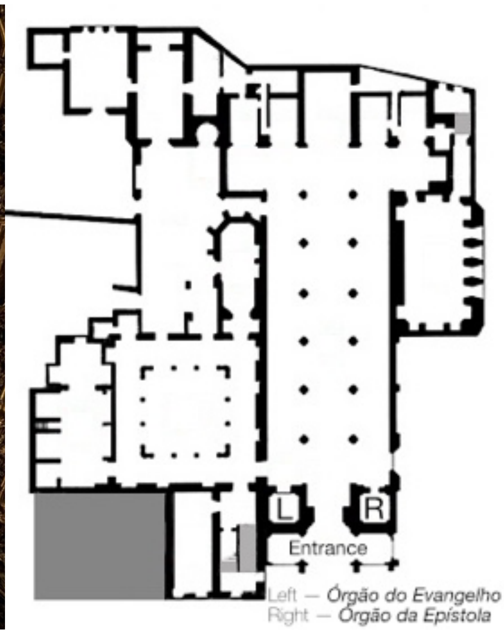

Figure 6 — [left] View of the [left] Órgão do Evangelho and [right] Órgão da Epístola. © Permission to reproduce this photo has been granted by Rinaldo Zirrah; and [right] Cathedral main hall blueprint. © Created by Manuelvbotelho (under CC BY-SA 4.0) and adapted by me.

The organs (fig. 7), and their mechanisms respectively, were built between 1737~1739 by Frei Simón Fontanes. Even though they went through a series of restorations over the years, some issues were encountered due to their present condition, their mechanical characteristics, and preservation regulations.

Figure 7 — Órgão do Evangelho [left] and Órgão da Epístola [right].

© Permission to reproduce this photo has been granted by Festival Internacional de Órgão de Braga.

The term *Flux* describes something that is constantly changing. As such, my main aim was to enhance my orchestration approach by adopting the spatial characteristics of the hall and its acoustics, as a fixed extra-musical modulator of the written flux of sound. To note, this work can be considered site-specific, however, there is a degree of structural flexibility and openness that allow for this work to be performed elsewhere if similar spatial and instrumental characteristics are met.

Additionally, this electronic-informed orchestration approach was necessary to explore given that spatialization is a pillar of electronic music composition and diffusion.[37]

Composition-wise, the development of the work's material was grounded in psychoacoustics and granular synthesis, a sound processing technique with its roots in digital electronic music. In the words of Curtis Road, *"an individual grain is an elementary signal created by a simple instrument. Yet by combining hundreds or thousands of elementary grains per second, we generate rich and complex textures. As the traditional practice of orchestration teaches us, by selecting and combining*

[37] [Suggested Reading] Parmerud, '*The Art of Diffusion in Electro-Acoustic Music*'.

different instruments, each of which is limited in its sonic range, we can manipulate a broad palette of timbral colors. The score interweaves these colors in detail."[38]

Thus, the composition unfolds from a simple 'grain' — with *solo* Órgão do Evangelho — and progressively develops into a texture while the orchestration focuses on controlling the density and timbre of such texture (fig. 8). Here, the *Órgão do Evangelho* gradually constructs a texture from a simple 'grain', but due to the long reverberance generated by the room acoustics, we can expect to keep hearing a long-sustained 'stream' of sound. As a result, the more the player keeps playing, the more timbrical content he keeps adding to this 'cloud' of modulated sound. By taking into consideration the concept of 'envelope' (usually found in synthesizers in the form of Attack, Decay, Sustain, and Release) to control the flow of harmonics, I was able to control the shape of the evolving frequency discourse.

Figure 8 - Bars 5~18; Development of a 'grain' into a texture ("river of sound") — Órgão do Evangelho.

[38] Roads, *Composing Electronic Music: A New Aesthetic*, 44.

Nevertheless, due to the ‘modulator’ and its ‘modulation’ respectively, the score is only capable of illustrating a fraction of what is heard; only what is performed by the organists is written, but what is sonically perceived is the result of the player’s performance modulated by the reverberant room acoustics.

In the case of reverberation, it is more than a reverb tail and even more than a 'modulator'. Reverb works as synthesis by convolution. This is where the real dynamics of the organ lie. Changing the listening point can change everything about the sound. In this work, reverberation acts as a ‘modulator’, a ‘resonator’, and a third ‘performer’.

It is possible to have swell boxes (for example, shutters) and echo registers (closed or set in another location) which is the feature that many think is used for dynamics. But they have much more significance. In most combinations of two organs, one of them usually functions as an echo (fig. 9), or in other words, space. There is an alteration to the timbre, pitch, and tuning (multiplied by the number of pipes and their different registers) that 'modulates' the sound. That is convolution within convolution with additive synthesis and other manigances if you include techniques such as turning off the motor as a filter.

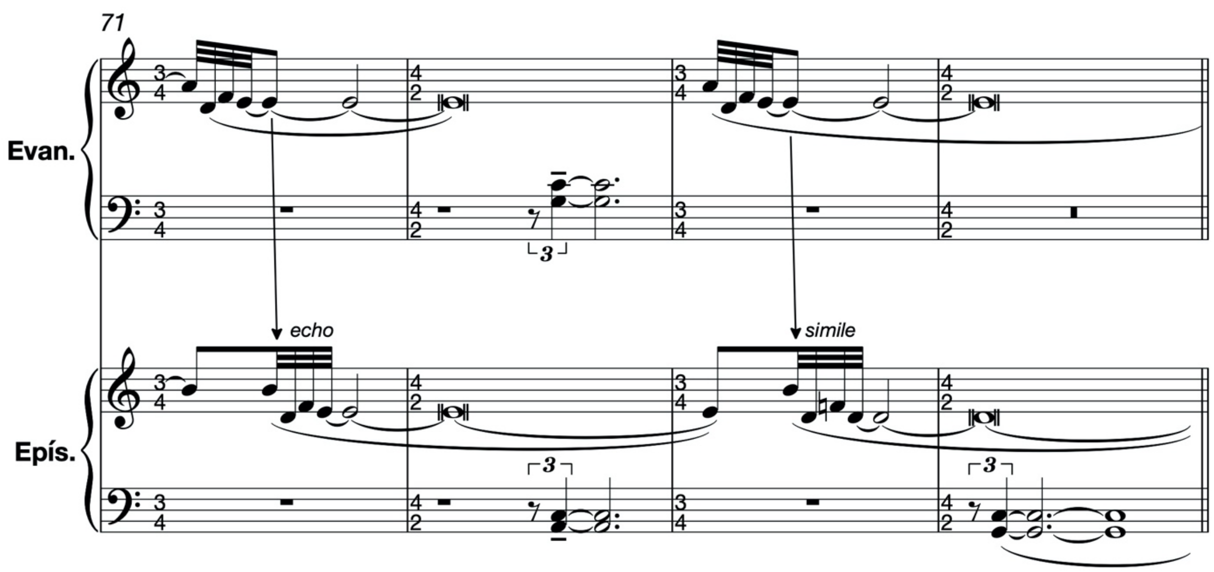

Figure 9 — Bars 71~74; Artificial 'echo’ proposed by my orchestration approach.

Echo is a clear example of how some sonic results can be obtained naturally or artificially due to the chosen orchestration approach. This effect can naturally occur due to the intrinsic acoustical properties of the Cathedral or in an artificial way where the desired 'echoing' effect is musically obtained by the composer's approach. In short, the organ is an orchestra of tubes, which can be compared to a loudspeaker orchestra, only in this case each tube influences the other. Or in the case of echo, it can resemble a modular synthesizer. Hence the difficulty in doing 'physical modeling' of the organ as a virtual instrument.

In terms of the score, I had to focus on balancing the written and produced sound by the players by way of addition and subtraction of different registers, resembling additive and subtractive synthesis in the electronic music domain, with the uncontrollable reverb 'algorithm', in reference to electronic algorithmic reverb within an environment in the realm of psychoacoustics. This is because the cathedral's stone structure and large dimensions contribute to a very large reverberation which in its case, is being affected in real-time by the weather conditions, the number of people in the room, the disposition of the windows/shutters and most importantly, by the minute differences in details that arise from a certain degree of indeterminacy found in human performance.

In addition, some registers are more effective in piercing — ones with higher-pitched harmonic content — through this "cloud" of sound, whereas others — ones with lower-pitched harmonic content — can cause the psychoacoustic effect of ambiguity in terms of source recognition. This approach helped me not only orchestrate the textural cloud of sound, but to further control the inner complexity of each musical 'grain', or as Barry Truax describes:

> "*In certain cases, the acoustic result resembles environmental sounds in terms of their inner complexity and statistical texture. However it is used, granular synthesis is clearly situated in a different psychoacoustic domain than that occupied by most computer music; it creates a unique sound world and suggests new approaches to the way music made with it is formed*."[39]

[39] Truax, '*Composing with Real-Time Granular Sound*', 131.

Furthermore, the unstable timbral qualities resulting from the immense reverberation — and often even echo — could cause the overall content quality of sound to behave in quite an unpredictable way, thus generating some timbral artifacts. Hence, I had to leave a considerable margin in my orchestration approach to deal with both the expected and unexpected timbral content oscillations. Otherwise, these alterations in timbre would lead to a chaotic, frenetic, and almost distorted stream of sound.

As opposed to more traditional approaches, we cannot in any way analyse this work without considering the sonic result as realised in this specific space. The score is only able to provide a limited amount of performance instructions in the pursuit of an imagined targeted-sounding result. Hence, here I began to observe the limits of traditional notation.

In the example below, we can imagine the duration of reverberation to be hugely affected by myriad of factors. For example, if the hall is full of people, then the reverberation tail is going to be short, therefore, reducing the size of the spectral 'freezing', and vice-versa. However, with longer reverb tails, some other effects start to become more perceptible, such as 'beat frequency' (fig. 10). This effect occurs when two sounds of different frequencies are playing and lead to an interference perceived as a periodic variation in volume whose rate is equal to the absolute value of the difference in frequency of the two waves.

Figure 10 — Bars 79~80; Example of how reverberance can modulate sound.

Another aspect to acknowledge is articulation, especially between close notes, duration-wise. To have more intelligibility, organists are trained to always listen to the reverb tail and to interpret with more *detaché* if necessary,

This work is also informed by a strong structural indeterministic and open characteristic that arises from dealing with all these constraints and resembles stochastic[40] processes that are often associated with computer and electronic music composition. In the example below (fig. 11), the performer is only given some general and semi-open instructions, as is often the case throughout the score. Here, the instructions give the player the freedom to control the duration of this chord progression. Thus, interpretation plays a significant role.

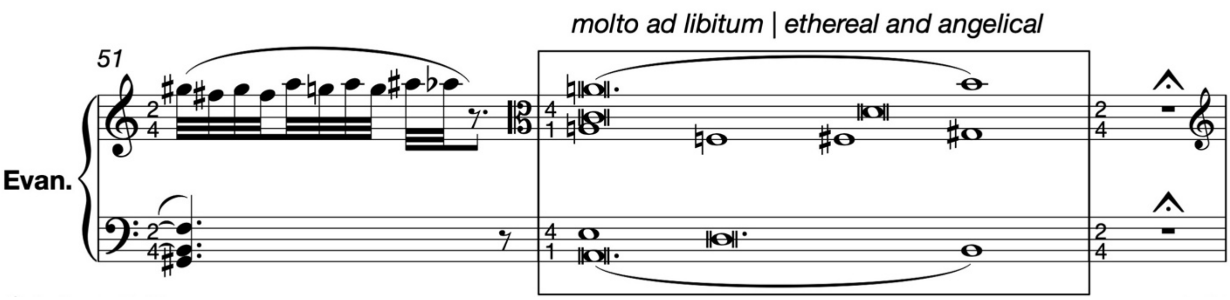

Figure 11 — Bars 51~53; An example of a simple stochastic orchestration approach.

In computer-based electronic music, the computer allows me to explore this on a larger scale. It is possible to define parameter ranges and their variation ratio in multiple layers for virtually all the parameters. We can also keep further adding multiple layers of variation to many other characteristics, even as to the 'instrument' in itself. In computer-music performance, it is possible to obtain an instrument that constantly changes and mutates according to the composer's ideals.

Furthermore, in (fig. 12) the performer is only suggested the start time and tempo mark. There is no fixed synchronicity between the players until an opposing indication is specified.

[40] "*Stochastic music emerged in the years 1953-55, when Iannis Xenakis introduced the theory of probability in music composition*. (…) *In the 1960s, Xenakis started to use the computer to automate and accelerate the many stochastic operations that were needed, entrusting the computer with important compositional decisions that are usually left to the composer*." Serra, '*Stochastic Composition and Stochastic Timbre*', 237.

Figure 12 — Bars 54~64; An example of a complex stochastic approach using both organs.

Regarding orchestration, the performer has some liberty to freely choose the combination of registers in use. Hence, even though the harmonic content remains the same, the timbral quality will always differ from performance to performance, and from performer to performer. This approach is highly related to what Barry Truax defines as the fundamental paradox of granular synthesis.

> "*(…) that the enormously rich and powerful textures it produces result from its being based on the most "trivial" grains of sound-suggested a*

metaphoric relation to the river whose power is based on the accumulation of countless "powerless" droplets of water."[41]

This mindset was key to dealing with the amount of 'droplets' that constitute the main 'river' of sound. Therefore, the orchestrational finesse of this work lies in the resulting 'cloud' of sound and not so much in the individual.

7.1.2 Impasto

Impasto [for wind orchestra] is a painting technique where the pigment is mixed with oil and beeswax and subsequently laid on the canvas in very thick layers, usually thick enough that the brush strokes are visible (fig. 13). Beeswax is used in place of any other element due to being easily accessible (cost-effective) as well as its ability to provide volume and shape to the colour without altering its properties, such as contrast ('frequency'). This technique allows the creation of moving shadows and reflections based on the direction of light and the volume of paint alongside enhancing the expressiveness and movement of the painting by being able to visualise the direction and pressure level of the brushstroke. Thus, transforming what was initially a two-dimensional drawing into a three-dimensional almost sculptural rendering, allowing for a different perception of the same painting depending on multiple extrinsic factors.

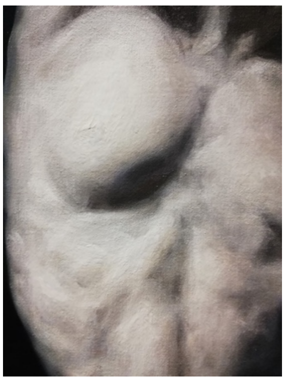

Figure 13— The *impasto* technique in practice. *Torso* (excerpt).

[41] Truax, '*Composing with Real-Time Granular Sound*', 124.

Afterwards, I began to dwell on the relationship of *impasto* with the aforementioned technique of multi-dimensionality through spatialization in electronic music, especially after having some fruitful encounters with acousmatic composers Trevor Wishart and Åke Parmerud.

Åke Parmerud taught me how to use his new diffusion software[42] and the importance of diffusion[43] in acousmatic music (fig. 14). Until then, I thought of acousmatic music as unperformable, playback-based, and limited to the venue's performance conditions. However, Parmerud's bespoke software *Hyperspace II* allowed me to assign one sonic spatial trajectory per MIDI key independently of the number of outputs, thus, unlocking the ability to place sound in space in real-time.

Figure 14 — Diffusing *Project 2* - using HyperSpace II by Åke Parmerud at Lisboa Incomum.
© Permission to reproduce this photo has been granted by Mariana Vieira.

Later, when I met with Trevor Wishart, he mentioned to me that while he is composing, he usually adds *vibrato* to an audio sample in the search for a more natural sound since in opposition to the electronic music domain, no perfectly static sound is found in nature. His practice shed a light on the possibility of enhancing multidimensionality

[42] Hyperspace II
[43] Parmerud, '*The Art of Diffusion in Electro-Acoustic Music*'.

through micro-composition/orchestration, as used by composers such as Horacio Vaggione; Carlos Caires, among others, at the ‘sample’ level as we can begin to observe through my intricate and minute attention to orchestration details (fig. 15).

Figure 15 — Bars 62~70; Example of orchestration detailing at the ‘sample’ (cell) level.

Also, another of my interests is performing electronic music (fig. 16) and the use of electronic instruments, such as synthesizers. One particularly interesting characteristic of vintage synths is that their circuit board is usually roughly assembled, and therefore the sonic result is susceptible to random variations largely due to interference from multiple causes. In the acoustic domain, this is paralleled by many examples such as the effect temperature and humidity have on the violin wood panels. The shrinking and expansion of these are directly related to the amount of tension in the strings, hence affecting the tuning of the strings. This opens the door to a degree of sonic instability, unpredictability, and openness.[44]

[44] [Suggested Reading] Eco, *Obra aberta*.

Figure 16 — Working on *Song of Happiness #* at the Escola Superior de Música de Lisboa in 2017.
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One last influence for me was the work of Giacinto Scelsi (1905 -1988) and viewing his biographical documentary[45], which presents some of his previously unknown quests in the study of sound and his pioneering research on bridging the world of electronic music and instrumental music to inform his composition, and most importantly his orchestration practice. As discussed by The Isabella Scelsi Foundation:

> *"His most significant compositions are characterized by the instrumentation of figures determined at random, improvising and applying new uses to traditional instruments, the introduction of the ondiola (the first electronic instrument able to produce quarter and eighth tone notes)* (…)
>
> *The score would then be completed with detailed instructions on its interpretation and measures in order to obtain the specific sound so meticulously researched by Scelsi (dampers especially designed for the strings section, stringed instruments played like percussions, sound filters*

[45] *Le premier mouvement de l'immobile*.

to distort the sound of the wind instruments, pre-existent recordings used to lead the performance).

His orchestration methods can also be regarded as highly original: he would pair similar instruments making sure that they were out-of-phase with each other by a quarter note, thus obtaining unexpected beat effects."[46]

These findings helped to contextualise some of Scelci's decisions. By way of analysis of his music, we can observe how he dwells on electronic-informed timbral shaping processes to extend the boundaries of the traditional orchestration approach through timbre-based orchestration, for example, his single-note approach to timbral composition in *Quattro pezzi su una nota sola* ('*Four pieces each on a single note*' (1959)) for chamber orchestra. In a way, we must acknowledge that Scelsi's music is a major example of a creative practice that prefigures French spectral music.

In his music, acoustic instruments tend to behave like early electronic synthesizers of the time (or *ondioline*). In respect to timbre, his aim is one and the same, whether to use a *sordino* in instrumental music or a filter in electronic music, to dampen or null certain frequencies and consequently alter the timbre. Thereby, by working closely with the *ondioline* and acoustic instruments, he began to study ways of shaping instrumental timbre in a more unconventional way.

In *Impasto*, my orchestration is informed by the analogue synthesizer (fig. 17). This unit includes a Voltage Controlled Oscillator (VCO) and an Amplifier Envelope Generator (AMP EG), among others. The latter is a built-in combination of two common modules: a Voltage Controlled Amplifier (VCA) and an Envelope Generator (EG). AMP EG is designated to sculpt the amplitude of sound, whereas the EG can be assigned to use the ADSR settings to sculpt any given parameter. Another difference is an EG not assigned to an AMP can output negative values. This provides a huge variety of timbres available depending on how the signal flow is routed within a particular patch.

[46] Scelsi, '*Biografia Di Giacinto Scelsi*'.

Figure 17 — Korg ® Minilogue XD Polyphonic Analogue Synthesiser Desktop Module

These are the essential modules to produce sound. Whenever a key is pressed, the VCO generates a signal, then this is almost simultaneously gated by an EG to shape the amplitude between the 'note-on' and 'note-off' events, and lastly, a VCA to raise the overall amplitude of the signal towards achieving an audible sound. Hence, the synthesizer works similarly to an acoustic instrument. In a paralleled description, the VCO is the string; EG is articulation; 'note-on' and 'note-off' events are the bowing movements, and the VCA is dynamics.

Nowadays, the synthesizer is often used in the same context as traditional instruments, whether it be orchestral music or *solo* music. Both are similar instruments powered by different mediums. Moreover, with open modular systems, one has the possibility to approach it in two different ways:

— Macroscopic (as a conductor), where one can divide his modular synth into grouped sections of modules. Thereafter, each of those groups would be then considered an instrument. This is generally the approach to using larger modular systems.
— Microscopic (as an orchestrator/timbral blender), where one's goals shift from focusing on the instrument to focusing on the target timbre. Here, all the modules are used for their characteristics and not for their traditional patching instructions. A VCO that is commonly used to generate an audible waveform can now be used to modulate other parameters. This approach is ideal for timbral blending and is usually achieved by using the modules in an unconventional way towards obtaining endless timbral possibilities.

Score-wise, below we can observe some synth-like orchestration details in the work (fig. 18).

- [Bar 2 & first half of Bar 4] Similar to an EG → Filter, *damp* is often necessary to dampen the excess amplitude of a signal, and consequently, filtering harmonics.
- [Second half of Bar 4] The tuning pedal is used similarly to a Low-Frequency Oscillator (LFO) → VCO. Since this is being mimicked by a human instead of a machine, I am, of course, unable to obtain a precise and stable oscillation. However, the right opposite of that was key to my musical aims. I consider both the performer's approach and the acoustics to be additional layers of orchestration. Additionally, I strongly believe that this way of orchestrating works best when human feedback is embraced, rather than 'overwriting' to a point where it can become notationally unclear and unperformable.
- [Bar 8] Expanding on the previous example of interference (p. 34), but now aiming for a *pitch-bending* effect by releasing the tension of the skin.

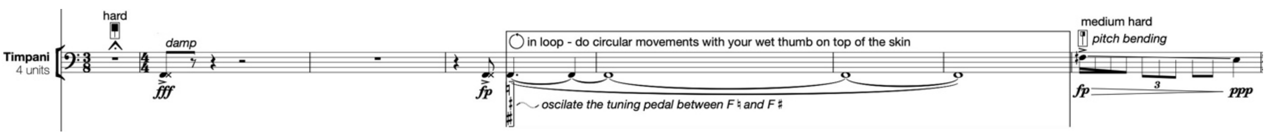

Figure 18 — Bars 1~8; A complex example of multiple synth-like behavioural properties that informed my timpani orchestration, and consequently, my notation.

These interferences can occur in multiple shapes or forms, such as voltage interference, 'filter bleed', or other design imperfections, most often found in vintage analogue electronics. Also, depending on the circuit, these imperfections can behave differently, like the Yamaha CS-80 sawtooth wave design as Kim Bjørn illustrates:

> *"Analog circuits are rarely perfect; these imperfections – and how designers deal with them – can create unique sounds. For example, Yamaha was apparently unhappy with how slow the sawtooth wave in their CS-80 oscillator reset, so they added a small pulse to the very start of the waveform to cover for this."*[47]

[47] Bjørn, Meyer, and Nagle, *Patch & Tweak*, 101.

In the following excerpt (fig. 19), there is a noticeable unstable 'stream' of sound surrounding F and F#. Comparatively to Scelsi's pairing of "*similar instruments making sure that they were out-of-phase with each other by a quarter note, thus obtaining unexpected beat effects*"[48] I expect the result to be very much alive. Throughout this piece, I merge this approach with *vibrato* instructions — being that *vibrato* is the result of pitch modulation (VCO) via low-frequency oscillation (LFO). This resembles an extended version of Wishart's idea on the use of *vibrato* in audio samples; to add a whole other layer of expressiveness. Sonically, through this approach I expect to achieve a higher degree of tension due to the sonic instability caused by dissonances and to improve the flow of sound since, as in nature, every sound is different and in perpetual movement.

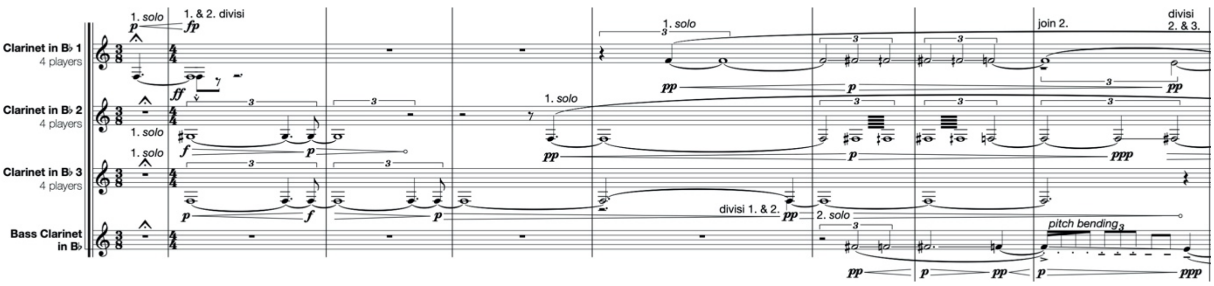

Figure 19 — Bars 1-8; The core instability of pitch within the clarinet section through orchestration informed by voltage interference inherent to synthesizer circuits.

Moreover, in bar eighty-five (fig. 20), we can observe an orchestration solution mimicking an LFO assigned to a low-pass filter (LPF) by the vibraphone.

Figure 20 — Bars 83~85; LFO → LPF orchestration solution.

I knew beforehand how this approach would result due to having used it before in my work *vibr-A-phone* (2015-2016) for *solo* vibraphone. The opening and closing of the

[48] Scelsi, '*Biografia Di Giacinto Scelsi*'.

mouth on top of the A key mimic the opening and closing of an actual LPF. As soon as the ‘size’ of the resonating “room” is augmented or reduced – via opening and closing the mouth – an oscillation between a brighter tone (open mouth; more harmonic partials) and a darker tone (closed mouth; less high and mid-range harmonics) is obtained. While this can be confused with the behaviour of the motor, there is a striking difference as the motor strictly closes and opens the resonating tubes at a certain rate, resulting in a *tremolo* effect, whereas the mouth allows to freely adjust the opening and closing gap in a specific tempo or rhythmic pattern. Thus, shaping timbre by damping certain frequencies without ever stopping resonating.

Throughout this portfolio, an endless number of electronic processes can be linked to my orchestration approach. Some are even densely orchestrated in layers on top of even more layers. However, the combination of multiple electronic-informed techniques is crucial to detail the timbral development in my work.

Below (fig. 21), both acousmatic music diffusion and filter automation are simultaneously acknowledged. The ‘dynamics’ replace the actual gesture of moving the fader on a mixer, and the clarinets produce a brighter sound when switching from the standard playing position to ‘bells up’. (i.e., by altering the direction, and consequently, the reflections of frequencies). Hence, they produce a brighter, more direct, and harsher sound than the standard playing position.

Figure 21 — Bars 12~19; Example of an orchestration solution informed by both acousmatic music diffusion and filter automation.

From my experience, due to the variable degree of versatility between common acoustic instruments, I believe that there are certain instruments that ‘lend themselves' to this electronic-informed approach more easily, such as the clarinet, strings, or most percussion instruments.

I sought out unstable sounds that do not flatten easily to notation and that resist having conceptual forms imposed upon them. Hence, this work led me to further acknowledge the gap in timbral shaping symbols in current traditional music notation. Thus, I expected a gradual move to a more graphical approach.

7.1.3 Plug-in

The main aim of *Plug-in* [for Violin, Clarinet in B♭, Trombone and Double Bass] was to focus on sketching electronic-informed orchestration solutions at the 'sample' level by using the Portuguese traditional melody *Lá vai uma, Lá vão duas* (fig. 22) as the foundation for the composition structure and form.

Figure 22 — Portuguese traditional melody. Lá *vai uma, lá vão duas*.

In Cantar em Português (June, 1999) by Domingo de Morais. Public domain.

The core of this piece is a simple run of the traditional melody. Not only was I able to test micro-orchestration here, but also micro-composition. Thus, I consider this work to be the first miniature of a set of three discussed in this research. Orchestrationally, my approach was to develop a multilayered orchestration arrangement in a short time frame by progressively moving towards a more timbre-based approach. This became a possibility only when I allowed myself to be free from the boundaries of traditional ideals of instrumentation, orchestration, notation, and performance.

Hence, in *Plug-in* I began to work with standard acoustic instruments in unconventional ways by adopting multiple extended techniques that I was not so comfortable with at that moment, for example, the use of microtonality, different types of mutes on the trombone, harmonics on the Violin and Double Bass, and multiphonics on the Clarinet in B♭ (fig. 23).

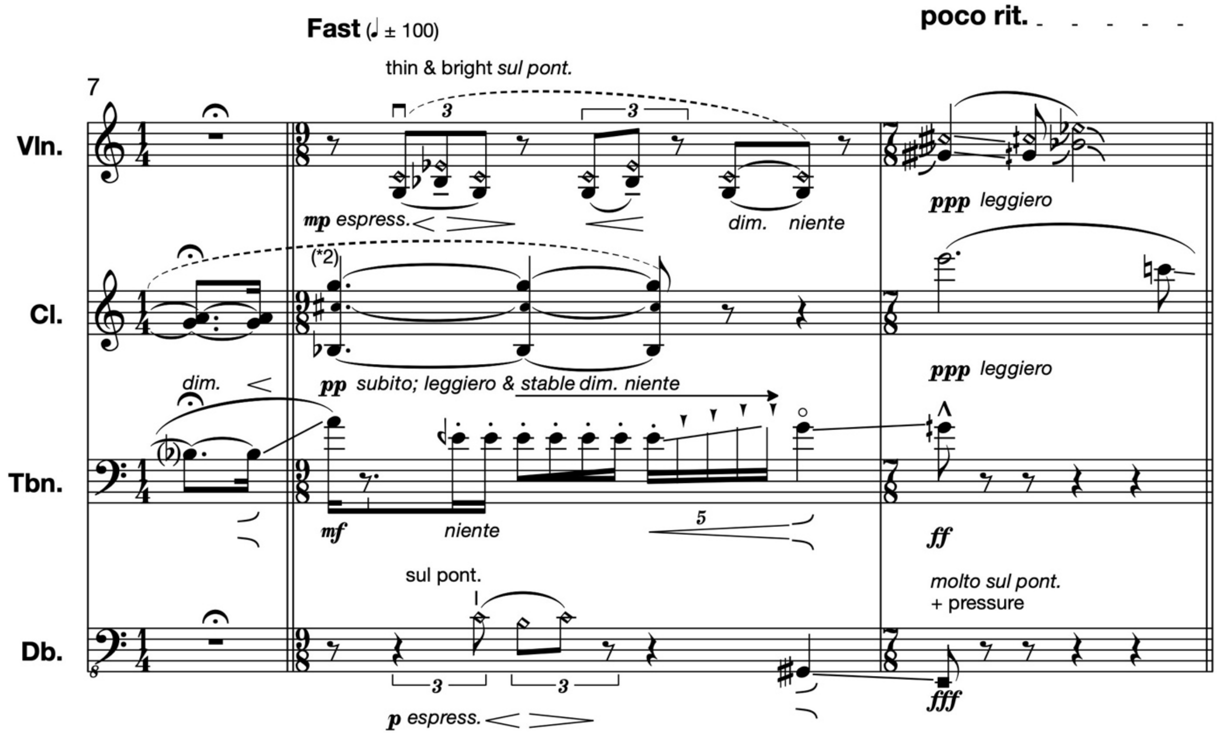

Figure 23 — Bars 7~9; Example of micro-orchestration at the sample level where microtonality, harmonics (Violin and Double Bass) multiphonics (Clarinet in B♭) are introduced.

In this piece, I began to expand my notation approach to include graphics and text-based instructions — at both the instrument and performer levels. In bars ten and eleven (fig. 24), there is an oscillating arrow graphic that resembles the behaviour of an LFO in the Trombone and Double Bass part. I consider indications such as *pizzicato*, *con sordino*, among others, to be considered at the instrument level because they are a technical and instrumental embodiment of a clear notation. On the other hand, text-based instructions such as "light unstable tuning", "transition smooth as possible", "*leggiero* & stable", "starting to fade out and stabilize", and "shake the bass to hear the resonance phasing", among others, requires the performer to position themself in a specific emotional world and are not so straightforward. Thus, this concept is inherently attached to the concept of both ‘feeling’ and ‘meaning’. These instructions call for a different level of understanding and intuition. In *Plug-in*, instructions are mostly focused on electronic composition techniques and body movement (‘embodiment’), *ergo*, the richness of an electronic-informed performance approach is directly related to the performer’s level of extra-(-instrument) knowledge in this domain.

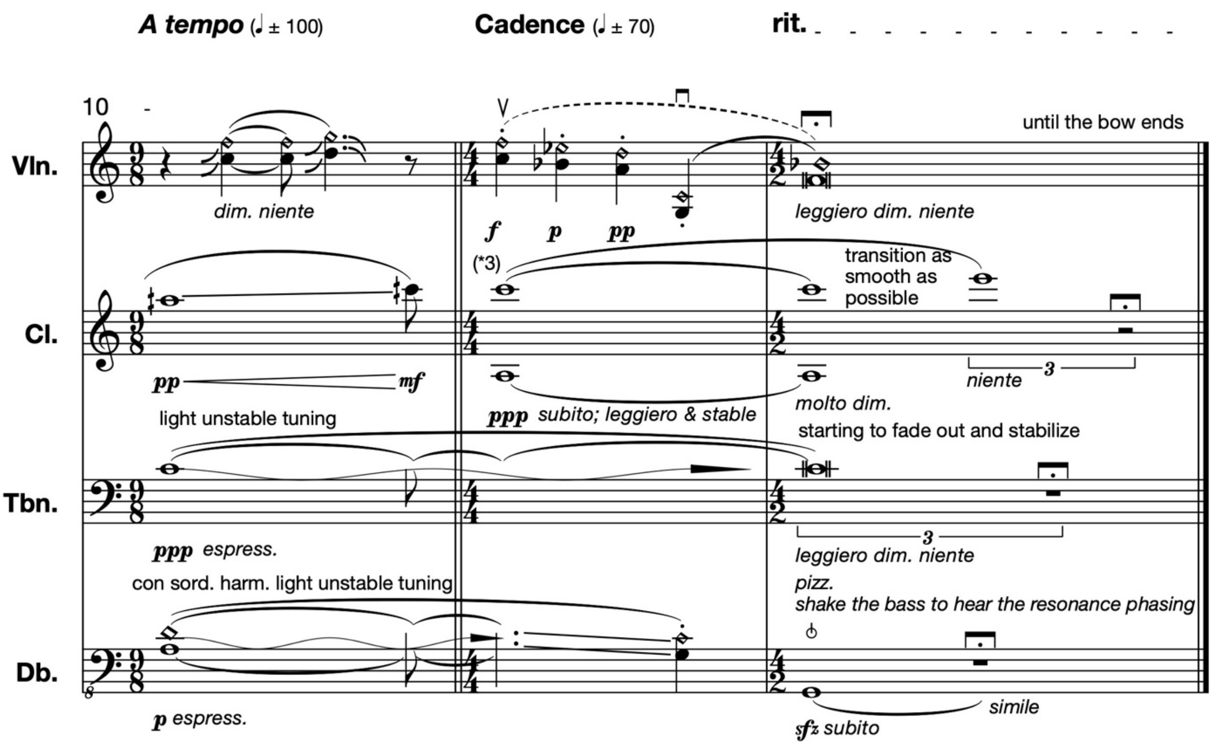

Figure 24 — Bars 10~12; Example of micro-orchestration at the sample level where text-based and graphical notation are introduced.

7.1.4 Layers

Layers [for two Violins, Clarinet in B♭ and Trombone] is the second miniature sketch that succeeds *Plug-in* in this research. This work also focuses on sketching electronic-informed orchestration solutions at the ‘sample’ level by using the Portuguese traditional melody *Fui ao jardim da Celeste* (fig. 25) as the foundation for the composition structure and form.

Figure 25 — Portuguese traditional melody. *Fui ao jardim da Celeste*.

In Cantar em Português (June, 1999) by Domingo de Morais. Public domain.

This work acts as a further sketch of *Plug-in* as multiple experiments with performers were necessary to understand the level of success of such orchestration solutions. Thus, as in *Plug-in*, the core of this piece is just a run of the traditional melody to test some other micro-orchestration, but also micro-composition techniques.

7.1.5 Cache

Cache [for Soprano, Clarinet in B♭, Harp and Double Bass] is the third miniature sketch that succeeds *Plug-in* and *Layers* in this research. This work also focuses on sketching electronic-informed orchestration solutions at the 'sample' level by using the Portuguese traditional melody *A loja do Mestre André* (fig. 26) as the foundation for the composition structure and form.

Figure 26 — Portuguese traditional melody. *A loja do Mestre André*

In Cantar em Português (June, 1999) by Domingo de Morais. Public domain.

As a result of the COVID-19 pandemic constraints, traveling was discouraged and social distancing was enforced by the Portuguese government, where I was located at that time. This meant I had to workshop the piece with The Hermes Experiment remotely via Zoom (fig. 27). In this case, I was fortunate to have the assistance of the University of Plymouth and Núria Bonet to arrange all the technicalities (i.-e., microphones, video cameras, computers, streaming, among others) in loco whereas I just had to log in to Zoom with minimal extra requirements. This experiment made me realize that remote collaboration within the *solo* and chamber music domain is perfectly possible if certain conditions are met, so there is a strong possibility that this method of collaboration will evolve and keep thriving in the future.

Figure 27 — Remote Workshop with The Hermes Experiment via Zoom ®.

Regarding composition and orchestration, in this sketch I started to use objects not meant to be used musically such as 'plastic cards' to aid me in the pursuit of a target timbre (fig. 28). Hence, by doing this I began to acknowledge the boundaries of instrumentation and the necessity to recur to extra-musical objects to expand the sonic possibilities of a given instrument, which in this case is the Harp.

Additionally, I took this chance to start experimenting with filter-like phonemes in the voice. By moving our mouths to speak, we alter the physical characteristics of the 'resonator'. Thus, by filtering the frequencies in excess, we shape the sound to a certain syllable, which *per se* is a different sound. In (fig. 28) I chose [i], [o], and [ai] as phonemes for this section. By carefully experimenting with the singer, I immediately started to recognize a pattern between both the use of phonemes and electronic filtering. If there is a possible direct link between these two domains, then [i] acts similarly to a High-Pass Filter (HPF) by reducing the number of low-end frequencies and prioritizing higher frequencies over the middle range; [o] is the right opposite, it reduces the number of high-end frequencies and prioritizes lower frequencies over the middle range, in a similar way to a Low-Pass Filter (LPF) and [ai] is used as a moving filter that goes from [a] to [i] where [a] works as close as possible to a non-artificially filtered sound.

Figure 28 — Bars 8~11; Example of micro-orchestration at the sample level where filter-like phonemes are introduced by the soprano.

In the end, I also wanted to embrace this opportunity to experiment with the musician's approach to instruction-based improvisation (fig. 29). However, I soon realized the fragilities of this since improvisation based on electronic-informed instructions will always be limited to the degree of electronic knowledge the performer has, which is rare to find to this extent. I thought about providing the performers with audio samples of the electronic sound that I idealized instead of written instructions. In the case of classically trained musicians, this approach is not ideal because they may memorize the sound and produce an acoustic sound as close as possible to the original source. The use of a strong reference can also lead to a lack of quality regarding the following improvisation. Musicians tend to avoid leaving this 'gravitational' force.

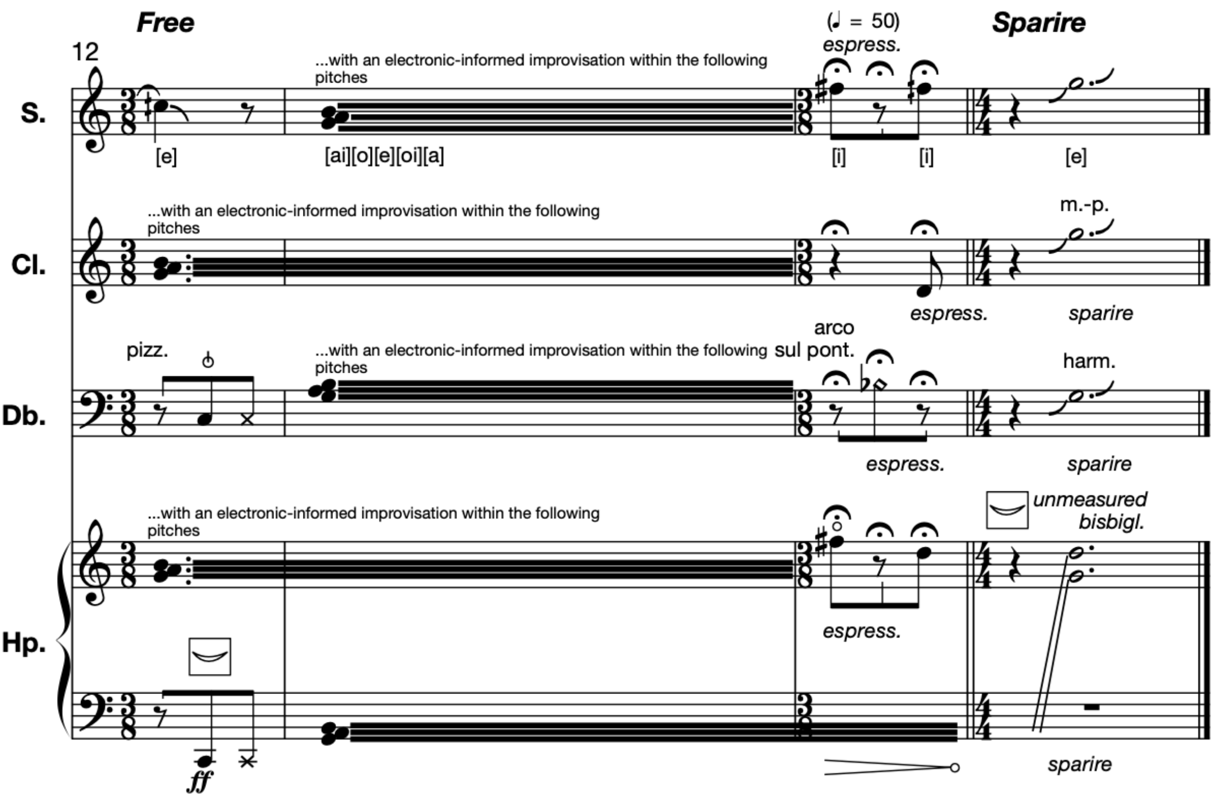

Figure 29 — Bars 12~15; Example of micro-orchestration at the sample level where improvisation is introduced.

Nevertheless, I do believe that like baroque music, electronic-informed music requires an extended degree of involvement and embodiment by the performer. This way of working relies heavily on the background and depth of knowledge a performer has in this domain. Here, the performer's feedback is crucial since modularity, 'error', 'glitches', and feedback are key to humanizing electronic music.

One example of a compositionally driven approach to orchestration is Jean-Claude Risset's desire "to sculpt and organize directly the sound material - to compose the sound itself, instead of merely composing with sounds."[49] Thus, technological knowledge helped Risset to fulfil certain aesthetic goals, such as:

> *"(…) resorting to a large vocabulary of sounds, including and going beyond those of musical instruments; sculpting and composing sounds[50], with due regard to the harmonic dimension; stimulate perceptual mechanisms to musically take advantage of auditory illusions; staging close encounters between acoustic sounds, audible traces of a visible world, and immaterial sounds, suggesting an imagined, illusory world, a separate, internal sonic reality."*[51]

Risset's statement also reflects the consensus on how technology seems to influence a composer's orchestration approach, something that can be applied to both the electronic and instrumental domains.

In electronic music, "musical material appears for the first time as a malleable continuum of every known and unknown, every conceivable and possible sound"[52] allowing for the composer to "invent sounds that do not exist in nature or radically transform natural sounds."[53]

[49] Risset, '*Composing Sounds, Linking Domains: The Musical Role of the Computer in My Music.*', 1.
[50] [Suggested Viewing] '*Discovering Electronic Music*'.
[51] *Ibid*, 2.
[52] Holmes and Holmes, '*What Is Electronic Music?*', 9.
[53] *Ibid*.

7.2 In Practice: Timbral Blend in *Braga Capital da Cultura 2027 Acusmática*, *Paysage,* and *Prelude*

Influenced by Risset's approach, and similar others, here I begin to address my experience in working in the field of acousmatic music. In this chapter, I will be describing some techniques that were key in the transition from the acoustic to the electronic domain.

7.2.1 Braga Capital da Cultura 2027 Acusmática

The commissioner's briefing for this was to develop a purely electronic track to introduce the whole commercial video for which *Braga Capital da Cultura 2027 Banda Sonora* was written. Thus, more details will be discussed in section 7.4.1 since these works were written with the purpose of being paired.

7.2.2 Paysage

In *Paysage*, the commission brief was to create a non-musical acousmatic work. The rules: no rhythm, no melody, and no lyrics. This cleared, I also wanted to develop a piece where my focus would be on the blending between the sounds that surrounded me during self-isolation and synthetic reproductions of these.

Due to the ongoing pandemic, I was forced to work from home. As such, I had to quickly adapt to work and live in the same environment, which is often full of distractions. In my case, this challenge was exacerbated due to the constant noises that bombarded my then workplace. A key detail that sparked my interest was the relationship between those unexpected sounds while I was trying to work on my music and the sounds from the music itself. Coincidentally, some of them happened to be very consonant and in sync, more like a soundscape composition written in collaboration between myself and nature.

I began to rethink the limitations of what a synthesizer could become and how acoustic — as in raw sampling of field recordings — and electronic sounds could be so intertwined that the recognition of a clear source would be difficult, if not impossible. This thought led me to write a soundscape piece based on the spectral processing of both the sounds that I recorded and the sounds that I synthesized.
The synthesizers were not yet present at the recording stage; however, I was aware that the recorded sounds were supposed to share some timbral characteristics with the possible outcome of the selected synthesizer architecture. This allowed for a higher degree of 'blending' during the merging process between the acoustic and electronic domains. This degree of resemblance did not follow any pre-defined schema. It was based on my personal judgment and intuition by having used these devices throughout my professional career and by carefully analysing the timbral properties of the sounds to be gathered.

As a non-exhaustive list, I collected the following non-synthesised (by myself) audio samples: Thin Plastic Sheet; Brise (Air Freshener Spray); Microwave Door; Music Box; Light Switch; Cat Purring; River Este (Braga, PT); Suonho moogment thrill (Synth Beeps); Cork Pop Loud; Fire Intense Crackle; Glass Clinks and Motion; Glasses Cup Movement; Ice Cube Glass Stir; Paper Quick Tear; Rain Heavy; Rainwhisper; Smoke; Splash Hard; Thunder Light Rain; TV Old ON/OFF; TV Static; Water and Wind Light.

Due to multiple constraints, I did not have access to ideal material and recording facilities. So, by seeking a higher degree of audio quality and uniformization, some sounds were collected via third-party sample libraries.

By deconstructing the collected sounds into their sound descriptors[54] and by linking this with the theory of reduced listening[55], I was then able to use these guidelines to formulate a recipe for synthetic reproduction. In (fig. 30) we can see how I use the Korg ® Minilogue and Korg ® Minilogue XD Desktop Module to synthesize similar waveforms to the agglomerate of sound composed by the river Este in Braga, Portugal, a thunderstorm, and a cat purring. At first glance these sounds might seem

[54] [Suggested Reading] Peeters, '*A Large Set of Audio Features for Sound Description (Similarity and Classification) in the CUIDADO Project*'.
[55] [Suggested Reading] Schaeffer and Reibel, *Solfejo do Objecto Sonoro*.

widely distant from themselves, however, the spectral resemblances over time are remarkable.

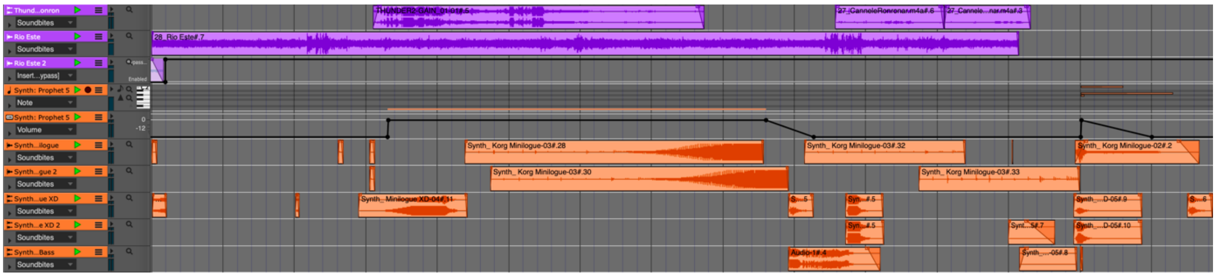

Figure 30 — 00:20~03:00; Example of timbral blend between acoustic waveforms and similar synthetic reproductions.

On the other hand, noise-based samples tend to lend themselves well to this approach. The degree to which the blurring of acoustic and synthesized noise can become almost indistinguishable is astonishing. Take (fig. 31) as an example. While I was working on this piece, I asked different people to listen to excerpts and try to recognize the source of as many sounds as possible. Most of them failed to distinguish between the acoustic sounds and their synthetic emulations. This showed me I was on the right path.

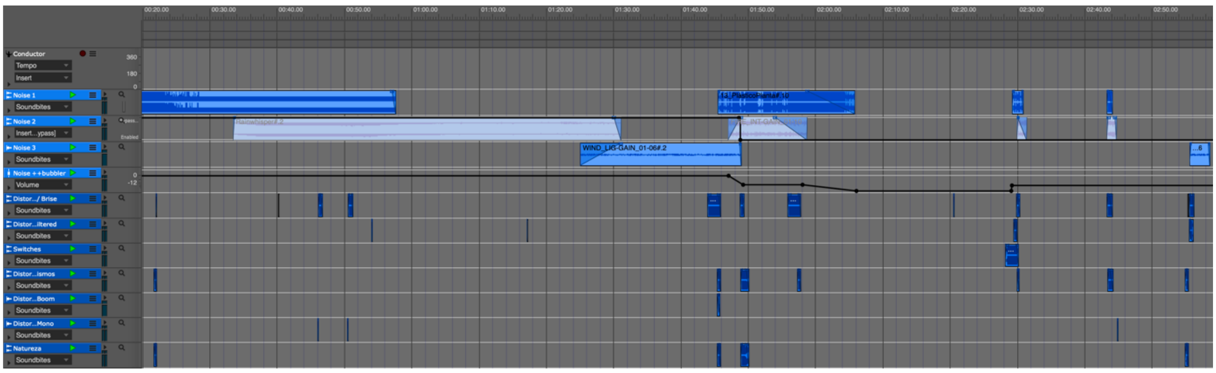

Figure 31 — 00:20~03:00; Example of timbral blend between acoustic and synthesized noise samples.

One other outcome of this effect was the development of my approach to timbral orchestration. The selected samples, either recorded or synthesized, were chosen because of their sources and their frequency content. By intertwining an acoustic and a synthesized sound with opposite spectral centroids (i. e., measure of the brightness of a sound) I was able to blend acoustic and synthetic sounds with a higher degree of efficacy resulting in a combined sound that blurs one's perception of source, cause, and nature. This can also be perceived by visualizing and analysing the spectrograms of these sounds. In (fig. 32) we can observe the spectrograms of three distinct recorded samples that contrast with the spectrograms of synthesized sounds in (fig. 33). We can immediately have a sense of how these can work together to generate a more complex and hybrid sound that blurs the acoustic and synthetic domain. Also, it is important to note that all these sounds were used in the creation of this work.

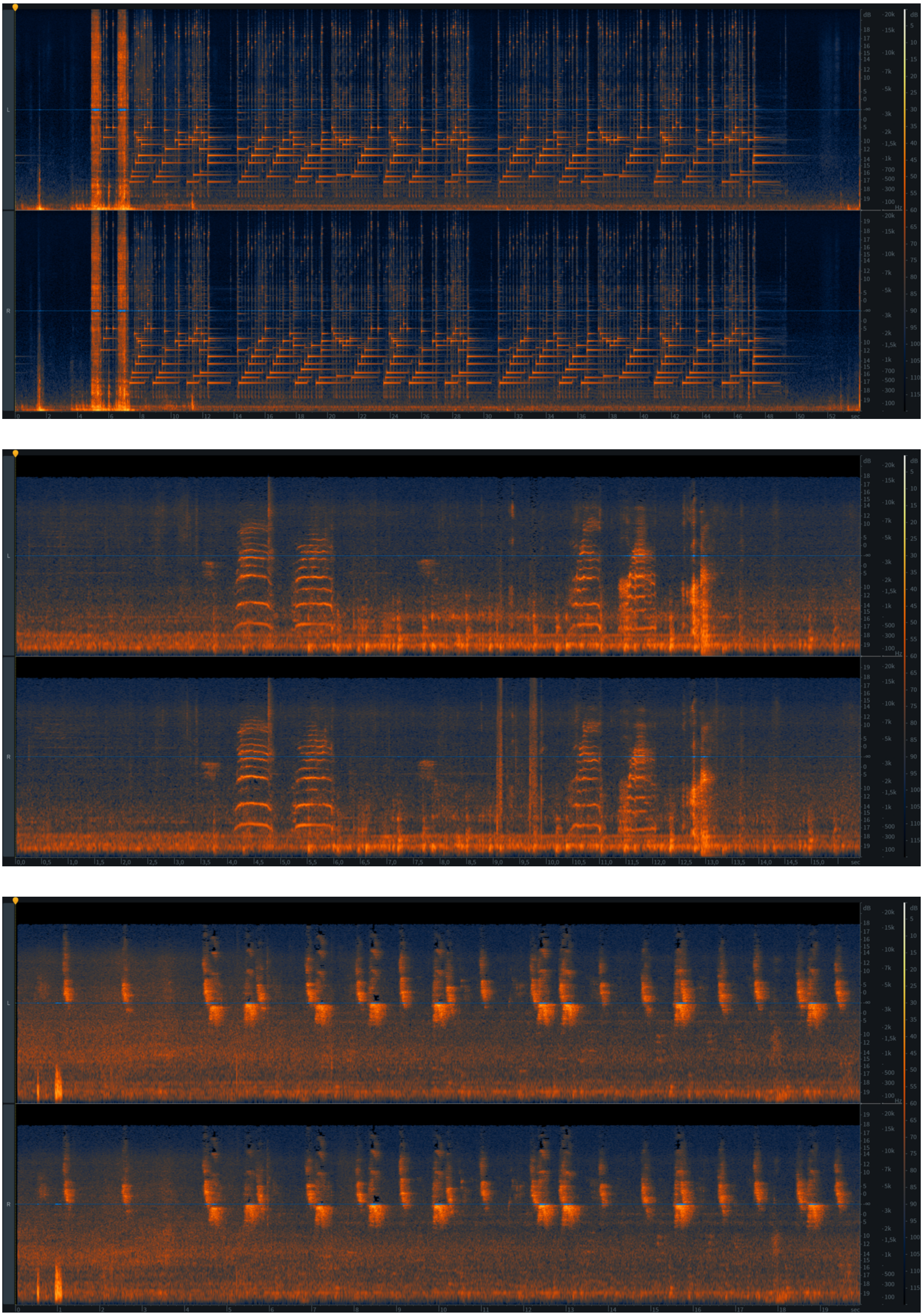

Figure 32 — Spectrograms of three recorded sounds used in this work. [From top to bottom] A) Music Box; B) Cat Meowing and C) Birds Chirping.

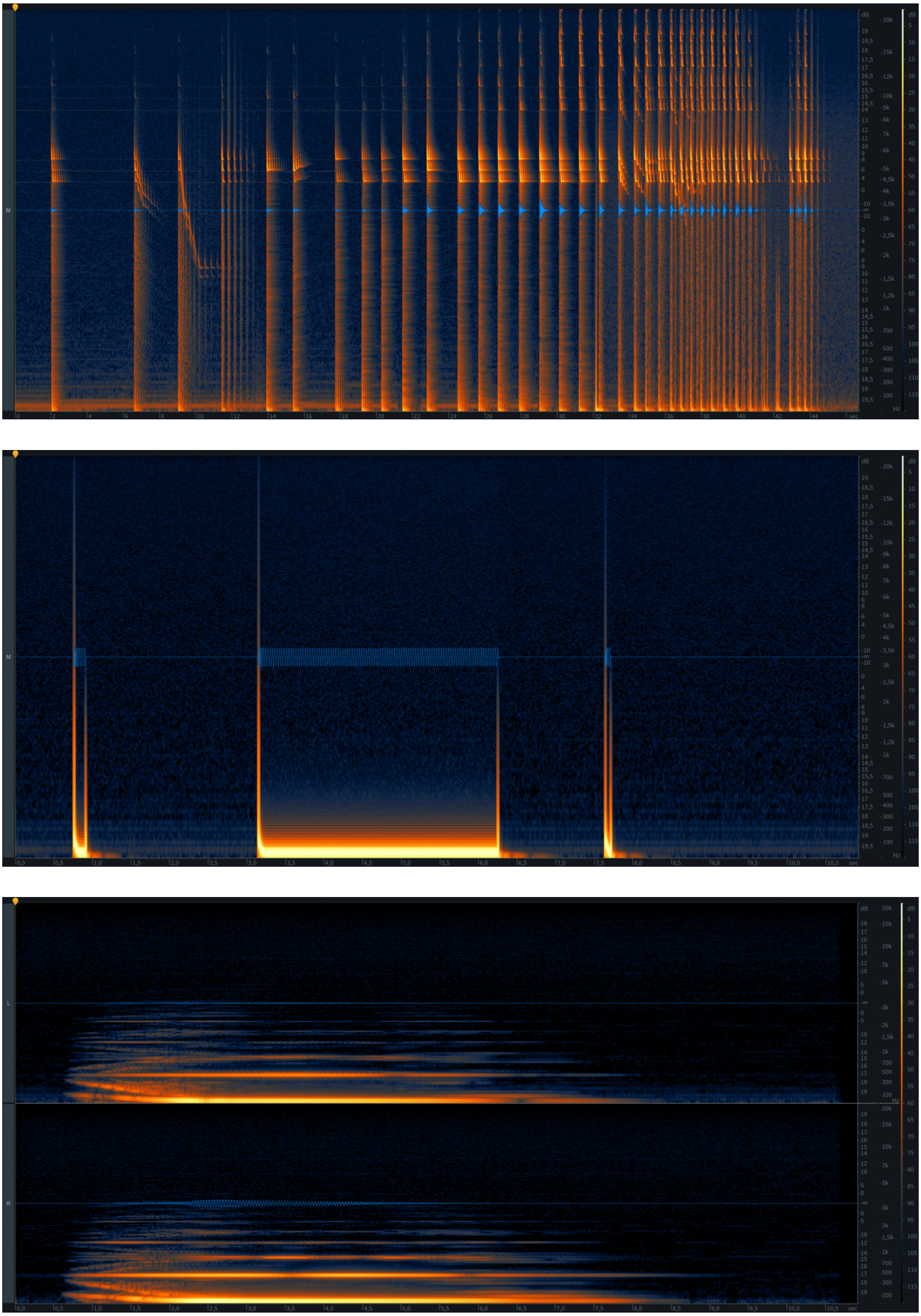

Figure 33 — Spectrograms of three synthesized sounds used in this work. [From top to bottom] A) Korg ® Minilogue (a); B) Korg ® Minilogue (b) and C) Korg ® Minilogue XD Desktop Module.

Research-wise, I began to dwell on a spectromorphological approach to source bonding. This approach turned out to be the ‘x-factor’ in the definition of this conceptual and narrative framework. Denis Smalley defines spectromorphology as followed:

> *“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). The spectro- cannot exist without the -morphology and vice versa: something has to be shaped, and a shape must have sonic content. (…)*
>
> *Spectromorphology is not a compositional theory or method, but a descriptive tool based on aural perception. (…) How composers conceive musical content and form — their aims, models, systems, techniques, and structural plans — is not the same as what listeners perceive in that same music. What the composer has to say (in programme notes, talks, sleeve notes) is not unimportant, and it undoubtedly influences (both helping and impeding) the listener’s appreciation of music and musical ideas, but it is not always perceptually informative or relevant.”*[56]

Dennis Smalley further defines source bonding as “the natural tendency to relate sounds to supposed sources and causes and to relate sounds to each other because they appear to have shared or associated origins.”[57] Thus, “bonding play is an inherent perceptual activity.”[57]

By drawing upon this approach, I began to rethink how and what to think about ‘sound’ and its behaviour, and most importantly, to hear ‘sound’ differently. This self-reflection on my sonic somatic knowledge led to a broader perspective on what I, as a composer and researcher, should perceive of sound as music. Furthermore, by having been working with electronics for some years, I have developed an ability to conduct detailed aural analysis of a given sound while relating it to the probable process used to create it. In short, by hearing a synthesized sample of sound I unconsciously begin to deconstruct the sound to detect how it could be synthesized,

[56] Smalley, ‘*Spectromorphology*’, 107.
[57] *Ibid*, 110.

thus, allowing me to identify and reproduce sound in a similar way to classical musicians with pitch identification training (i.e., relative/perfect pitch). This is what Denis Smalley acknowledges as technological listening, as he further explains:

> "*The composer, or other listeners conversant with technology and techniques, cannot easily brush aside a particular listening mode which I call technological listening. Technological listening occurs when a listener 'perceives' the technology or technique behind the music rather than the music itself, perhaps to such an extent that true musical meaning is blocked. Many methods and devices easily impose their own spectromorphological character cliches on the music.*"[58]

Whilst I can apply a technological listening approach, this is inevitably biased by my toolkit. Technological listening isn't ubiquitous since, similarly to *Cache* and electronic-informed improvisatory instructions, it requires a certain accumulation of technical knowledge gained from first-hand experience with technologies.

Regarding technology, it is vital to mention that this work was written to be ideally heard through a pair of stereo headphones. Hence, the atmosphere of the piece is then amplified, producing a more intense and immersive experience. This effect is also enhanced by the loop structure of the piece where some sounds span through the whole work to avoid disruptions in the listener's perception (fig. 34). It is, therefore, a never-ending cycle of provoking the listener with ambiguous sonic information that they are familiar with but incapable of distinguishing under these circumstances.

[58] Smalley, '*Spectromorphology*', 109.

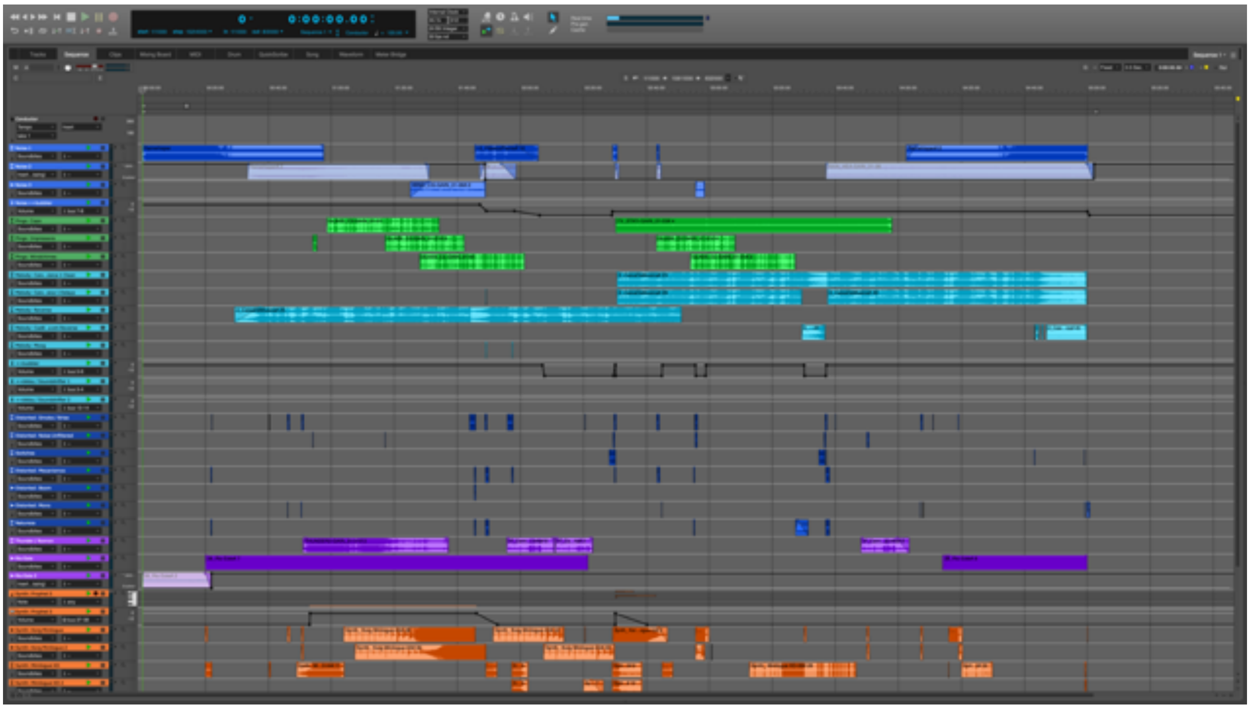

Figure 34 — 00:00~05:02; Screenshot of the whole MOTU Digital Performer session view.

Additionally, this work allowed me to further question the role of 'gesture' and 'meaning' throughout this piece. This is something that I have also become more aware of after exploring the music and research of composers such as Rebecca Saunders and Brian Ferneyhough. It is not my intention to focus deeply on the psychological aspect of meaning perception and aural recognition. However, since I was dealing with very recognizable sound sources, this issue was inevitable. As in text-based music and *musique concrète*, 'meaning' is heavily related to the text and source recognition respectively, as Dennis Smalley summarizes:

> *"In this type of electroacoustic music, meaning is closely allied to recognising the sources, identifying with them, knowing which context they have been drawn from, and reinterpreting their meaning in their new musical context. Such music is therefore transcontextual or intertextual."*[59]

'Gesture' is usually a given in *musique concrète* due to the often-complex nature of these recorded sounds. Unless one isolates a sound in an anechoic chamber, field recordings pick up several sources leading to an amalgam of sonic data in time. This

59 Smalley, '*Spectromorphology*', 109-110.

makes it possible to relate the evolution of the spectrum to one's idea of 'meaning', whereas in text-based music, 'meaning' and/or 'gesture' can be achieved without the need for spectral evolution and/or blend. If I did not address it properly at an early stage of composition, this frailty would pose a severe threat to the 'blended' properties of this piece. Going along the proposed definition of spectromorphology by Dennis Smally, he then proceeds towards relating his proposed approach with 'gesture':

> *"We should not think of the gesture process only in the one direction of cause–source–spectromorphology, but also in reverse – spectromorphology–source cause. When we hear spectromorphologies we detect the humanity behind them by deducing gestural activity, referring back through gesture to proprioceptive and psychological experience in general. Everyone uses this spectromorphological referral process when listening to recordings of instrumental music. Not only do we listen to the music, but we also decode the human activity behind the spectromorphologies through which we automatically gain a wealth of psycho-physical information."*[60]

In summary, this work blends 'meaning', 'gesture', and 'aural perception' using acoustic and synthesized materials to blur these domains.

7.2.3 Prelude

Prelude is the result of a similar commission to *Paysage*, only that here I had to re-imagine the work of the psychedelic rock band 10000 Russos and merge both of our soundworlds into an acousmatic work.

In this work, my compositional, timbral blending, and research aims were similar to *Paysage*, however, here I sought to inform, and as a result enhance, the performance of this work on human unpredictability and variability by delving into real-time and

[60] Smalley, '*Spectromorphology*', 111.

modular electronics, as I started to discuss in *Cache*. The figure below (fig. 35) shows us that the sequencer timeline is relatively sparse, not in any way crowded with samples or automation information.

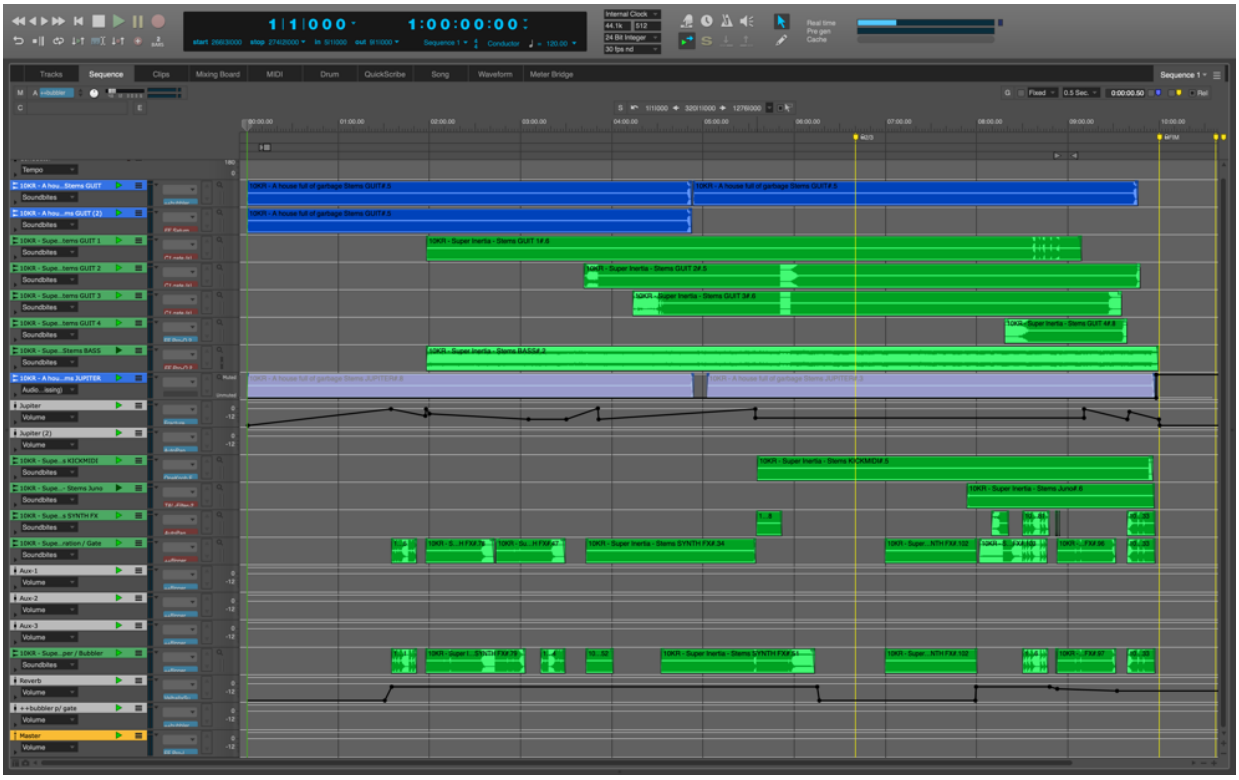

Figure 35 — 00:00~11:00; Screenshot of the whole MOTU Digital Performer session view.

On the other hand, the mixing board is filled with a wide array of granulators, saturation, distortion, stereo imagers, equalizers, filters, delays, compressors, panners, samplers, transposers, limiters, and most importantly, gating plug-ins (fig.36).

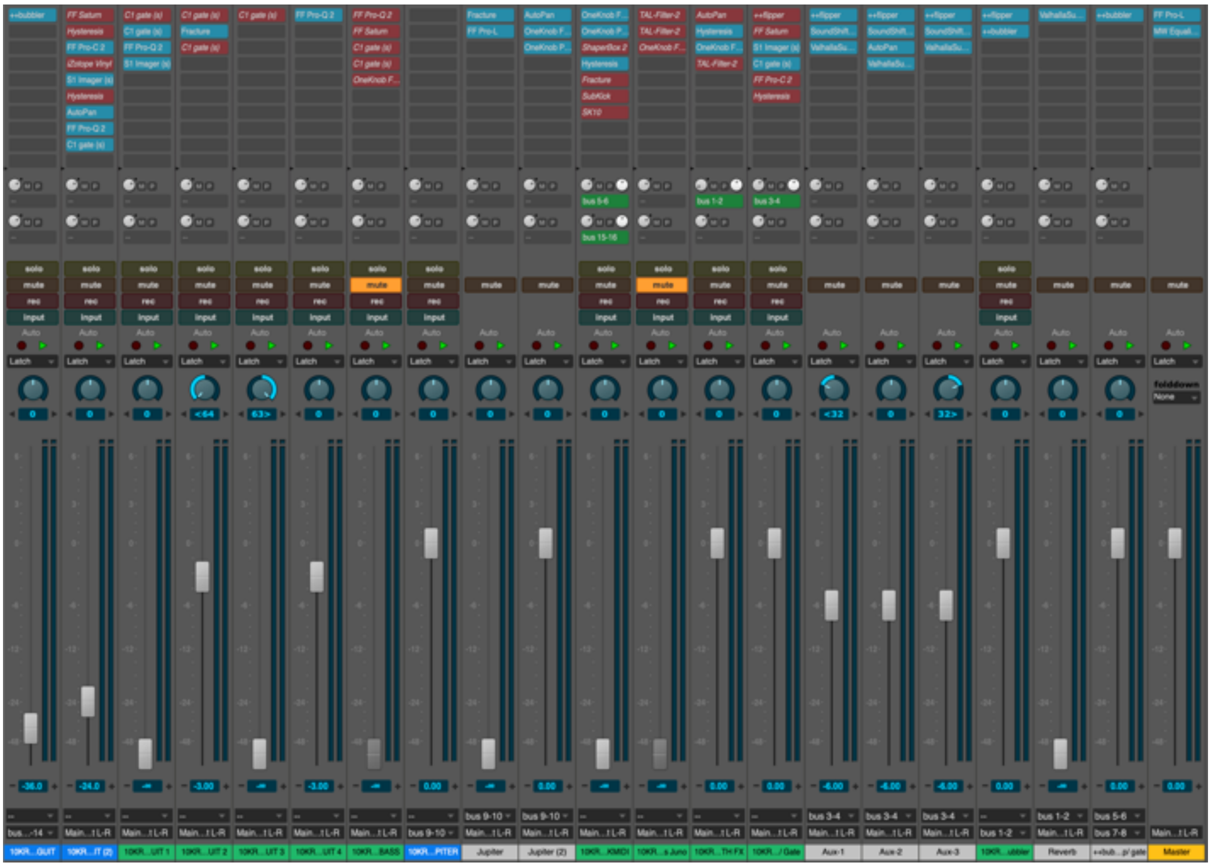

Figure 36 — *Prelude*; MOTU Digital Performer mixing board view.

The Waves C1 gate (s) plug-in (fig. 37) was key in shaping this approach, by using multiple instances of this plug-in in most of the tracks, I was able to open and close the signal flow between tracks and their plug-ins. In this work, form is achieved by layering and re-arranging some of the original stems in a sequence followed by a complex network of gating plug-ins that either play/mute a track or routes sound via another chain of effect plug-ins such as granulators and delays. This is all controlled in real time by sidechaining the amplitude threshold of each track to the opening or closing of these gates. This means that most of what this work is and can become is influenced by a set of gating instructions, such as the threshold (i. e. amplitude level), envelope, and behaviour. Thus, picking up on the performance aims of *Cache*, this work is slightly different every time it is realised in the sequencer.

Figure 37 — Waves C1 gate (2) Plug-in.

(Orchestra)tion as Instrumental Synthesis | The Computer

With powerful computer algorithms at our fingertips, the extension of electronic music principles into the instrumental domain might appear simple, however, there are several aspects to consider when 'transcoding' electronic timbre for instrumental performance. Yan Maresz believes that:

> "(…) *we still live from our heritage. And if some composers have surpassed it, we must admit that orchestration is still too often approached in quite an archaic manner in the age of computer music, and that a rational and scientific approach to it is still to be achieved*."[61]

[61] Maresz, '*On Computer-Assisted Orchestration*', 99.

Today, this ‘rational and scientific approach’ is available through computer-assisted orchestration. Orchestration is so often limited by the orchestrator’s knowledge of instrumental timbre. By delving into the acoustic makeup of sounds, which is impossible for a human to do, there are new possibilities offered by using the computer to search for the best combinations of orchestral sounds to match a target sound under specified metrics and constraints. Nonetheless, as I will further discuss, this emerging technology raises many questions about the role of the computer and composer/orchestrator in my creative process.

> *“The main idea behind computer-assisted orchestration is to provide computational support for composers in order to automate or semi-automate some tasks related to complex music orchestrations, beyond standard orchestrational practices of doublings and enrichments and into complex new timbres and textures.”*[62]

Target-based computer-aided/assisted orchestration results in generating orchestration solutions by cross-referencing the spectral contents of an audio sample with the loaded instrumental database by combining individual timbres of the instruments under a set of constraints.

> *“In real-world situations, the target sound is not static and changes over time. In order to generate a realistic orchestration of an evolving sound, it is therefore necessary to represent these changes. This problem is at the origin of the classification of target-based assisted orchestration in two main categories: static and dynamic.”*[63]

- **Static**
  - *“(…) the target sound is represented as a single non-varying vector in the feature space; in other words, as an orchestral chord. (…) a solution can be generated after a single search phase, as it is only necessary to determine a single note for each of the requested instruments.”*[64]

[62] Cella, ‘*Orchidea*’, 2.
[63] *Ibid*, 5.
[64] *Ibid*.

- *"(…) sounds are represented by feature vectors that describe the average of descriptors across time."*[65]
- First <u>static</u> orchestration software – Orchidée and Orchis – launched around 2008, though they were found to be impractical and unreliable to use, resulting in unpredictable and unperformable orchestral solutions.

— **Dynamic**

- *"(…) the target is described by a temporally evolving set of features. The two cases are essentially different and require different strategies, since the latter introduces time. (…) a solution must include multiple notes for each instrument and multiple search phases are required."*[66]
- *"(…) sounds are represented by a set of time series of descriptors that describe the temporal evolution of sounds."*[67]
- First <u>dynamic</u> orchestration software – Orchids and Orchidea – launched around 2013-2014 and 2018 respectively.

I will also further attempt to explore Antescofo, a real-time score following software, as an assistant for mixed music performative events in *Suivi*.

7.3 In Practice: Computer-Aided/Assisted Systems in *Suivi*, *Moving Sources*, *Point of Departure*, *Keep up!* and *Nuances*

In this section, I will be reflecting on my artistic journey alongside the multiple experiments I have conducted whilst using computer-aided/assisted systems for composition, orchestration, and performance practice. As such, here I began to rely more on a scientifical approach to timbre blending and music making.

[65] *Ibid*, 10.
[66] *Ibid*, 5.
[67] *Ibid*, 10.

7.3.1 Suivi

Suivi is born out of a collaboration with the bass clarinettist Frederic Cardoso, supported by the Portuguese Republic — Ministry of Culture. My main aim with this work was to keep refining my previous research interests, while now recurring to the assistance of computer systems. Here, I experimented with Antescofo, which:

> *"(…) is a modular anticipatory score following system that holds both instrumental and electronic scores together and is capable of executing electronic scores in synchronization with a live performance and using various controls over time. (…) Antescofo comes with a simple score language for flexible writing of time and interaction in computer music."*[68]

As an example, a draft of an Antescofo score used at the beginning of *Suivi*'s development is shown below.

```
; Antescofo score generated using native importer
; Copyright (c) IRCAM 2015
; Designed by Robert Piéchaud
; Original file: Suivi (A)_AS.xml
; exported from Sibelius 21.2.0 ~ Direct export, not from Dolet
; MusicXML version 3.0
; Converted to Antescofo on Tue Aug 17 15:01:08 2021
; Credits: Suivi

; start
; ----------- measure 1 --- beat 0 --- time signature 3/4
antescofo::suivi 1
BPM 88 ; ( ← □ =176)
Note C#3+50 2 measure1
NOTE C#3 1/4 @staccato
     D1 Set_Delay_Time_10000
     D2 Stop_Delay
NOTE D#4 1/4 @staccato
NOTE 0 1/2
; ----------- measure 2 --- beat 3 --- time signature 3/8
```

[68] Cont, '*ANTESCOFO: Anticipatory Synchronization and Control of Interactive Parameters in Computer Music.*', 1.

```
NOTE D4 1/4 @staccato measure2
NOTE 0 1/2 @staccato
NOTE F#4 1/4 @staccato
NOTE 0 1/4 @staccato
NOTE A3 1/4 @staccato
; ----------- measure 3 --- beat   4.5 --- time signature 4/4
NOTE 0 3 measure3
NOTE D3 1/4 @staccato
NOTE 0 1/4
NOTE D4+25 1/4 @staccato
NOTE 0 1/4
; ----------- measure 4 --- beat   8.5 --- time signature 3/8
NOTE 0 3/2 measure4
; ----------- measure 5 --- beat 10 --- time signature 4/4
NOTE 0 5/4 measure5
NOTE D5+25 1/2
NOTE D#5 1/4
NOTE 0 2
```

In short, the score is just a text file containing text-based descriptions of what consists of the written musical score. There it contains events (notes, chords, metronome marks, among others) and within events, we can set an endless number of actions. Under the written instructions, in measure 1, `NOTE C#3 1/4 @staccato` contains actions `D1` and `D2`. This means that whenever the system picks up this 'event'(note), action `D1` will be triggered, and when this is completed, action `D2` will follow.

However, through human performance, this score is shaped and not every detail is picked accurately by the computer. The clearest example of this is pitch. Antescofo can track pitch by specifying a pitch to track, and it is possible to set a certain degree of pitch deviation, but that does not inevitably mean that either the performer will play within the given range, or the computer will be able to distinguish the pitch. Since the software is not able to distinguish sources in performance, if for example, a mobile phone rings within the given frequency range, then it might trigger the system.

This meant that from the outset I was facing huge constraints in my approach due to, as an example, not every (western) musical symbol or even graphical notation being possible to transcode without time-consuming and very ineffective workarounds, or not being able to fully predict all the performance variables in play. As a result, the interaction was "most often limited to mere triggering of a separate electronic score."[69]

Thus, for the sake of my musical goals, I discarded Antescofo and instead focused on a timbral mixed music composition using fixed electronics. Closely collaborating and experimenting with tones, embodiment, and fingering positions with Frederic Cardoso made me use the bass clarinet to search for timbres with high spectral proximity with noise-based electronic synthesis.

Three key techniques that sprouted from this collaboration were:

- the use of harmonics and/or multiphonics. Due to spectral instability and inharmonicity, their use allowed me to better blend the timbre of the bass clarinet with unstable noise-based electronic sounds (fig. 38);

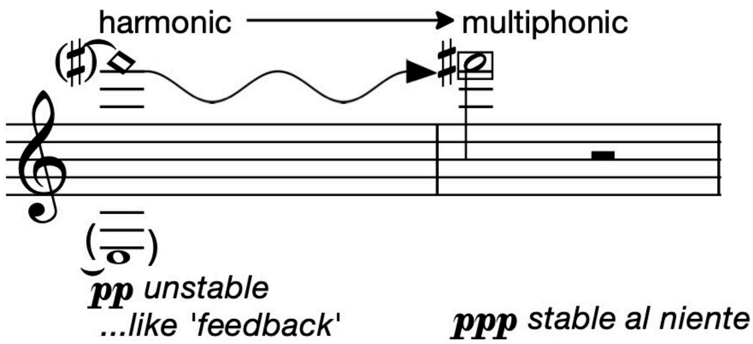

Figure 38 — Bars 21~22; Unstable harmonic tone transitioning to a similar unstable multiphonic.

- extended air instructions since pitch-based spectra is quickly engulfed by noise if the instrument is inaccurately blown or overblown. Also, it can lead to unexpected tones and sonic artifacts. Thus, further reducing the divide between these opposite timbral realms (fig. 39);

[69] Cont, '*ANTESCOFO: Anticipatory Synchronization and Control of Interactive Parameters in Computer Music.*', 1.

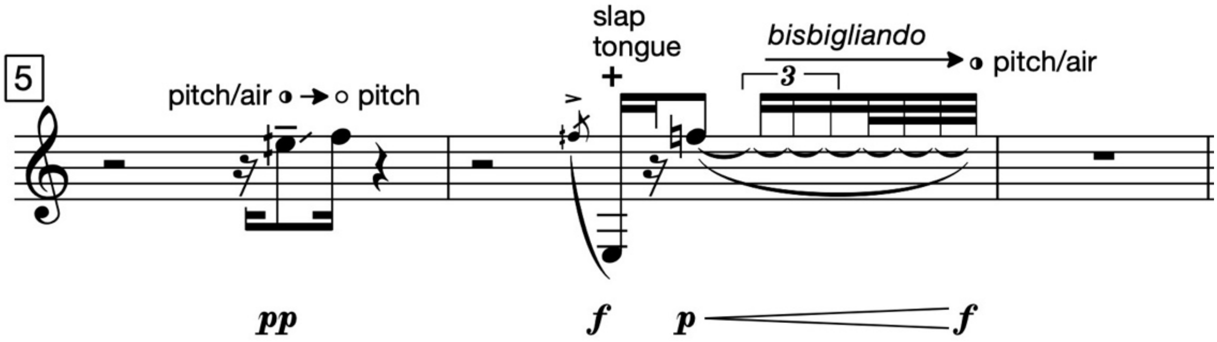

Figure 39 — Bars 5~7; Extended air instructions. A closed dot is used when air/noise is preferred, and the opposite is true for the white dot. Half-open/closed refers to airy tones.

— non-idiomatic writing and the attempt of doing it (fig. 40). This was, I must confess, my favourite takeaway from this work. Building on the work of other composers, such as Brian Ferneyough, and by acknowledging the physiological limitations of both the instrument and the performer, I sought to notate beyond these so that the written musical goals would be purposely out of reach.

Figure 40 — Bars 176~193; non-idiomatic approach.

At ♩ = 88 beats per minute, the previous example is almost impossible to perform accurately, hence, while working with both Frederic Cardoso (premiere) and Rowan Jones (second performance), my immediate feedback was to instruct the musicians to commit to the performance and not the score, which is not often the case. Then, they just tried to play as best as they could on the given tempo. This was, of course, bound to fail since the huge leaps in registers (pitch) with multiple different articulations are not an idiomatic way of writing for the Bass Clarinet, especially in such a short time span.

Sonically, this immediately resulted in two sonic layers, the written layer where snippets of the score are perceived, and the abstract instrumental synthesis of unpredictable sonic artifacts, which I call glitches, from the attempt of trying to commit to the score while bound by the tempo indication.

This approach was immensely inspiring to me. I suddenly realized that I was now able to focus on multiple layers of sound by relinquishing idiomatic ideals even when using a single monophonic instrument. Here, this was achieved by controlling one layer with idiomatic writing and a whole other layer by pushing against that, which is something that I was keen to explore further.

7.3.2 Moving Sources

Moving Sources [for Chamber Orchestra] is a 'study' that facilitated experimentation with and evaluation of traditional spectral procedures by exploring the relationship between orchestration and electronics primarily through the means of manual spectral analysis and subsequent electronic-informed timbral-blending techniques such as filtering, reverberation, granular synthesis, pitch freezing, noise, delays, and spatialization.

My main aim was to manually transcode both the physical and sonic properties of wind chimes into orchestration solutions with the assistance of spectral analysis.

Most of the compositional materials were extrapolated from a wind chimes recording[70] which then served as the framework for laying out the form, the harmonic progression, and spectral density.

Firstly, I did a spectral analysis[71] of the audio sample using SPEAR v0.8[72] to extract data referring to only the strongest harmonic partials (fig. 41).

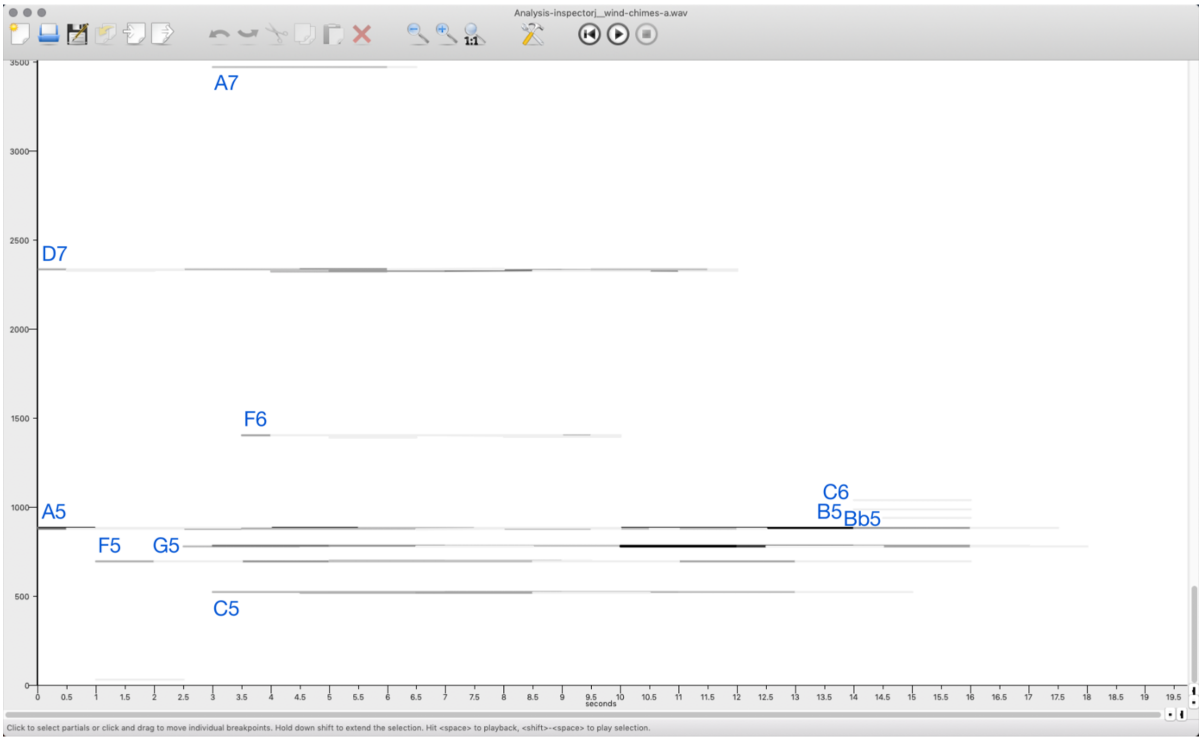

Figure 41 – Obtained spectral analysis from the chosen sample.

Initially, I only intended to extract the most relevant pitch data, however, I further based the melodic and harmonic contour on the overarching progression of harmonic partials (x-axis). This process was realized in an intuitive way without limiting myself to a precise transcription of the analysis information. Otherwise, this piece would have the same exact duration and proportions of the obtained data. This approach was essential to take over the development of pitch and timbre throughout the piece.

---

[70] "Wind Chimes, A.wav" by InspectorJ. Uploaded to https://freesound.org on the 1st of September of 2016 and accessed on the 23rd of July 2020. Author description: "*A quick extract of a collection of wind chimes I stumbled across at a gift shop at the Jacksonville Zoo, Florida. I have added a little bit of echo and reverberation using Audacity. The sound was recorded using a "H1 Zoom recorder" on 26th August 2016*".

[71] This technique was popularized in the 1970s by spectral composers such as Gérard Grisey (1946-1998) and Tristant Murail (b. 1947) and is one of the predecessors of computer-assisted orchestration.

[72] [Suggested Reading] Klingbeil, '*SOFTWARE FOR SPECTRAL ANALYSIS, EDITING, AND SYNTHESIS*'.

Regarding orchestration, my approach was informed by my personal experience with the wind chimes. On their own, wind chimes are instruments that can be elicited to move and play by themselves (with the natural stimulus of the wind) in a generative-like style. Thus, I wanted the orchestra to portray this movement. To do so, I approached the orchestral timbre palette as a multidimensional and malleable mass of sound that can shift within the orchestral sections.

This technique consequently shifts the orchestration focus from instrument-based orchestration to timbre-based, which goes against most traditional treatises in instrumentation and orchestration. Additionally, this position derived from my ever-growing interest in timbre and the progressive acknowledgment that instrument-based techniques did not serve my compositional and orchestrational aims to their full potential by disregarding timbre and sound quality in favour of instrumental hierarchies. On the other hand, timbre functions in the realm of frequency and not musical pitches, thus there are always compromises to be made due to the physiological inability of acoustic instruments to meet certain requirements, such as micro-tonality. In notation, micro-tonal pitches are usually part of what is commonly understood under timbre by the spectral tradition of timbral orchestration. However, timbre-based orchestration does not imply microtonality. This is decided on a case-by-case and often semitone quantification and the tempered scale are the ideal approaches to avoid unwanted dissonances or timbral instability when orchestrating for a large instrumental setup or sections where instruments more physically inclined to the tempered scale are used, such as the oboe. This expansion of orchestration into timbre, and subsequently, spatial domain (just as it is fully integrated into electronic music) is one of the critical aspects of both this research and work development (fig. 42).

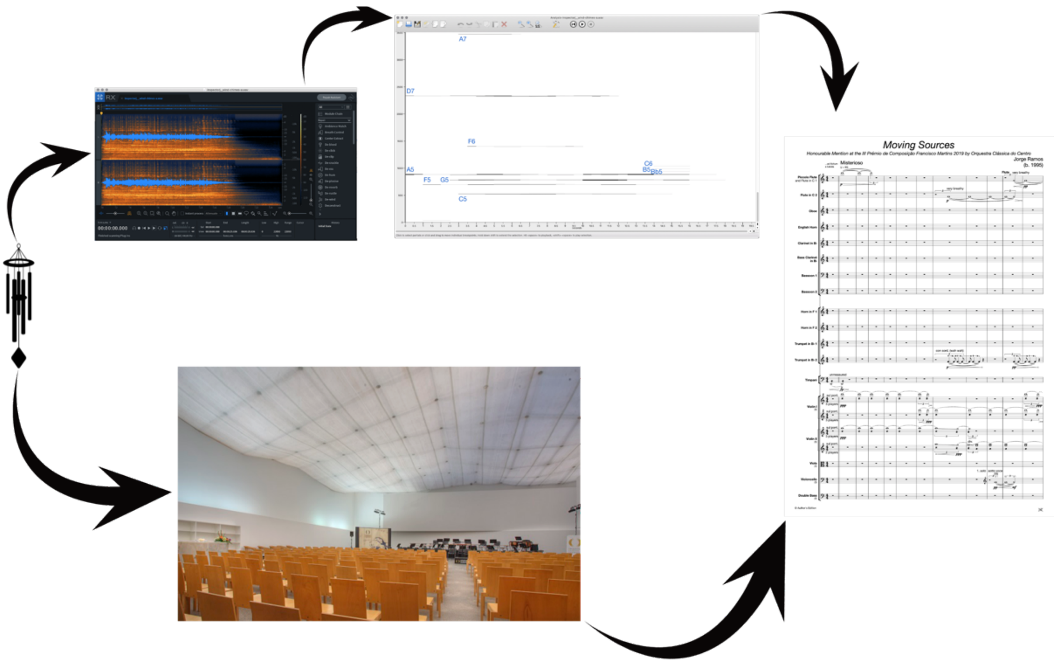

Figure 42 — (Composition) Audio → Spectral De-noising → Manual Spectral Analysis → Score. (Orchestration) Instrument → Behavioural & Site-responsive-informed orchestration → Score

Spatialization as a compositional and orchestration parameter is not new. This principle was often used in polychoral compositions (for two or more choirs) by many liturgy-related composers — such as Giovanni Gabrieli (± 1554/7-1612). In *Moving Sources*, the instrumental disposition on stage (fig. 43) was key to determining the kind of possible timbral trajectories since changing the instrument's position live was not desired.

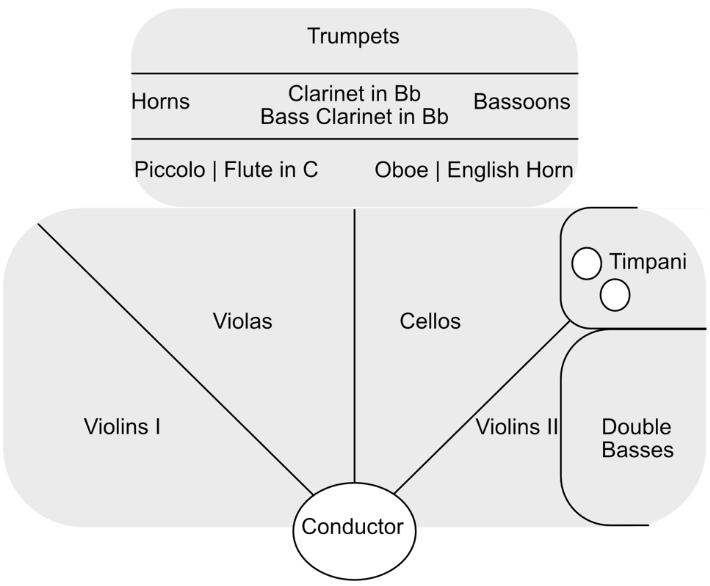

Figure 43 — Instrumental disposition on stage.

Besides, this ear-led distinction between the foreground and background presence of sound layers was impossible to obtain through spectral analysis since most computer software is not perceptually aware of sonic depths.

Given the range of the stage covered by the strings section, these were key in acting as a 'bridge' for timbral transitions. However, most of them were being used to mimic both the reverberation and the pitch-freezing effect found in the original recording. Also, due to their voice-like tone quality and spectral blandness, the strings acted as a cohesive element between all different sections (brass; woodwinds; strings, and percussion). This meant that a combination of a non-string instrument with a string instrument helped me achieve a timbral blend of a higher quality (fig. 44).

Figure 44 — Bars 99~107; Timbral blend between Bassoon 1; Horn in F 1 and Violoncellos.

Secondly, their disposition covered almost the entire left-to-right range on stage which meant that I was simultaneously able to fully control the 'stereo' image. This technique was informed by electronic multi-channel ‘diffusion’ tools and their impact on timbre. As an example, instruments placed further away on the stage are the first ones to lose high-pitched harmonics since these frequencies need a shorter amount of space than lower frequencies to travel in space. However, I soon realized that putting too much focus on the strings section was too two-dimensional and lacked depth perspective.

Thirdly, strings are the only section able to obtain a constant and uninterrupted stream of sound throughout a considerable amount of time (i.e., with the use of *divisi* and nonsynchronous bowing techniques). To enhance this, I embraced the clarinets as timbral pivots since they are placed further in the center of the stage. This allowed me to transition from a bi-dimensional axis (left ⟷ right) to a multidimensional axis (left ⟷ right and front ⟷ back) as observed in (fig. 45), where sound moves from the foreground (strings) to the background (woodwinds and brass) and then is precisely located on just the brass section, on the left-rear side of the stage.

Figure 45 — Bars 70~77; An example of a timbral trajectory.

Moreover, the decision to use the clarinets as a subsidiary section to the strings was based on my personal judgment of how I perceive the timbral similarities between the two. In my opinion, every other combination between the strings, the woodwinds, percussion, or brass was too easily distinguishable in terms of disposition and timbral identity. This undermined the purpose of having a unique blended sonority throughout the piece. Additionally, this use of spatialization was only perceivable between the medium-high to high registers such as violins and trumpets since low frequencies take more time and space to develop and are perceptually harder to locate.

Naturally, this constraint is directly related to the size of the reverberation. On the other hand, it also served as an expansion to the timbral blend. In some cases, reverb was a useful tool to shroud the timbre in a 'cluster-like' cloud of sound (fig. 46). Timbrally, I found very rhythmic sections to be too blurry to be of any interest by themselves but were ideal to mask or accentuate other timbral effects.

Figure 46 – Bars 35~41; Rhythmic section on the strings.

Oppositely, some decisions were made towards producing a more sharply piercing timbre, such as the combination of the brass and string instruments in *sul ponticello* (fig. 47). The *staccatissimo sul ponticello* in the strings and closed 'wah wah' *sordino* in the trumpets produces a piercing timbre allowing the audience to immediately precise their exact playing position. In electronic terms, this timbre was informed by the filtering of electric-generated impulses through a High-Pass Filter. Also, the adoption of harmonics, *con sordino* (fig. 48), *sul ponticello*, *sul tasto*, bowing pressure ('noisy'), pitch bending (fig. 49), and general dynamics allowed me to shape timbre akin to the use of envelope generators, noise generators, and filters in electronics.

Figure 47 — Bars 59~64; A piercing timbral combination between the trumpets, violas, and double basses.

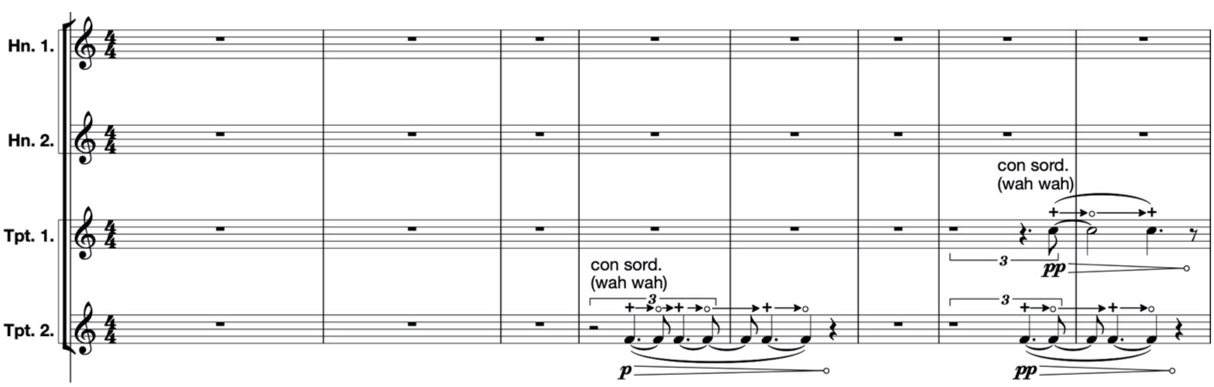

Figure 48 — Bars 81~88; Example of harmonic 'filtering'. The use of 'wah wah' mutes allow the player to freely shape the emitted sound by filtering the higher partials. This resembles an LPF.

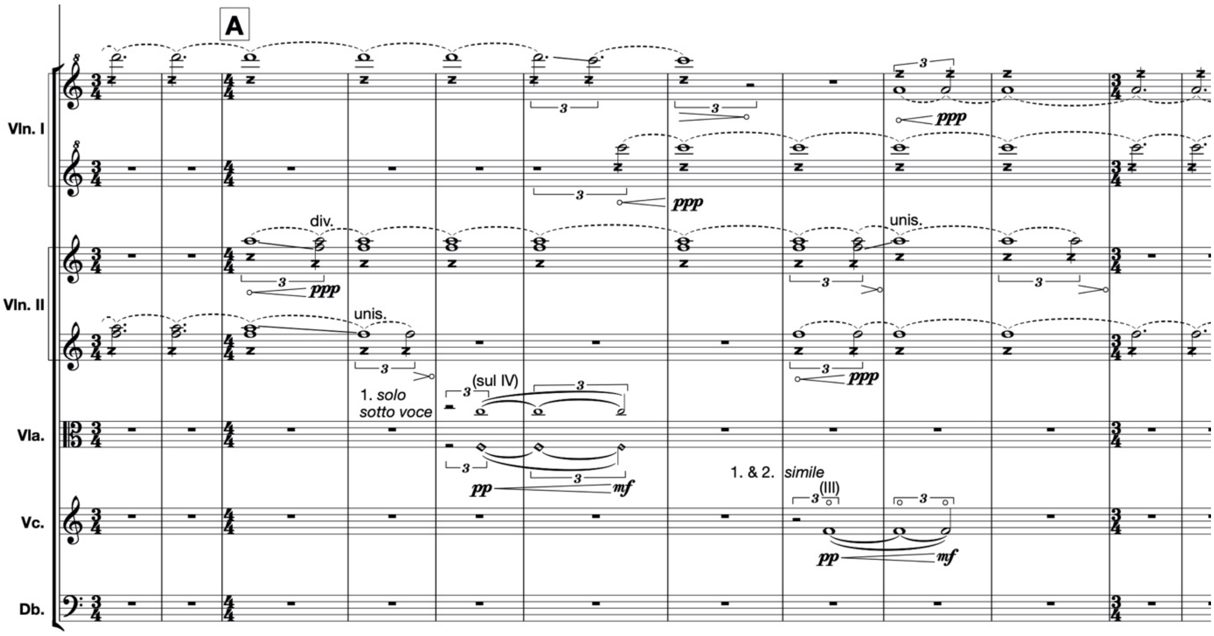

Figure 49 — Bars 12~23; Example of ‘pitch bending’ within the Violins section.

Furthermore, by informing orchestration from simple electronic processes such as delay (fig. 50) and combining them into more complex solutions (fig. 51), I was referring to modular synthesis such as physical analogue modular synthesizers[73] and software replicas. In these environments, each event can become a controller for an endless number of actions, or both an impulse generator and an event trigger.

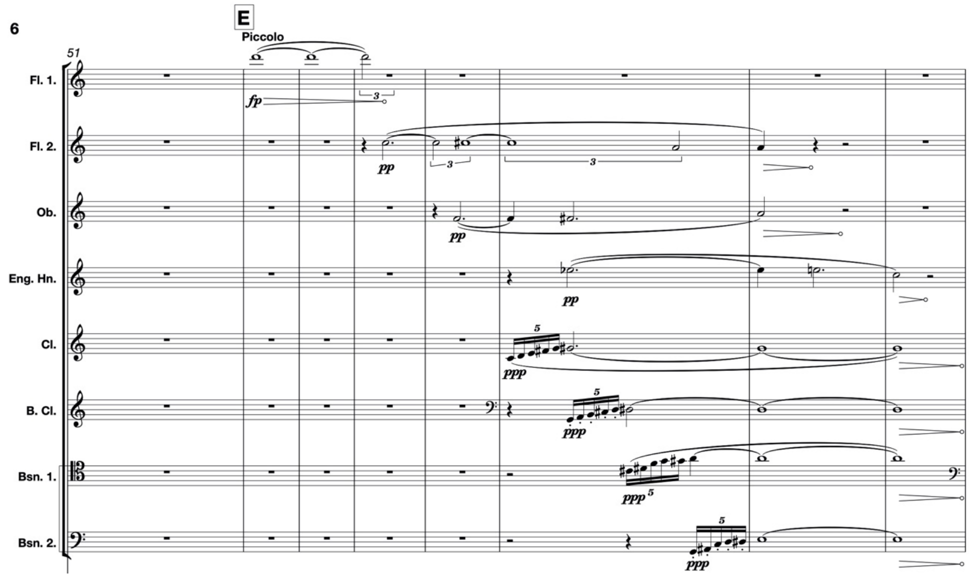

Figure 50 — Bars 51~58; An example of a ‘delay’. The quintuplet found in the Clarinet in B♭ is orderly delayed by the lower woodwinds in a 1:1 ratio (1 beat of displacement from the triggering impulse).

[73] [Suggested Reading] Bjørn, Meyer, and Nagle, *Patch & Tweak*.

Figure 51 — Bars 59~60; The last impulse of the clarinets and bassoons triggers an impulse on the flutes, oboe, and English horn. This is then progressively delayed and filtered when crossfaded from the Piccolo to the English Horn.

These techniques are not necessarily new, as they have been used by Tristan Murail, Luciano Berio, György Ligeti, Edgard Varèse, amongst others, throughout the history of computer music. Even so, this was essential to familiarise my creative practice with traditional computer-aided electronic-informed orchestration processes before moving on to other systems.

7.3.3 Point of Departure

Point of Departure [for Symphony Orchestra] was my first attempt using computer-assisted orchestration (Orchidea v0.6.1 standalone application loaded with the IRCAM FullSOL2020 database), where my main goal was to transcode as much as possible from my stereo acousmatic work — *Project 2* (2012-2013) (fig. 52) into the orchestral domain with this software assistance. This involved a more direct and systematic approach to linking the electronic and instrumental, an approach that had a radical impact on creative control and decision-making.

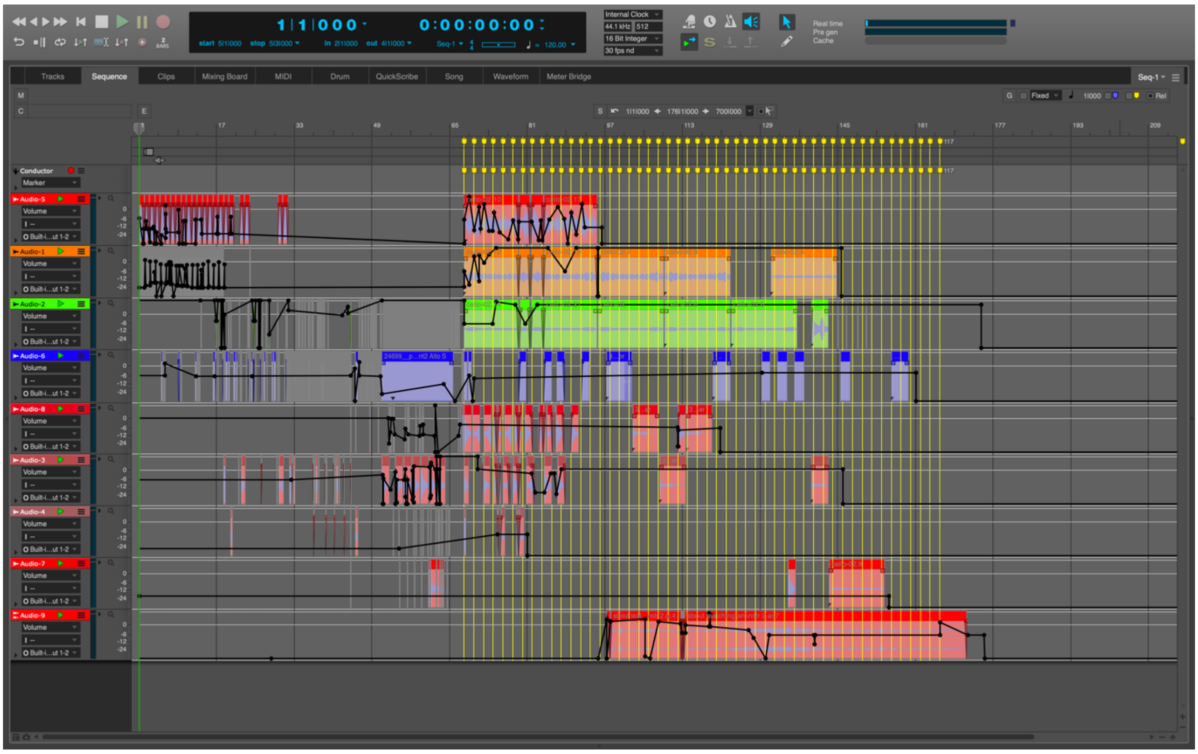

Figure 52 — *Project 2* (2013-2013); Screenshot of the MOTU Digital Performer 10 session view.

I tried to transcribe as much material from the acousmatic to the instrumental domain as faithfully as possible, measure by measure. Nonetheless, before any transcription process was able to occur, I first had to agree on a time scale. Hence, the structural *tempo* (BPM) of this work is two-fold:

- There was no need to use a metronome mark in the sequencer since I chose to use the timeline instead, where one second is equivalent to one beat under the standard metronome mark of 60 beats per minute. However, the sequencer assumed the general background tempo of 120 BPMs.
- For the sake of clarity, I used the aforementioned BPMs as framework. Otherwise, a complex mathematical formula to scale time to note duration had to be used. Also, since the electronic material is denser until bar 68 and sparse

hereinafter, I decided to go with 120 BPMs for the denser part and 60 BPMs for the further slower section allowing me to both control the density of notated information and avoid the overcomplication of the performer's part.

— Regarding the last stereo track — Audio-9 — this is being processed in real-time through a digital reverb plug-in (fig. 53) to colour[74] and extend all the musical material allocated to this track. Hence, the full duration of each sample on this track is not visually observed.

Figure 53 — MOTU eVerb ™ 4.4.5 (83385) digital reverb plug-in.

This textural differentiation can be easily observed, where the first part is filled with movement from multiple audio samples and volume and panning MIDI information, and the second part is based on longer and fewer audio samples with less MIDI data. Thus, from bar 68 onwards a mathematical formula of 2:1 ratio was used for this macro scaling — the timeline to metronome mark — and the respective micro temporal and behavioural properties of the artificial reverberation plug-in were taken into consideration — 'fade away' effect due to the fading of frequencies/harmonics in a defined ratio — for the formalization of my approach.

Naturally, soon after the very first few pages, and due to the artificial inharmonic

[74] I was able to control the perceived deepness and spectral richness through filtering each sound with eVerb.

content of multiple audio samples — such as noises, glitch-based and/or heavily synthesized samples — I realized that a pure transcription from the electroacoustic to the instrumental domain was an impossible task to accomplish. In the instrumental domain, timbre blending (i.e., orchestration) is only possible to a certain extent. Henceforth, it is always limited to the possible timbral combinations between the available instruments.

On the other hand, in electronic music there is no limit to timbral blend since every combination of frequencies is made possible until 'noise' (fig. 54) is achieved. This said the timbral gap between the timbres offered by instrumental and electronic domains meant that some sounds were rendered impossible to be portrayed in the orchestral domain. This finding was crucial and influenced all further creative decisions. I was forced to reroute my perspective from a pure transcription-wise point of view to a broader use of Orchidea's output material as a point of departure.

Figure 54 — Bars 11~20; In the instrumental domain, 'white noise' is obtainable by extended air techniques as previously tested and described in *Suivi*.

Regarding Orchidea, this shift allowed me to extend the scope of my timbral blend techniques by having a more direct and intuitive back-and-forth feedback collaboration with the software. Seeing things from this perspective, I was now allowing myself to agree or disagree with the solutions offered by the software instead of just trying to make those solutions work. In a way, this was where I began to use the software as an assistant and not the other way around.

Beforehand, I was too skeptical of such tools. Their previous versions always seemed to output very random and unreliable solutions; however, with Orchidea, I began to obtain some interesting results. Meanwhile, I must say that, up until this day, it is not possible to generate a complete and reliable full score with computer-assisted orchestration software, as "there has not been much previous research in the area of automatic orchestration in the sense of autonomously assigning sounds to a score."[75]

This said, Orchidea is dependent on human-machine interaction, whereas in automatic orchestration the role of the human composer and orchestrator is nulled and assumed by the computer. Also, the suggested solutions will largely depend on the chosen database since it requires a dataset of each instrument's sound descriptors[76] to further relate the audio spectral analysis with the loaded instrumentation spectral database. Likewise, the way this software works is also hugely dependent on the given audio file and the composer's-imposed constraints.

In any event, and depending on the density and texture of the desired target orchestration, I dealt with the audio files in two different ways (fig. 55):

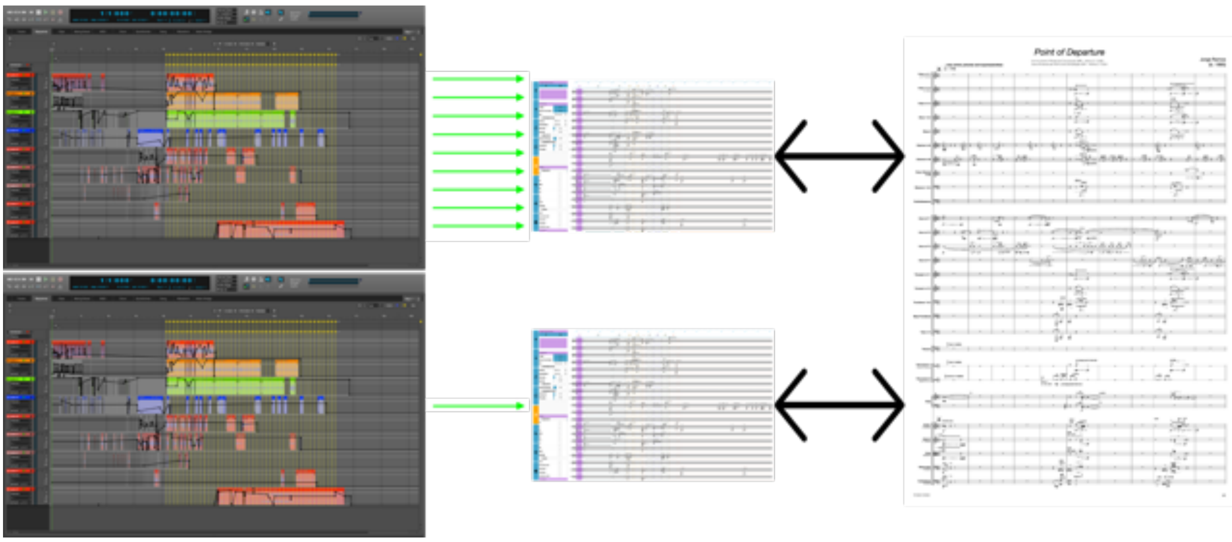

Figure 55 — [top] Using a selective approach to generate an orchestration solution. [bottom] Using a per audio file or per track approach to generate an orchestration solution.

[75] Handelman, Sigler, and Donna, '*Automatic Orchestration for Automatic Composition*', 43.
[76] [Suggested Reading] Peeters, '*A Large Set of Audio Features for Sound Description (Similarity and Classification) in the CUIDADO Project*'.

— An **individual** solution is generated from the analysis of a single audio sample or track. This approach is better for a more detailed representation of the given sound file since you are dealing with an independent solution for track/file (fig. 56). However, if you have a pool of five audio samples playing simultaneously, you will respectively obtain five different orchestration solutions. Afterward, the merging of these different solutions into one performable and readable solution is the composer's responsibility. This was my approach for the writing of the first three pages of *Point of Departure*'s.

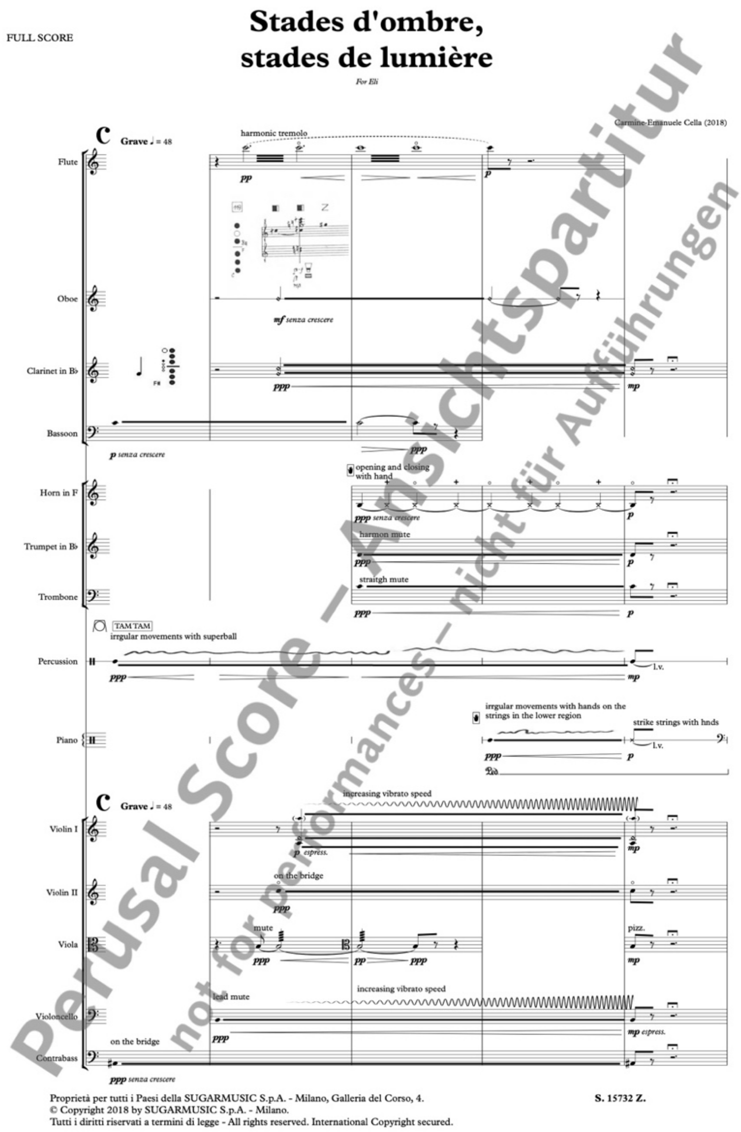

Figure 56 — Excerpt [1st page] of *Stades d'ombre, stades de lumière* (2018) by Carmine-Emanuele Cella (b. 1976) — composer and developer of Orchidea. The composer used this tool to obtain an orchestration solution from a bell audio recording and here we can see it reworked by the composer. © Permission to reproduce this excerpt has been granted by Carmine-Emanuele Cella.

— A **combinatorial** solution is generated from a combination of multiple tracks or files. This is better for a more textural-based representation. In any event, you must bear in mind that, the suggested results are often unperformable by a human interpreter and only resemble the given sound combination to a certain extent. Therefore, it is not ideal when all details of each sample are needed to be perceived. This approach works best when the composer is only looking for a textural envelope and pitched sonority, such as the sound of crickets for example. Instead of obtaining a solution for the sound of each cricket, you get a solution for the whole ambiance noise. In this case, the software is incapable of detecting the number of different sources (i.e., how many crickets) and which cricket is producing exactly which sound, therefore, the suggested solution is an amalgam of the sound of all crickets and is only useful to set the tone (pitch) and texture of the targeted orchestration. Regarding *Point of Departure*, this was the predominantly used approach from page 4 onwards.

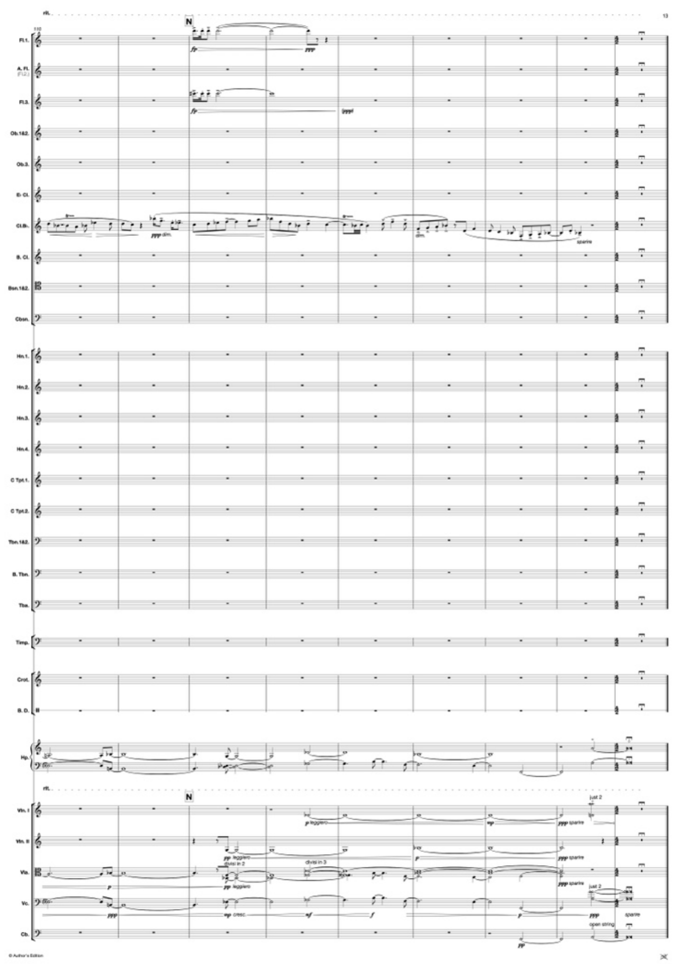

Figure 57— Bars 110~118; An example of both individual and combinatorial approaches in use.

Nevertheless, computer-assisted orchestration software is still in its early stages, and as such, severely limited. The most recent iteration of the software omits much information about space and how space affects sound. Thus, it strips the context out of a sound source. Even though a dataset is recorded in a resonant space, Orchidea will interpret the samples as having no spatial properties. Hence, Orchidea will interpret the affected sound as just another sample, and naturally, adopt the recorded 'acoustics' for the following orchestration solutions instead of being able to predict and strip spatial descriptors out of a sample to be able to generate an orchestration solution as close as possible to the sound emitter in the sample. Here, the problem lies in the summing of multiple 'acoustics' which leads to a less instrumentally representative orchestration solution of the original sample. As an example, if a sample of an organ being played in a cathedral is uploaded to the software, then a score of that will be suggested. On the other hand, that same score can be performed in a wide variety of locations, thus summing the acoustics of the cathedral with the acoustics of the location where the newer score is meant to be performed. This means that what the organ originally played will be progressively lost and newer material will be created as this process is recreated.

This resembles the sound-art piece *I Am Sitting in a Room* (1969) composed by Alvin Lucier where he is featured recording himself narrating a text and then playing the tape recording back into the room, re-recording it. The new recording is then played back and re-recorded, and this process is repeated. Due to the room's characteristics, certain frequencies are emphasized while others are attenuated. Eventually, the words become unintelligible, replaced by the resonant frequencies that make the acoustics of the room itself. As just an approach, this effect can be either an advantage or a drawback depending on the composer's intentions.

Additionally, the use of computer-aided orchestration systems helped me to improve my intuitive approach regarding ear-led sonic analysis. This was a major step in improving the accuracy of my transcription. Regarding acoustic recordings, there is a limit to the number of harmonic partials that a human can perceive, on the other hand, for the software, this is much less limited depending on the amplitude threshold imposed by the composer.

In the previous example (fig. 57), all the material was extrapolated from just two samples: one for the flutes (sample approach); and one that included both the recorded piano and clarinet (selection approach). The latter is an intentionally amateur recording of Paulo Bastos — my former composition professor — improvising at the piano. To perceive every detail of the performed extended techniques I had to raise the amplitude of the recording. By doing this, I noticed that the microphone also picked up the sound of a young clarinettist studying in the room next door. Instead of discarding this element as Orchidea would have done, I decided to transcribe his performance for a more faithful representation. Hence, both the errors and frustrations of his recorded performance were integrated into my transcription. Since the young clarinettist was recorded through a wall (from room to room), it was only natural that I would try to keep this effect in *Point of Departure* (fig. 58). Thus, I had to intuitively orchestrate this spatial effect by ear.

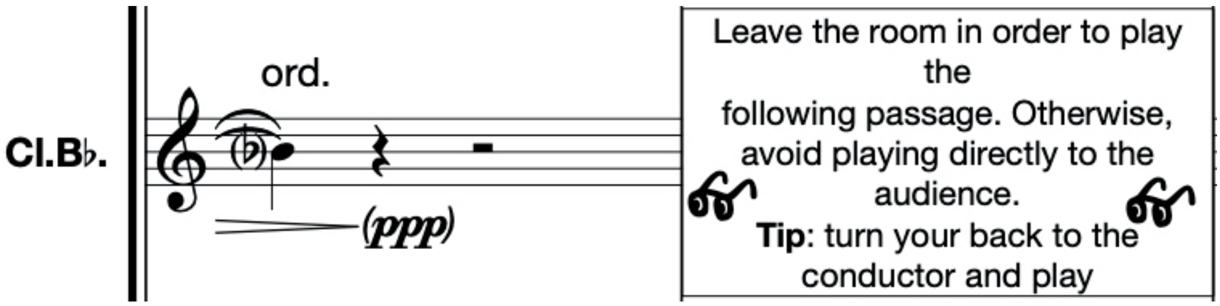

Figure 58 — Bars 74-75; Chosen instruction and notation for this spatial effect.

Opposing the Clarinet in B♭, the harp and strings section were more focused on portraying the piano improvisation including the sustain pedal and the overall spatial effect of proximity present in the original recording to the extent of what was possible (fig. 59).

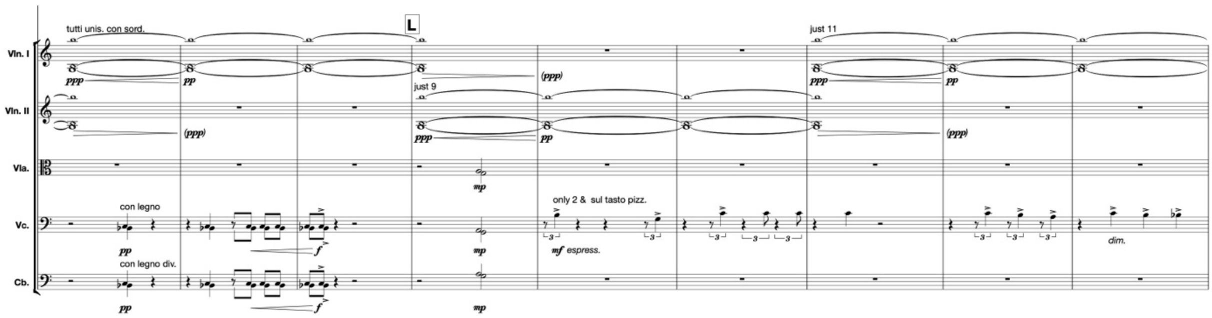

Figure 59 — Bars 92-100; Harp and strings portraying the piano improvisation and spatial effect.

This approach can help provide the composer with extreme freedom — if the software is used as a tool — or the other way around, imprisoning the uninspired composer for which every solution is more creative than the one he was thinking. After all the challenges, this approach allowed me to deepen my decision-making and collaborative skills by keeping both an open and critical mind to the creative input provided by the software.

7.3.4 Keep up!

Keep up! [for Alto Saxophone and Live Electronics] marks the transition to full real-time use of computer-assisted orchestration using Orchidea within Max/MSP. Here, everything is being generated in real-time, materials; composition; orchestration, and electronics. A back-to-back collaboration between human and machine where gesture is also integrated into both human and machine decision-making processes.

The patch functions by cross-referencing the spectral analysis of the incoming signal with a database of multiple alto saxophone samples every five seconds. This database is crucial to programming the machine decision-making approach. The cross-referencing process works by acknowledging the initial spectral data and then referencing to the database to figure out which sample has the closest spectral profile for each section, depending on the chosen resolution. Hence, the score is only able to include notes, dynamics and articulations of what is included in the given database.

Despite this, there are endless possibilities to affect the transcoding process, such as the resolution of the spectral analysis. The time frame and the listening threshold are, among many, the most important control since time affects rhythm - a shorter time frame leads to shorter/quicker rhythms - and density - a lower-listening threshold includes more pitch information and vice-versa. Here lies the real role of the composer and orchestrator. Here, my approach was two-fold: 1) allowing the resolution to randomly change from semiquaver, to quaver or crochet every time a pre-defined amplitude threshold is crossed, or by 2) formalizing the pacing of the resolution by fixing the first third in a crochet resolution, the second third is randomly chosen as the previous approach, and the third third is set to a semiquaver resolution. In the end, the decision to choose between these two options is left to the performer. This immediately caused additional strain on the performer, as described below by Ricardo Pires:

> *"The fact that both the electronic part and the score are in real-time, increases the work's degree of difficulty because the performer does not have the possibility to prepare the interpretation or performance in advance. Despite knowing which expressive resources, articulations and dynamics may appear in the score, is impossible to predict when they are going to show up, this means that the performer must have extremely high levels of concentration and reaction to create a coherent interpretation of the piece."*[77]

At first, the performer is not playing, thus the computer is unable to collect a sample of its timbre to start the process. So, the first recording is of the room tone (fig. 58). I thought about writing the first score, but I preferred the unpredictable nature of the room tone and how this was closer to the conceptual approach. Thus, there are, of course, many frequencies that overlap both samples, but the computer is instructed to keep only the strongest partial to serve as the playing note for the player. This will set the tone for the overall arch of the piece given that the performer will start playing what is shown here and subsequently recorded. Then, the patch will continue the process of cross-referencing in a feedback process. Everything that is present in one recording is taken into consideration as a structural element for the rendering of the following score. Hence, the idea of 'error' is now subjective. The computer is not able to distinguish errors, so there is an inevitable 'amplification/incorporation' of errors into the process. What was a recorded 'error' in the previous sample, is now a notated structural element of the given score. This process has its risks; however, the computer is instructed to replace every note that falls out of the alto saxophone register with a rest.

[77] Written by Ricardo Pires, the saxophone player who commissioned and premiered *Keep up!*

Figure 60 — Recording of *Keep up!* by Ricardo Pires at the Escola Superior de Música de Lisboa.
© Permission to reproduce this photo has been granted by Ricardo Pires.

Also, in *Keep up!*, the performer (fig. 60) is key, and every detail of his/her movement has an impact on the score. Variables such as the distance from the microphone; the type of microphone; the room; the interpretation; amongst many others, will always affect this process given that these inevitably affect timbre and consequently, the spectral analysis, or as Ricardo further describes:

> *"I consider that the most challenging and difficult task of this piece is to create a coherent and stylistic interpretation because the acoustic and electronic elements are being created in real-time. In this way, it is possible to observe a constant interaction between the human-machine. This interaction is bidirectional since the performer's actions affect the computer's output, and the computer's actions affect the performer's*

output, with direct musical and interpretative consequences for the performance."[78]

This work was the subject of multiple testing sessions in remote collaboration with the performer via Zoom (fig. 61). These were key in defining what audio descriptor would be useful to transcode into data to affect the score and the creation of the electronics. Basically, I decided to just go with the amplitude information and scale it on multiple levels to every different control. This data is used two-fold: 1) as a trigger, whenever the amplitude of the incoming signal crosses a pre-defined threshold; and 2) as a continuous control, by using an envelope follower to scale the amplitude of the signal into real-time numerical data ranging from 0 to 1. The first approach is better for more immediate results where the second one is useful for continuous changes over time.

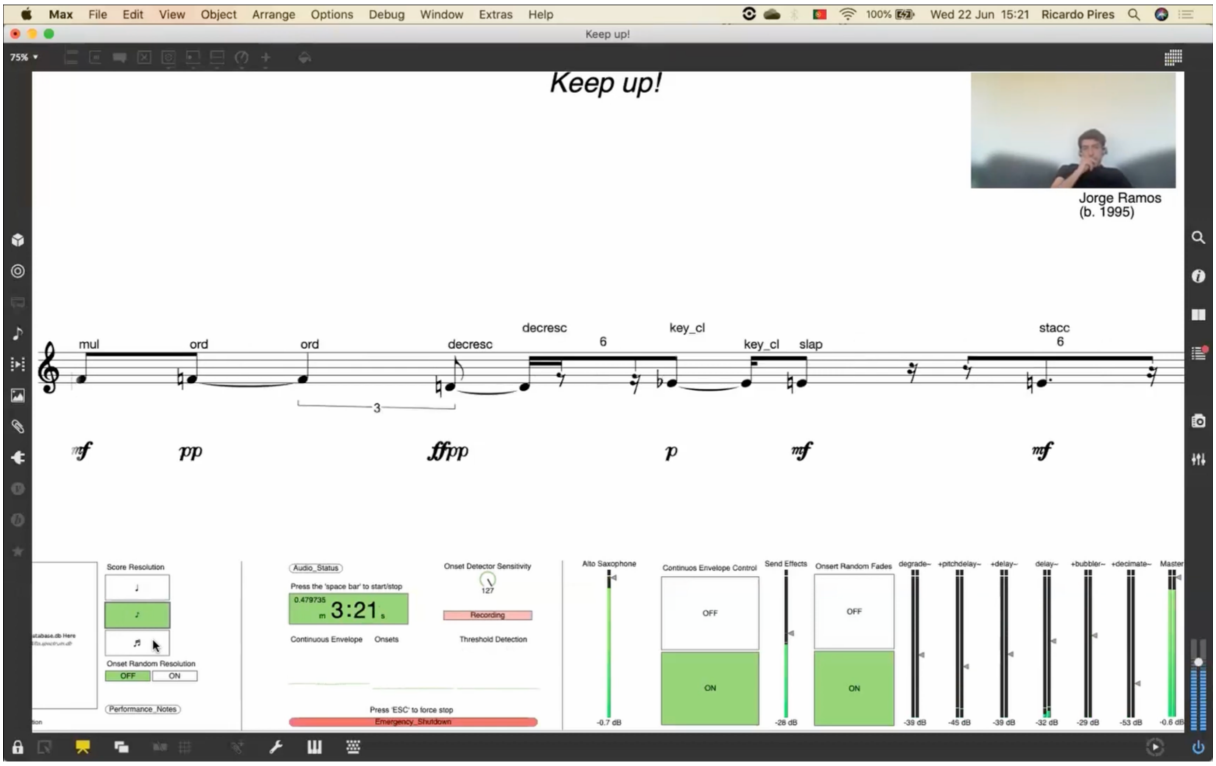

Figure 61 — One of the multiple remote testing sessions with Ricardo Pires.

[78] *Ibid*.

The electronics consist of a selection of Max objects such as general delays, pitch delays, granulators, bit crusher, and distortion. These are mostly controlled in real-time by an envelope follower.

After seven minutes, every time a trigger is generated by the crossing of the amplitude threshold, the computer is allowed to randomly choose between shutting down or continuing playing. All of this leads to some unpredictable results in a pre-defined and confined environment, or as Ricardo says:

> *"In this way, it becomes impossible to predict the final sound result, which is extremely complex regarding the interpretive coherence and in terms of the articulation of the electronic and acoustic medium. The performer is therefore required to carry out all his interpretation in real time, where he has a decisive role as a link between the creation of the electronic sonic material, the score, and the final sonic result."*[79]

This field of generative scores and live computer-assisted orchestration is still relatively unexplored; however, *Comprovização* by Pedro Louzeiro is another example that uses a similar approach. In this project, a soloist and an ensemble are bridged by a computer. Here, the computer is only used to generate an automatic orchestration for the ensemble based on the improvised playing by the soloist. This does not involve computer-assisted orchestration software given that it requires a human performer to be making all these decisions in real time on the computer.

7.3.5 Nuances

All these experiments led me to *Nuances*, the pinnacle of this research. This is a work for string quartet and live electronics which bundles (fig. 62) intuitive electronic-informed writing, graphical notation, performance/improvisatory-based instructions, live electronics, and a newer version of Orchidea which included the new orchestral qualities package. These orchestral qualities are a set of additional features that allow one to modulate a score by using electronic music composition processes such as

[79] *Ibid*.

Ring Modulation (fig. 63), Filtering, Clipping, Reverb, Overdrive (Distortion), Equalisation, Frequency Shift, and Spectral Blur, among others.

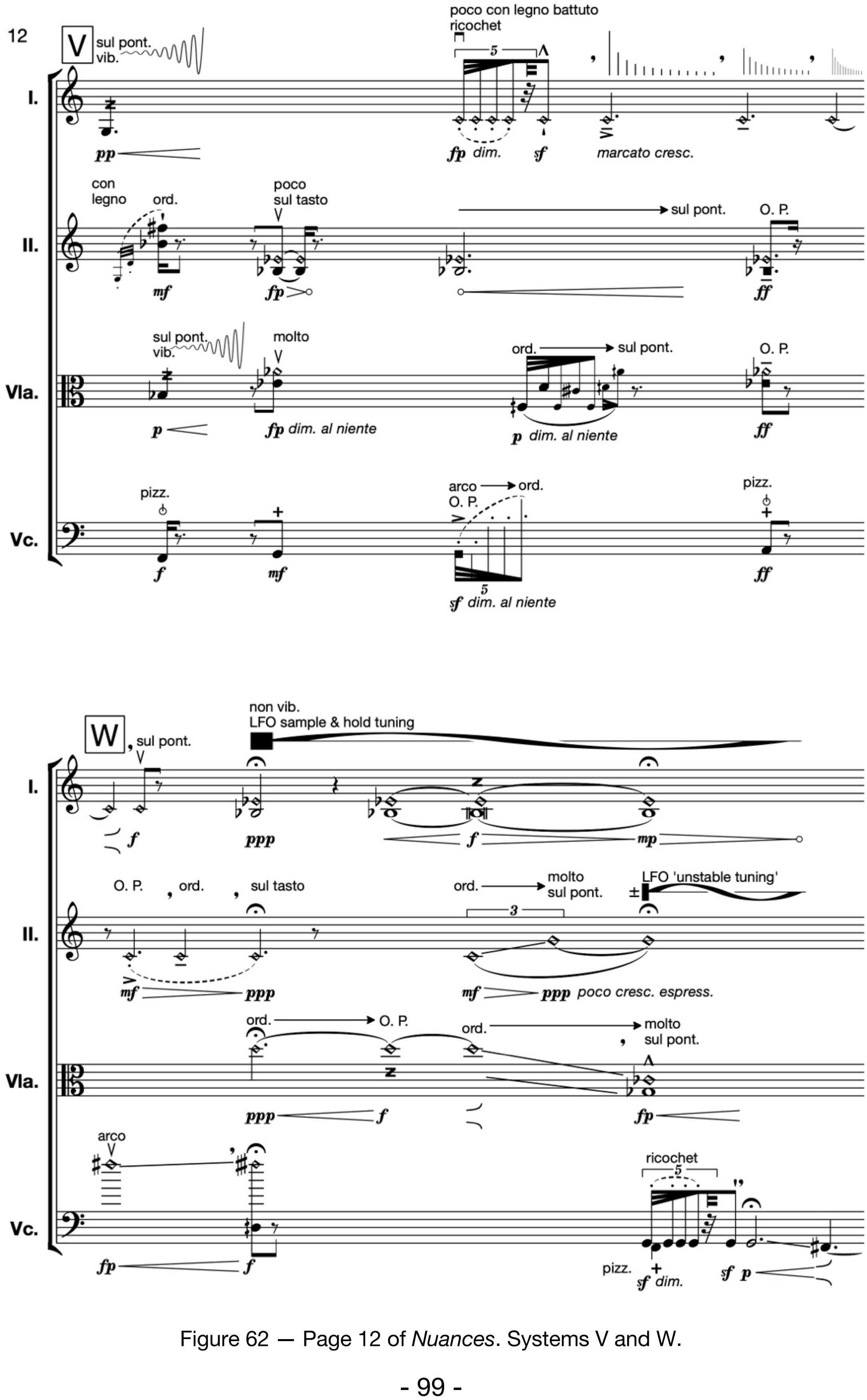

Figure 62 — Page 12 of *Nuances*. Systems V and W.

Apart from all the experiments I had done, this work was essential to test the recent orchestral qualities package. Here, I opted to use Orchidea within Max/MSP to modulate a previously generated orchestration solution using ring modulation.

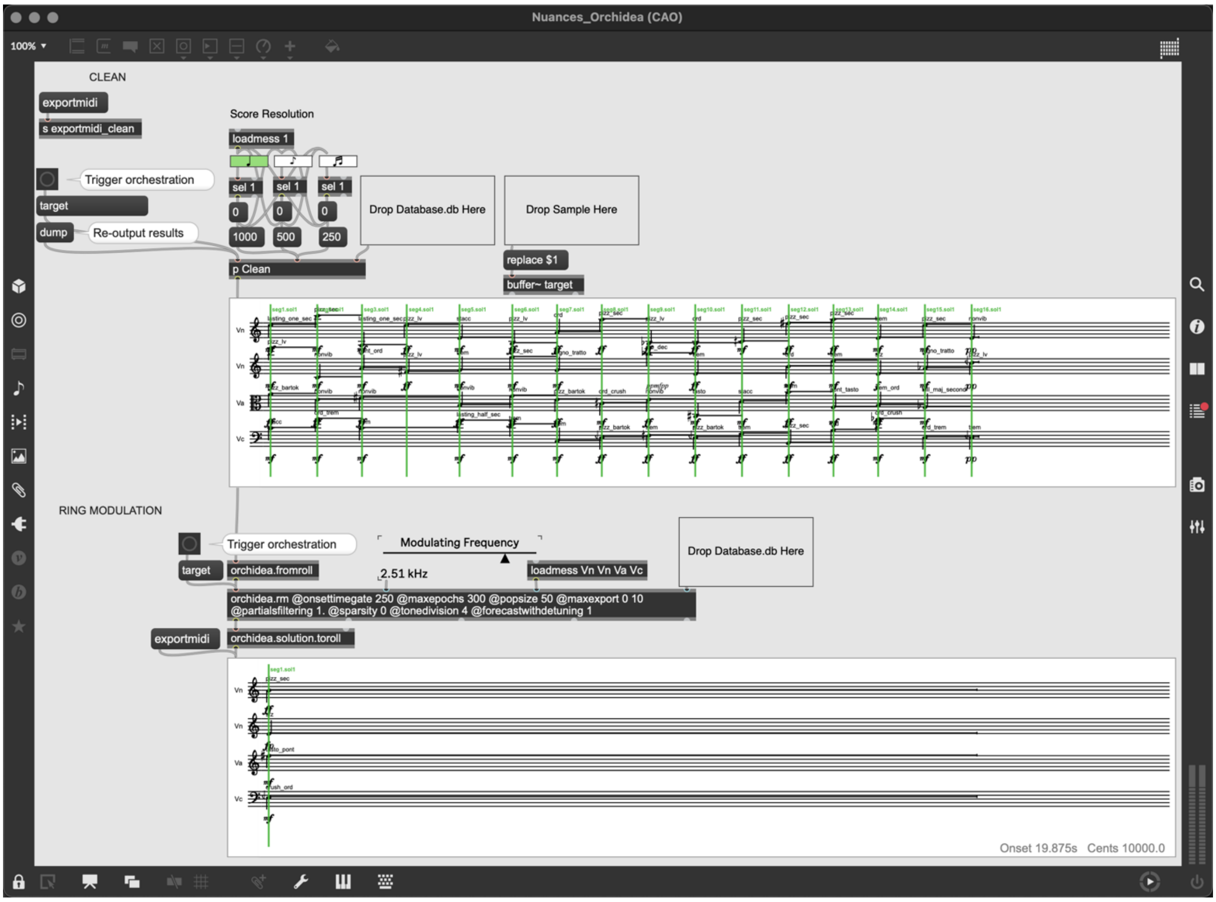

Figure 63 — Patch used to modulate an orchestration solution by using Ring Modulation.

The result of this modulation is shown in (fig. 64) alongside an additional layer of modulation affected by the perceptional interpretation of both the instructions and the graphics by the performers. This was the only use of Orchidea, including the orchestral qualities package, in this work. In this domain, this piece served as an exploratory sketch solely focused on the newer possibilities that the version used in *Point of Departure* was not able to provide.

Also, both (fig. 60) and (fig. 62) are useful examples to show a further step in focusing on the enhancement of sound quality by refining my text-based instructions. To do so, I had to come up with different terminology or transport terms often used in electronic music composition to the acoustic domain, such as LFO, Delay, and Granular Synthesis (fig. 64), among others.

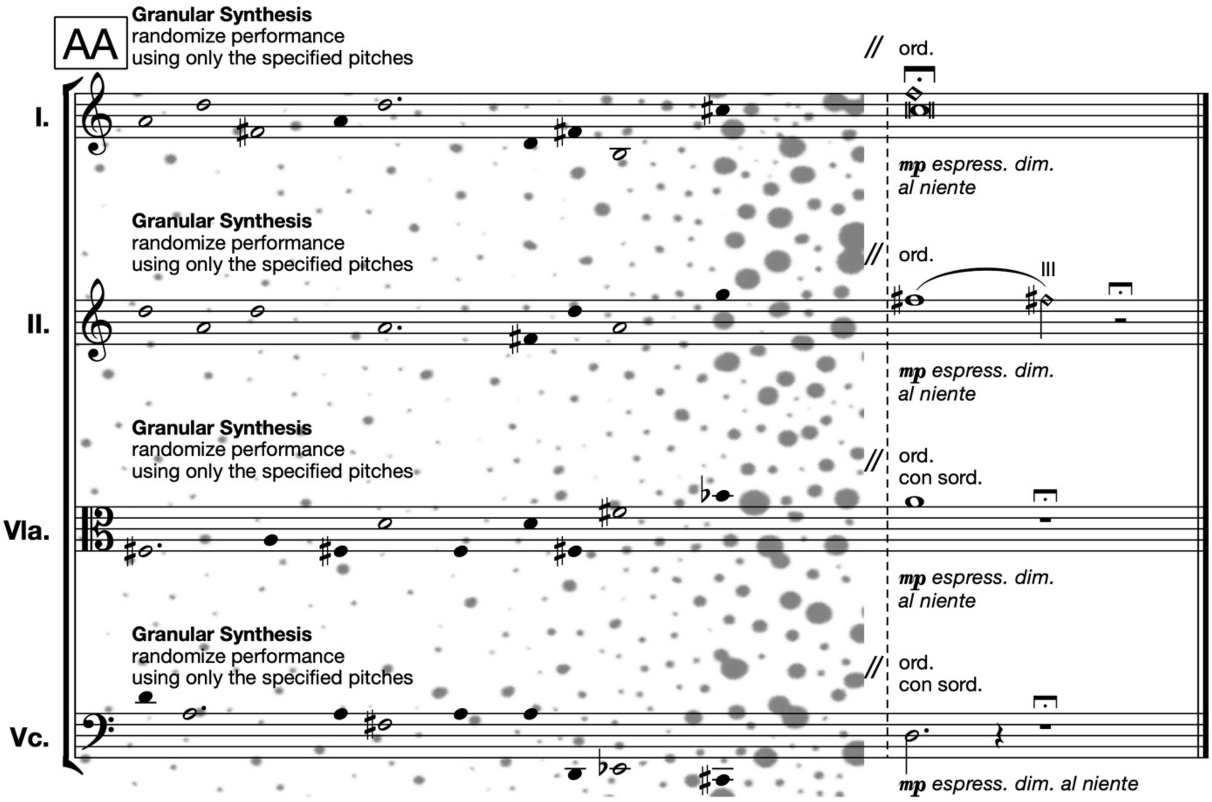

Figure 64 — System AA of *Nuances*.

Regarding electronics, these are akin to the approach used in *Keep up!* However, here I wanted to enhance the minute details of sound that are already being generated by the instruments. Thus, the electronics are only composed of a network of filters and granulators to amplify these signals.

Additionally, in *Nuances* duration is highly subjective as my intention was to allow the freedom necessary for each performer to play each section with the highest degree of sound quality and fidelity to the target timbre. However, synchronicity is key in order to preserving timbral integrity. Then, this piece should ideally last anywhere between fifteen to twenty minutes, and it also marks a shift from prioritizing the macroscopic sonic experience — signal flow, form, evolution, and development — to the microscopic experience at the event level where each cell or section gains a new and individual higher degree of relevance.

7.4 In Practice: Immersion in *Braga Capital Europeia da Cultura 2027 Banda Sonora*, *BLUR*, and *BLUR 2.0*

Here I reflect on how visual and spatial elements can enhance the result of my approach through the interaction of different forms of media and spatial characteristics in immersive audio-visual collaborations such as film and/or installations. Spatial audio allows artists to conjure shared spaces of artistic expression that blur the divide between artists and audiences; here and now, space becomes an instrument, a multidimensional canvas where sound can be metaphorically sculpted. Thus, immersive spaces can become the setting of dreamlike experiences, shared with, and lived through by everybody.

7.4.1 Braga Capital Europeia da Cultura 2027 Banda Sonora

This was a commercial commission, so in this work, I was not able to fully develop my research interests as it was a particularly defined brief. However, it did enable me to further experiment with new synthesizer archetypes and effects and to practice timbral blend in a rigid environment. I was not permitted the same degree of creative freedom to avoid cluttering the frequency range and risk nulling the message that the project was trying to convey.

7.4.2 BLUR

BLUR was a collaboration between me (music and sound design), Anna Kim (Virtual Reality), and Julien Gaillac (Choreography and Video Editing) commissioned by the cities of Braga (Braga Media Arts, Portugal), Enghien-les-Bains (France), and Gwangju (South Korea), members of the Media Arts Cluster of the UNESCO Creative Cities Network for the City to City: PLAY! 2021 Project.

This work was fully developed amid the first COVID-19 lockdown and our brief was to re-imagine the meaning of 'PLAY' in any scenario we would like. As such, we sought to dwell on our artistic perception of playing with multi-dimensionality via the creation of our own reality where past, present, and future collapse.

Given that we have yet to meet in person, and we live in different time zones, the collaborative process was very different from the norm. Often, we would all be working on our part of the project and meeting remotely on a weekly basis (fig. 65). Here, we would discuss future steps and the merging of our materials. This process was very fluid and made us realize that collaboration in this format is more than feasible and is even more manageable given the location and agendas of each artist. Hence, we continued using this formula for BLUR 2.0.

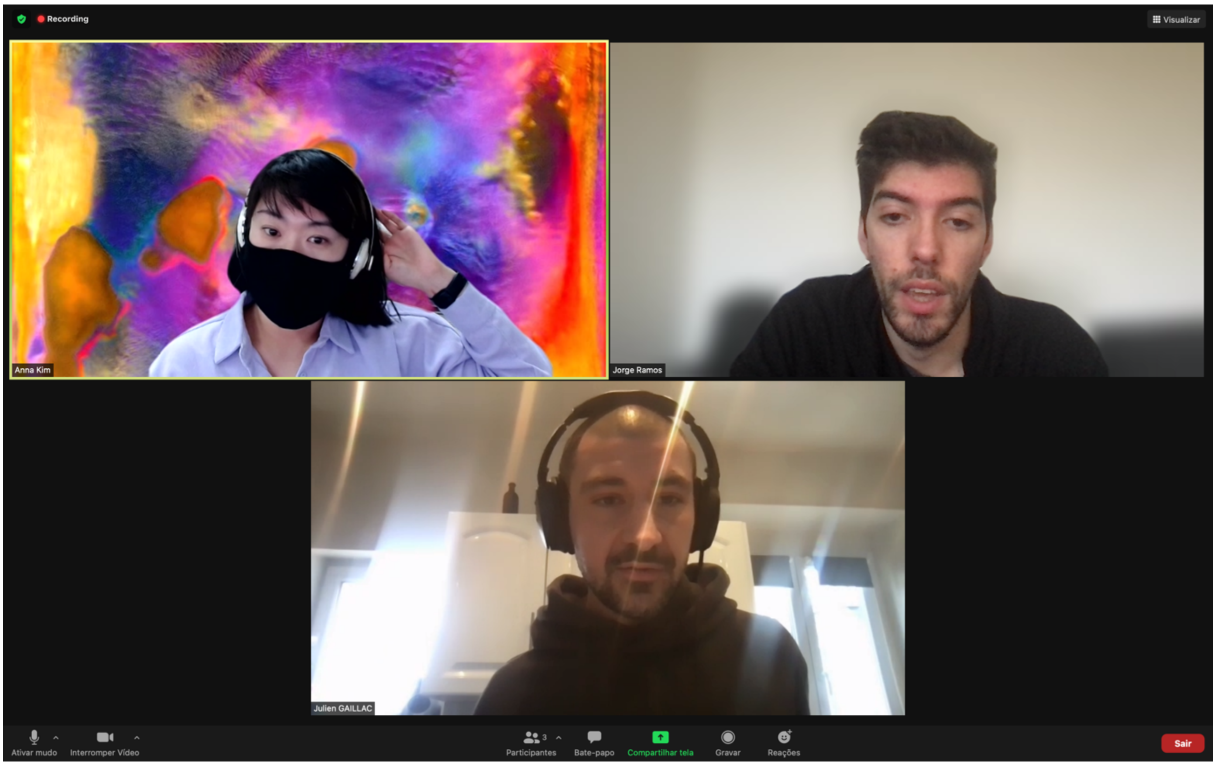

Figure 65 — One of our Zoom ® meetings to discuss further steps on the development of *BLUR*.

Picking up on the aims to merge the past, present, and 'future' in this work, there were three elements that were essential to my timbral blending approach. At first, we decided to use the original recording from Marcel Duchamp giving a talk in Houston at the meeting of the American Federation of the Arts in April 1957 where he presents his insights on the creative act (fig. 66). This would span most of *BLUR* and would be the leading line for the structure.

The Creative Act

Let us consider two important factors, the two poles of the creation of art: the artist on one hand, and on the other the spectator who later becomes the posterity.

To all appearances, the artist acts like a mediumistic being who, from the labyrinth beyond time and space, seeks his way out to a clearing.

If we give the attributes of a medium to the artist, we must then deny him the state of consciousness on the esthetic plane about what he is doing or why he is doing it. All his decisions in the artistic execution of the work rest with pure intuition and cannot be translated into a self-analysis, spoken or written, or even thought out.

T. S. Eliot, in his essay on "Tradition and the Individual Talent," writes: "The more perfect the artist, the more completely separate in him will be the man who suffers and the mind which creates; the more perfectly will the mind digest and transmute the passions which are its material."

Millions of artists create; only a few thousands are discussed or accepted by the spectator and many less again are consecrated by posterity.

In the last analysis, the artist may shout from all the rooftops that he is a genius; he will have to wait for the verdict of the spectator in order that his declarations take a social value and that, finally, posterity includes him in the primers of Art History.

Text of a talk given by Duchamp in Houston at the meeting of the American Federation of the Arts, April 1957. Duchamp, who labeled himself a "mere artist," participated in a roundtable with William C. Seitz of Princeton University, Rudolf Arnheim of Sarah Lawrence College, and Gregory Bateson. Reprinted from *ARTnews*, Vol. 56, no. 4 (Summer 1957). The French translation, done by Duchamp himself, appeared in *MDS*.

I know that this statement will not meet with the approval of many artists who refuse this mediumistic role and insist on the validity of their awareness in the creative act—yet, art history has consistently decided upon the virtues of a work of art through considerations completely divorced from the rationalized explanations of the artist.

If the artist, as a human being, full of the best intentions toward himself and the whole world, plays no role at all in the judgment of his own work, how can one describe the phenomenon which prompts the spectator to react critically to the work of art? In other words how does this reaction come about?

This phenomenon is comparable to a transference from the artist to the spectator in the form of an esthetic osmosis taking place through the inert matter, such as pigment, piano or marble.

But before we go further, I want to clarify our understanding of the word "art"—to be sure, without an attempt to a definition.

What I have in mind is that art may be bad, good or indifferent, but, whatever adjective is used, we must call it art, and bad art is still art in the same way as a bad emotion is still an emotion.

Therefore, when I refer to "art coefficient," it will be understood that I refer not only to great art, but I am trying to describe the subjective mechanism which produces art in a raw state—*à l'état brut*—bad, good or indifferent.

In the creative act, the artist goes from intention to realization through a chain of totally subjective reactions. His struggle toward the realization is a series of efforts, pains, satisfactions, refusals, decisions, which also cannot and must not be fully self-conscious, at least on the esthetic plane.

The result of this struggle is a difference between the intention and its realization, a difference which the artist is not aware of.

Consequently, in the chain of reactions accompanying the creative act, a link is missing. This gap which represents the inability of the artist to express fully his intention; this difference between what he intended to realize and did realize, is the personal "art coefficient" contained in the work.

In other words, the personal "art coefficient" is like an arithmetical relation between the unexpressed but intended and the unintentionally expressed.

To avoid a misunderstanding, we must remember that this "art coefficient" is a personal expression of art "*à l'état brut*," that is, still in a raw state, which must be "refined" as pure sugar from molasses, by the spectator; the digit of this coefficient has no bearing whatsoever on his verdict. The creative act takes another aspect when the spectator experiences the phenomenon of transmutation; through the change from

Figure 66 — © Marcel Duchamp's *The Creative Act*; Excerpts used are shown in red.

Second, there is the flow and fluidity of the movement and its choreography. One key detail of this is that we are all used to observing the movement of humans. However, since that was not permitted in this project, we decided to digitize Julien's movement and place it on the body of a virtual doll in our imaginary set (fig. 67). This worked by having Julien in the studio generating movement and recording it on a camera and then Anna would upload those recordings to a system — Deepmotion ® — that was capable of detecting body parts and its movement to an exceptional resolution given that no other sensors were used. After that, it was just a matter of using the X/Y/Z data of the virtual doll and placing it in our set.

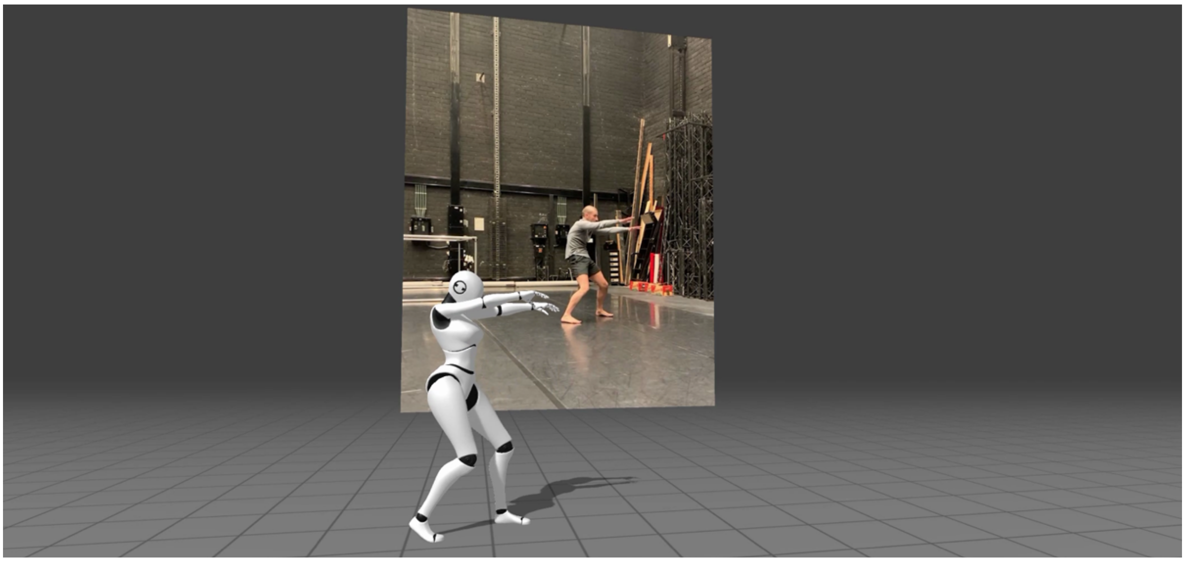

Figure 67 — Julien Gaillac in the studio while Deepmotion ® captures the X/Y/Z position of his body.

Thirdly, the colour frequency was what struck me the most. My perceptional resemblance between colour and sonic frequency was so intertwined that the blending of timbres and compositional and material development was inevitably tied to this. From my approach, harsher colours such as vivid red, bright green, or yellow (fig. 68) would mean harsher and more piercing sounds (thinner in the frequency range, sounding artificial, and often referred to as 'digital' given that most of these spectral profiles are not found in nature) and/or less filter use in synthesizers, and more noise-based techniques such as glitches and other forms of sonic 'artifacts' to orchestrate the movement/visual glitches derived from the transcoding process described above.

Figure 68 — Wide screenshot of Julien's virtual replica in our highly colourful imagined set.

The merging of all these elements was not a collage but a blend. It is also important to note that the set was also useful to locate the viewer in a specific 'time' since some shown elements were 'retrieved' from other sources, such as the round arches informed by the paintings of Giorgio di Chirico. Also, this work was also a huge step forward in our artistic conception of reality. We began to wonder if virtual reality will still exist in a time when our reality has long been virtual. This led us to *BLUR 2.0*.

7.4.3 BLUR 2.0

BLUR 2.0 was a collaboration between me (music and sound design), Anna Kim (Virtual Reality), and Julien Gaillac (Choreography and Video Editing) commissioned by Braga '27 & Braga Media Arts for the NOITE BRANCA 2022 City Festival in the city of Braga, Portugal. Here, our brief was to resume where we left off with BLUR and realise a version that would let the audience be immersed by it in an installation format. Thus, we were now dealing with some other constraints, the variation of current artwork by creating a new iteration, embracing physical space in our creation as an installation, and being as immersible as possible to further blur the line between, for a lack of a better description, digital and physical reality.

Visually, we decided to extend our previously developed scenario and include some more human and city-like elements/shots (fig. 69). We did this by recording Julien in the studio with a selection of building structures and placing these recordings in multiple outdoor-like screens in our virtual set. This served both as a criticism of the current societal dependency on screens and as a representation of a possible evolution of digital outdoors and billboards often found in big capitals such as New York (USA) or London (UK).

Figure 69 — Julien Gaillac in the studio generating movement within city-like structures.

Additionally, the chosen space — a fully made concrete ‘black-box’ (fig. 70) – was both a blessing and a drawback. This was ideal to enhance the immersive aspect of this work given that all the walls were dark, clean, and even, but it also meant that the concrete would lead to too many sonic reflections, hence it was crucial to control the timbrical development in order to avoid sonic ‘muddiness’ and listening fatigue. Thus, the ’orchestration’ based frequency arrangement was molded by site-specific constraints. As an example, lower frequencies take more time and space to travel within a certain area, so these were tackled with care to avoid issues such as phase cancellation or reverb/delay repeats in higher frequencies.

Figure 70 — The INL – Instituto Ibérico Internacional de Nanotecnologia – gallery located on the ground floor of gnration in Braga, Portugal, was the room used to showcase *BLUR 2.0*.

As for the immersive aspect, this is further obtained by placing two speakers opposite to each other on the ceiling, a small television on the floor, and a projector on the ceiling while pointing to the floor. To avoid disrupting the user's experience, it was important to have the room as unobstructed as possible. This was also helpful to allow people to roam around the room. The patch worked by playing the original version of *BLUR* on the TV and when this finished, it would immediately trigger the newer iteration (*BLUR 2.0*) being projected on the floor with way more quality and contrast.

The use of a vintage small TV was perceptual of huge importance because our (human) initial reaction is to suspect everything when we enter the room. Thus, by having a low-resolution TV located further in the room, meant that people would have to walk and be close to it to perceive what was going on (fig. 71). At the same time, they were precisely locating themselves in the sweet spot of the sonic image.

Figure 71 — The effect of 'attraction' that the low-resolution TV unconsciously caused on the audience. © Permission to reproduce this photo has been granted by Lais Pereira.

After the initial video, the second would then immediately start by being projected on the floor with way more contrast than the previous one (fig. 71) and invite people to almost engage with this new 'reality' (fig. 72) (fig. 73).

Figure 72 — The second video is projected on the floor while the attracted audience by the TV is allowed to freely roam around the room and experience visual and sonic distortion caused by the reflections of sound in the concrete walls and one's position within the room.
© Permission to use this photo has been granted by Lais Pereira.

Figure 73 — A child interacting with our imagined world for *BLUR 2.0*.

"Spectralism is not a system. It's not a system like serial music or even tonal music. It's an attitude. It considers sounds, not as dead objects that you can easily and arbitrarily permutate in all directions, but as being like living objects with a birth, lifetime, and death."[80]

Gérard Grisey

8. Conclusion | Afterword

It is with a huge sense of achievement that I loop back around to where I started, with even more questions than before; with works to be written, and little more than an illusion of the direction this will take me in. Having variously addressed my evolving perspective on spectral ideals, instrumentation, orchestration, notation, and technological involvement of electronic composition techniques and devices, I now find myself in a position in which the threads of my compositional and orchestration approaches are conceptionally tangled with my somatic 'technological' knowledge of sound. By adopting this approach to both instrumental music composition and orchestration I can free myself from common constraints generally imposed by tradition while creating distinctive artistic and audience experiences.

Notation-wise, my approach to performance instructions has shifted to a more timbre-based approach whereas in terms of symbols, this has become gradually more graphical and distant from standard symbols often applied in traditional orchestration. This is more obvious when comparing my approach between *Moving Sources*, written during my first year of this project, and *Nuances*, the last work to be written for this research. This evolution allows me to prioritize timbre over any other parameters, which clearly shows my continuing interest in expanding the 'common' orchestration lexicon.

[80] Grisey, *Gérard Grisey*.

Regarding instrumental synthesis, some recorded or synthesized sounds lent themselves more to this practice as can be heard in *Moving Sources* or *Point of Departure (A&B)*. The spectral difference between the sonic source and the instruments to be used is key in shaping the 'blending' aims of one's orchestration. Inharmonic, noise, and sounds with plenty of sonic content beyond the possibilities of the instrumental frequency range are less prone to be tackled by instrumental synthesis and vice-versa.

An additional layer to this technique revolves around how spatial and human physiological constraints inform orchestration discourse as addressed in most works of this research, such as *Flux*, *Moving Sources*, *Point of Departure (A&B)*, *Cache*, *Keep up!*, *BLUR 2.0,* and *Nuances*. The degree of reverberance, the vocal range and the technical agility of performers are three among many other possible examples of how external specifications can shape timbre. Thus, the structural role in guiding my orchestration approach is inevitably shaped by these aspects.

Furthermore, in *Impasto* I aimed for a closer instrumental representation of electronic sound synthesis, signal flow, and signal processing techniques. This approach was key to enhancing the multidimensionality of sound and linking orchestration solutions to electronic references as often used in *Paysage*, *Prelude,* and *BLUR*. Also, *Plug-in*, *Layers,* and *Cache* served as sketches to push for the boundaries of this approach.

The pinnacle of this research happens with the collision between all the aforementioned aims and the introduction of computer-aided/assisted orchestration software (Orchidea). *Moving Souces*, *Point of Departure (A&B)*, *Keep up!* and *Nuances* are works that were written using the assistance of orchestration software to progressively different extents. The first was written with the assistance of manual spectral analysis; the second began the introduction of computer-aided/assisted software by passively using Orchidea to shape orchestration solutions; the third ruptured with previous practice by pushing computer-aided/assisted composition, orchestration, notation, and electronics towards a real-time practice; and the latter building on this but making use of the orchestral qualities package which allowed me to further shape orchestration solutions from electronic processes such as ring modulation with the assistance of dedicated computer software.

In prospect, new sonic realms and creative paths of discovery are opening before me as I follow my intuition guided by my practice. The radical overhaul of my orchestration approach has served to highlight just how much more work there is to be made in the realm of human-machine creative collaboration and that sound has many more lessons to teach me. This research marks a 'checkpoint' of life-long research as contemporary arts and science work hand in hand. The artist relies on science for new tools and perceptual guidance and science looks to art as a communication and inspirational device.

We cannot disregard the fact that the gap between the world of instrumental music and electronic music is still too unexplored in the timbral-based orchestration domain, especially with the integration and development of physical modelling and artificial intelligence. Despite my contributions to the current repertoire, much more is yet to be done.

In the future, we can probably expect to see the use of these programs in larger forms or different contexts, such as film music, where the orchestration of a cue could be shaped by the dialogue or the foley/sound effects within a DAW in real-time, or even writing and orchestrating concert music in real-time by just feeding the software with a sequence of pre-recorded material. Also, depending on the evolution of the sampling of virtual instruments and physical modeling, this output could very well be played in real-time in a life-like simulation by computers. There are many exciting possibilities for further exploration and collaboration between humans and computers, and I am looking forward to exploring this.

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9.1. Music [in alphabetical order]

[1]. António Pinho Vargas — *Acting Out* (1998) for piano, percussion, and orchestra (A & B strings sections; in opposite positions on stage)

[2]. Ben Frost — *Stomp* (2007) for electric guitar, percussion and electronics

[3]. Bernard Parmegiani — *De Natura Sonorum* (1975) for electroacoustic

[4]. Carlos Caires — *Instante* (2011) for orchestra and electronics

[5]. Carmine Emanuele Cella — *Stades d'ombre, stade de lumière* (2018) for large ensemble

[6]. Claude Vivier — *Zipangu* (1980) for string orchestra

[7]. Edgard Varèse — *Ionisation* (1929-32) for 13 percussionists

[8]. Enrique Mendoza Mejía — *El Viejo Errante* (2006) for amplified contrabass in 4-channels

[9]. Fausto Romitelli — *Professor Bad Trip: Lesson I* (1998) for 8 performers and electronics
[10]. Giacinto Scelsi — *Hymnos* (1963) for two orchestras
[11]. Giacinto Scelsi — *Quattro Pezzi* (1959) for orchestra
[12]. György Kurtág — *Grabstein für Stephan* (1989) for orchestra
[13]. György Ligeti — *Lux Aeterna* (1966) for 16 voices
[14]. Heiner Goebbels — *Suite for Sampler & Orchestra* (1994) for sampler and orchestra
[15]. Helmut Lachenmann — *Air* (1968–69 ; revised in 1994) for percussion, 2 ad libitum players, large orchestra (78 players)
[16]. Helmut Lachenmann — *Pression* (1969-70 ; revised in 2010) for cello
[17]. Iannis Xenakis — *Empreintes* (1975) for 85 musicians
[18]. Igor C. Silva — *My Empty Hands* (2018) for flexible percussion ensemble, electronics and video
[19]. João Ceitil — *Prece Em* (2013) for orchestra
[20]. John Adams — *Dharma At Big Sur* (2003) for electric violin and orchestra
[21]. John Tavener — *Two Hymns to the Mother of God* (1985) for two choirs
[22]. Jonathan Harvey — *Speakings* (2007-8) for symphony orchestra
[23]. Julian Anderson — *Imagin'd Corners* (2002) for orchestra
[24]. Karlheinz Stockhausen — *Gruppen* (1955-57) for three orchestras
[25]. Luciano Berio — *Formazioni* (1987) for orchestra
[26]. Luis Tinoco — *Cercle Intérieur* (2012) for 85 musicians
[27]. Marc-André Dalbavie — *Color* (2001) for orchestra
[28]. Miklos Rosza — *Spellbound Concerto* (1945) for piano, orchestra and theremin
[29]. Peter Ablinger — *DEUS CANTANDO* (2009) for computer-controlled piano and screened text
[30]. Pierre Henry — *La dixième symphonie de Beethoven* (2019) for 3 symphony orchestras and choir [adaptation]
[31]. Rebecca Saunders — *Still* (2011) for violin and orchestra
[32]. Sara Marita — *-hipnAGOgic -* (2018-2019) for saxophone and electronics
[33]. Suzanne Ciani — *Buchla Concerts 1975* (2016) for live-electronics
[34]. Tristan Murail — *Gondwana* (1980) for orchestra

[35]. Yan Maresz — *Metal Extensions* (2001) for trumpet and ensemble

[36]. Yan Maresz — *Metallics* (1995) for trumpet and live-electronics