Mutations in the Composable

Compositional Practice as a Space of Experimentation, Tension, and Uncertainty

Garnero, Fernando

2025

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Garnero, F. (2025). *Mutations in the Composable: Compositional Practice as a Space of Experimentation, Tension, and Uncertainty*. Malmö Faculty of Fine and Performing Arts, Lund University.

Total number of authors:
1

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Mutations in the Composable

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Compositional Practice as a Space of Experimentation, Tension, and Uncertainty

Fernando Garnero

DOCTORAL DISSERTATION
Doctoral dissertation for the degree of Doctor of Philosophy (PhD) at the Faculty of Fine and Performing Arts at Lund University, Sweden.
To be publicly defended on May 12, 10:00, at Inter Arts Center, Malmö.

Faculty opponent
Prof. Andrea Valle

Organization: LUND UNIVERSITY, Faculty of Fine and Performing Arts, Malmö Academy of Music

Document name: Doctoral dissertation

Date of issue: May 12, 2025

Author(s): Fernando Garnero

Sponsoring organization:

Title and subtitle: Mutations in the Composable.
Compositional Practice as a Space of Experimentation, Tension, and Uncertainty

Abstract:

At the core of this artistic research project is the idea that composing music can entail more than structuring sonic material; it may involve constructing the very space in which musical thoughts take shape. This space, the *composable*, is understood not as a fixed, pre-existing framework but as a space in flux—shaped by instruments, devices, spatial configurations, and performative gestures—where musical form materialises through recursive interactions between micro- and macro-levels and between sonic textures and their larger temporal organisation. Within this composable space, musical composition is approached and explored as a dynamic field of interaction where musical knowledge emerges through engagement with sound, technology, and performance.

Through this framework, a central question has emerged: how does musical composition function as an epistemic act—not merely as the organisation of sound but as a process of discovery? In response, this work draws upon a constellation of theoretical frameworks, including Francisco Varela's enactive cognition, Hans-Jörg Rheinberger's notion of experimental systems, and Horacio Vaggione's multi-scale approach to compositional time. These perspectives support a vision of music-making as the construction of contexts in which new aesthetic, sonic, and conceptual possibilities can emerge through material negotiation and artistic action.

The creative part of the thesis consists of a series of new, experimental musical works for instruments, acoustic objects coupled with transducers, microphones, and electronic systems. Each work departs from particular artistic approaches and methods, including hybrid instruments within multidimensional diapositives, instrumental feedback, symbolic granulation, and sonic translation. These methods are approached as operational logics that mutate across projects, depending on the material behaviours, performance conditions, and technologies engaged. The composable space is a space of tension—between control and contingency, between symbolic systems and acoustic phenomena, and between abstraction and embodiment. The works discussed serve as case studies through which the composable is enacted and articulated, each one constructing its own field of operations, relationships, and emergent structures.

Ultimately, this research suggests that to compose is to think with sound, to make sense through provisional articulations. Composition is shown to be both a speculative and practical endeavour, one that produces knowledge through friction, failure, intuition, and transformation. In this way, the thesis contributes to the discussion on contemporary and experimental music within the field of artistic research, offering a model of composition as a mode of knowledge-making and aesthetic inquiry.

Key words: Art Music, Musical Composition, Composable Spaces, Audio Feedback, Multidimensionality, Symbolic Granulation, Sonic Translation, Hybrid Instruments, Experimental Systems, Multi-Scale, Composed Emergences

Classification system and/or index terms (if any)

Supplementary bibliographical information

Language: Eng

Number of pages: 297

ISSN and key title: 1653-8617: 35

ISBN: 978-91-88409-38-6

Recipient's notes

Price

Security classification

Signature

Date 2025-04-14

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Faculty of Fine and Performing Arts

Malmö Academy of Music

ISBN 978-91-88409-38-6

ISSN 1653-8617: 35

Printed in Sweden by Media-Tryck, Lund University

Lund 2025

NORDIC SWAN ECOLABEL

Printed matter
3041 0903

Media-Tryck is a Nordic Swan Ecolabel
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Dedication

*This dissertation is dedicated to my son Simón Garnero Palacios,
my sister Natalia Garnero, and to my parents,
Cristina Alicia Lima and Hugo Raúl Garnero,
with infinite love.*

Acknowledgements

I want to warmly thank my main supervisor, Kent Olofsson, for his support, friendship, patience, and for being there throughout this long but exciting journey. His guidance and thoughtful feedback really helped shape this work. I'm also grateful to my co-supervisor, Michael Edgerton, for giving me the chance to embark on this adventure. I also want to thank my colleague and friend, Mauricio Carrasco—performer, curator, and researcher—for his invaluable insights, advice, and thoughtful comments. His support and perspective have meant a lot along the way. I'd also like to thank Karin Johansson for her inspiring seminars, great teaching, and her invaluable sense of humour—always present, no matter the weather.

I thank my opponent Andrea Valle and the examination committee of my thesis, Hedvig Jalhed, Pierre Alexandre Tremblay, Mattias Sköld, and Staffan Storm. I'd also like to thank Mauro Lanza, Pavlos Antoniadis, and Eric Maestri for their thoughtful feedback and insights during my percentage seminars. I want to thank my friend and colleague, composer, curator, and researcher David Chisholm, for his encouragement, constant feedback, support, and friendship.

A special thanks to my fellow PhD candidates and companions on this artistic journey: Felicita Brusoni, Bertrand Chavarria-Aldrete, Francesco Palmieri, and Yann Coppier. I'd like to thank my friend and adventure companion, the tuba player, researcher, and curator Jack Adler-McKean—currently a postdoctoral fellow at Lund University and a trusted partner in several artistic conspiracies. I want to warmly thank my guardian angels at MHM, Jenny Svensson and Annika Westberg, for their constant support, patience, and wonderful sense of humour.

I also thank Margot Edström, Sylvia Lysko, Lili Nottrott, Jonas Jönsson, and Magnus Pålsson for their wonderful work, support, and kindness throughout the journey. The list of people I'd like to thank could go on forever, but I must not forget my dear friends and partners in crime from Ensemble Vortex: Rada Hadjikostova, Anne Gillot, Jocelyne Rudasigwa, Béatrice Zawodnik, Benoît Morel, Patrick Schleuter, Arturo Corrales, Denis Schuler, and Daniel Zea. I also want to thank my friends from Ensemble L'Imaginaire for all the wonderful projects we've shared—and those still to come: Keiko Murakami, Wychariy Cruz, Philippe Koerper, Eric Maestri, Nicolas Medero Larrosa, Olivier Maurel, Michel Bentz, and Maxime Springer (in his loving memory). Finally, I want also to thank the wonderful persons of the Ensemble Lucilin: Florence Martin, Floriane Weber, Sophie Deshayes, Danielle Hennicot, Winnie Cheng, Guy Frisch, Pascal Meyer, Olivier Sliepen, André Pons-Valdès, and Max Mausen.

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Thesis Structure

The thesis consists of two parts:

- The written dissertation that explores composition as a site of knowledge production, where musical ideas emerge through active engagement with material, technology, and performance.
- The artistic component consisting of a series of works for instruments and electronics, purely electronics pieces, orchestral composition, videos, audiovisual and site-specific sound installations, as well as conceptual and hybrid works. Audiovisual documentation, scores, and excerpts of some of the works associated with the dissertation, and the dissertation text as PDF are found in:
  https://portal.research.lu.se/sv/publications/mutations-in-the-composable-compositional-practice-as-a-space-of-

List of Works

List of Works made during PhD studies 2020-2024. The works submitted for the dissertation are marked in bold in the list.

Audio-Article

Carrasco, Mauricio, and Fernando Garnero. 2023. Midnight Reflections about Our Own Northern Ventriloquist's Skills. *Performance Philosophy* 8 (1):101-10. https://doi.org/10.21476/PP.2023.81399. This article is found at: https://www.performancephilosophy.org/journal/article/view/399/515

Audio-visual

There's a hole in the bucket (2020) Video made in collaboration with Jacques Julien

Des Avantages du plat sur le rond (2020) Video made in collaboration with Anne-James Chaton et Valeria Giuga

La espera (2020) Video

Joss's Birthday party (2021) Video

Da B-sista's tune 4 Alice G birthday (2021) Video

Combien de mots are the same word? (2021) Video (with text by Anne-James Chaton and collective CINC)

Down the hole (2021) Video made in collaboration with Jacques Julien

Arthur's Yodel (2022) Video made in collaboration with Jacques Julien

Blocco (2022) Video made in collaboration with Jacques Julien

Compleanno di Mairé (2022) Video made in collaboration with Jacques Julien

Compleanno di Francesco (2022) Video made in collaboration with Jacques Julien

Noriko's day (2022) Video made in collaboration with Jacques Julien

Piano piano piano piano (2022) Video made in collaboration with Jacques Julien

Chamber Music

Trans-étude #2 (2020) For Flute, Viola and Harp

Contraccolpo (2020) Percussion and microphone, Filter Sax, and electronics

Campo amniotico (2021) Two performers playing controlled feedback, synthetic voices and live-electronics

Cada trozo/cada ganglio (2022) For five instruments, Feed-Timpani, electronics and video. Video made by Alexis-Moreano Banda

Mutante (2023) Four Instruments, Feed-Timpani and electronics

Neon Frog (2024) Five Instruments and electronics

Electronics

Clown control studies (2020) Stereo tape
Ah vous dirais-je PAN PAN (2020) Stereo tape
Birthday's cycle (2020/2024) 29 short pieces for Stereo tape
Practical guide to holes (fall, rise, death & resurrection) (2020) Stereo tape
piano, piano, piano, piano (2020) Stereo tape
blocco, blocco, blocco (2020) Stereo tape
Arthur's Yodel (2021) Stereo tape
Blocco_Ganglio_Yodel (2024) Stereo tape
Matter of Scale #1 (2025) Stereo tape

Installations

V15 (2020) 17 channel tape, 1600 piezo amplifiers and 2 subwoofers

Les sons ne sont pas des hommes (2020) site specific installation for the of Villa Medici's Vineyard, 8 channel tape, 8 rows of 9 piezo amplifiers each and speakers

Practical guide to extended anatomy (2021) Audiovisual installation

Orchestra

Trans-étude #3 (2022) Orchestra and white noise re-amplified and modulated by Two Timpani

Solo with Electronics

Practical guide to amniotic fields (2022) Comprovisation with Jack Adler-McKean for Tuba and Live-electronics.

Trans-étude #4 (2022/23) For Tuba, field recordings and electronics

Visual

Practical guide to anatomy (2021) Graphic Poem
Practical guide to Wandering (2021) 8 Digital montages with original drawings

Introduction

This thesis seeks to articulate a theoretical and practical investigation into the notion of the composable, understood as a space where musical knowledge emerges through engaged interaction with sound, technology, and performance. Driven by a fundamental question, which is: how does composition function as an epistemic act, not merely as the organisation of sound events but as a dynamic process of discovery?

I conceive composition as an experimental field in which artistic practice is informed by the evolving relationships between material, conceptual, and technological elements. My practice unfolds according to a logic that resists closure, one that embraces heterogeneity not as something to be resolved but as a condition to be inhabited. It is a practice in a permanent process of becoming, shaped by movement, negotiation, and the continuous reconfiguration of diverse materials, methods, and temporalities. It emerges as a persistent need to articulate multiplicity, an impulse that has shaped my artistic practice from the outset. For this reason, I consider it appropriate to trace the steps that have led me to this moment through a background.

Background

My life has been shaped by migration, an experience that spans across generations, from my ancestors to my immediate family and myself. Some of these migrations were acts of survival, like that of my great-grandfather, a Piedmontese farmer who left Italy for Argentina at the end of the nineteenth century, driven by hunger and economic hardship. Others were marked by political urgency, such as my family's move to Brazil just months after my birth, in the wake of Argentina's most violent military coup. As I reflected in an article co-written with Mauricio Carrasco (2023): "The first thing I knew when I was born was exile: well, what an idea to be born in Argentina in 1976, child of a left-wing militant couple." Since then, my life has been defined by migration, linguistic and cultural transitions, and the unmistakable imprint of a strong South American accent in every language I speak—an integral part of my subjectivity. Embodying otherness, wherever I am: "*Xenos*, the stranger, the foreigner, was the signifier around which was possible to build an 'I'." (Carrasco & Garnero, 2023).

My relationship with music began in my childhood, around the age of ten or eleven. For years, it remained sporadic, shaped by the omnivorous and shifting nature of my curiosity, which led me to explore multiple fields simultaneously. At secondary school, my reading continued to expand, and my curiosity drew me towards the visual arts. At the same time, my interest in philosophy, history, and politics deepened.

Musically, my main instrument was the electric bass, while the guitar played a secondary role. It was not until I was fourteen that I began to study and play more regularly, marking the start of a voracious period of musical discovery. I immersed myself in a wide range of popular and experimental music, moving fluidly from folk to progressive rock. Music was not an isolated pursuit but part of a broader intellectual and artistic exploration, inextricably linked to the ways I engaged with the world.

Music gradually expanded its presence in my life, as classical music began to infiltrate my listening habits. I cannot point to a single defining moment that set this process in motion. Instead, I imagine a symbolic union—a *hierogamic* marriage—between Bill Evans and Debussy as the fertility rite that gave birth to my youthful *melomania*, my *phonophilia*. By the time I was sixteen or seventeen, I had gone from being a novice jazz pianist to a struggling classical pianist, beginning my studies at what felt like an advanced age. Far from being methodical, my practice was shaped by the multiplicity of my desires.

I began formal music studies when I entered university at the age of eighteen. Gradually, I moved away from the bass and from playing rock and jazz, as this transition coincided with two discoveries that profoundly changed my trajectory: two forms of complexity, separated by centuries—the *Ars subtilior* and the work of G. Ligeti, particularly his *Kammerkonzert*. The defining feature of these years was the intersection of practice and listening: a broad engagement with popular music, rigorous academic training, and an intensifying passion for both early music and post-1945 contemporary music. Yet my primary mode of learning was shaped less by structured instruction than by attending concerts, listening to records, and following scores in parallel with their recordings. The deepest impressions that my musical desire inscribed in my body came from the initiatory journeys through Buenos Aires in search of records and scores—an education shaped as much by exploration as by formal study. In the end, my training was essentially *hetero-didactic*.

Paths of Formation: Towards an Art of Multiplicity

I arrived in Switzerland in 1998, drawn by the simultaneous—and at times conflicting—desire to study both early music and composition. I began at the *Centre de Musiques Anciennes* in Geneva, immersed in harpsichord, basso continuo, counterpoint, and historical notation. A year later, I joined Éric Gaudibert's composition class at the Geneva Conservatory, where my training expanded to include orchestration, analysis, and harmony. Gaudibert's intellectual openness encouraged me to embrace my heterogeneous interests, treating composition as a space for articulating multiplicity rather than conforming to stylistic norms.

In 2000, I began working in the *Musik Akademie der Stadt Basel* electronic studio with Thomas Kessler—a pivotal shift in my practice. I later studied algorithmic composition with Hans-Peter Kyburz, using the LISP-based software *Stella*. Eventually, I had to abandon my early music studies; trying to span the fourteenth to the twentieth century proved unsustainable. But that confrontation with my limits was decisive. These formative years not only deepened my technical training but also shaped a compositional approach grounded in plurality, experimentation, and the productive tension between historical knowledge and contemporary practice.

Before completing my composition studies at the Geneva Conservatory, I co-founded Ensemble Vortex with fellow students. From its inception, Vortex has functioned as a collective space for artistic experimentation and continues to play a central role in my work as a composer and curator. In its scale, Vortex embodies the idea that music is fundamentally a social phenomenon—a complex emergence shaped through interaction among agents.

From Craft to Cut & Paste: Rethinking Composition through Technological and Cultural Assemblage

In 2004, I continued my composition studies at the *Haute École des Arts du Rhin* in Strasbourg, joining Ivan Fedele's class. His pedagogical approach echoed, in subtle ways, the spirit of the Renaissance atelier—where learning is grounded in solid craftsmanship and shaped by continuous collective exchange between teacher and students. My compositional practice during this period focused primarily on writing for acoustic instruments, and my subjective position was torn between an instinct to conceive music as a perpetually evolving experimental space and a misinterpreted Boulezian mandate to pursue an *artisanat furieux*—furious craftsmanship—which I naïvely regarded as something absolute. Fedele's guidance helped me to dispel these ghosts through the concrete act of writing, where knowledge emerged through trial and error, through doing.

In 2008, I joined Paris IRCAM's composition course after completing my composition studies with Fedele. With only limited experience in an electronic studio and a rudimentary understanding of digital processing and programming, this demanding environment was the beginning of a new and steadily expanding phase of diversification, during which I gradually integrated new media, methods, techniques, and research areas into my practice.

I began to conceive digital signal processes not only as tools but as conceptual models for thinking about composition—frameworks through which artistic practice could be questioned and reconfigured. This period marked the beginning of my ongoing experiments with hybrid instruments and with the use of samples as both compositional material and a central element in the creation of hybrid sound objects. It was then that I began to think of music beyond sound—beyond the traditional conception of music as a sum of discrete parameters, as it is typically understood in European art music. Instead, I aspired to make a kind of music grounded in a logic of *cut & paste*, of *chop & mix*, a music of assemblage: one that manipulates and combines malleable cultural objects, rich with meaning, and primed for constant recontextualisation. A music capable of appropriating even the most revered artefacts of Western culture—not to negate them, but to expose the discursive strategies and axiological frameworks they embody.

In short, a music that, through its engagement with the audio sample, opens a space for critical reflection on its pervasive presence in our social interactions and its commodified, fleeting temporality. From my earliest experiments with looping, sampling, phasing, and shifting—techniques inspired by digital processes—a non-linear, iterative conception of musical time gradually emerged, contrasting with the process-based models I had previously inherited from the spectral tradition.

From Framework to Field: Reimagining the Composable Between Craft and Concept

In 2007 I had the opportunity to attend Horacio Vaggione's courses at the University of Paris VIII, where I encountered his multi-scale approach to musical time and the central concept of *composable space*. I found this notion fascinating from the outset, though initially, I regarded it as closely tied to the practices of acousmatic and mixed music—somewhat distant from my own compositional experience. It took several years before I was able to integrate it more broadly as an operational concept, both in theoretical terms and in practice.

Between 2017 and 2019, Vaggione's ideas already held a central place at the time of my master's studies at the same university. At the time, I still struggled to incorporate key aspects of my work—such as my early explorations with audiovisual media and feedback—into this framework. Yet this marked my first attempt to conceive the composable as a space of articulation between multiple forms of diversity.

Between 2020 and 2021, I was a resident at the French Academy in Rome, during the global COVID-19 pandemic. This unusual and privileged context brought a sudden halt to the temporal structures that had long shaped my life as both educator and creator. For the first time, I experienced a prolonged period of undisturbed time—unbound from production cycles, deadlines, and institutional expectations. This allowed for an intense year of interdisciplinary exchange and artistic experimentation, in which I explored unfamiliar territories and revisited dormant ones. Outside the usual frameworks of commissions and mediation, I created several collaborative works, including two site-specific installations—one audiovisual—as well as 'comprovisations' and two cycles of what I call Open-data compositions: pieces made entirely from found audio, shaped through editing and spatialisation. These works function both as compositions and as studies in micro-montage. I also developed conceptual pieces using montage instructions and works that blur the lines between poetry, notation, and sound art. This period of unpredictably prolific output allowed me to give form to a question I had long felt but had never been able to clearly articulate—one that now seems, in retrospect, surprisingly simple: that the current dichotomy between craft and concept is not only unproductive but fundamentally flawed.

Composing the Composable: Toward a Situated Epistemology of Musical Practice

Composing music entails more than structuring sonic material; it involves constructing the very space in which musical thought takes shape. The composable, in this sense, is not a pre-existing framework but a site where technical objects, aesthetic decisions, and performative actions interact to generate new forms of knowledge. Drawing from diverse theoretical perspectives—ranging from Walter Benjamin's (1936) reflections on mechanical reproduction to Francisco Varela's (1996) enactive cognition and Horacio Vaggione's (2007, 2010) multi-scale compositional approach—I position composition as a process of articulation, in which musical ideas emerge through material interactions rather than being imposed from external models.

This perspective aligns with a broader understanding of artistic research, one that resists static definitions and situates instead knowledge production within the complexities of practice. Composition operates as an investigative field, where epistemic and aesthetic concerns converge. The works examined in this text—both my own and those of other composers—serve as case studies in which the composable is approached not as a fixed system but as a dynamic environment shaped by the interplay of instruments, spatial configurations, and performative engagement. My engagement with multidimensional dispositives with hybrid instruments, sonic translation, instrumental feedback and symbolic granulation reflects an interest in the ways in which compositional space can be expanded through technological mediation and experimental methodologies.

The question of emergence is central to this inquiry. Rather than viewing composition as a process of applying predetermined structures, I consider how musical form materialises through recursive interactions between micro and macro levels, between sonic textures and their larger temporal organisation. The composable is thus framed as an experimental system, borrowing from Hans-Jörg Rheinberger's concept of scientific research as a site of epistemic uncertainty (Rheinberger, 1997b). Just as scientific experimentation produces knowledge through iteration and material resistance, composition generates new understandings through its engagement with sound and technology.

Throughout this exegesis, I situate my practice within a broader lineage of composers and theorists who have approached music as a space of exploration rather than formalisation. From Lachenmann's instrumental deconstruction to Xenakis ' stochastic processes, from Bauckholt's sonic mimicry to Di Scipio's self-regulating systems, I engage with a network of ideas that expand the scope of what composition can encompass. My own approach seeks to navigate this terrain by incorporating methodologies that foreground interaction, instability, and multiplicity as fundamental compositional principles.

Ultimately, this text proposes that composition is not solely about control but about engagement—an ongoing negotiation between the composer, the materials, and the performative conditions of a work. The composable space is a space of tension, where musical thought is not given but emerges through the very act of making. By framing composition as a site of knowledge production, I aim to contribute to a broader discourse on artistic research, highlighting the ways in which music-making functions as a form of inquiry—one that is as much about discovering the unknown as it is about shaping the sonic world.

A Space of Relationships[1]

> The composable is the articulable: it is the locus of emergences, but these are not phenomena 'found' or provoked by a kind of stacking of elementary processes, but the result of a stratified construction of carefully articulated, composed interactions. (Vaggione, 2008, p. 168)

In my compositional practice, a wide range of methodologies, techniques, and strategies come into play in creating a single work within an experimental space.

This space is composed of concurrent forms of knowledge production, unfolding through a complex, non-linear process constituted of multiple layers and deployed across several interacting—or simply superimposed—stages. Composing is, therefore, an act carried out under epistemic tension, bringing together different modes of knowledge production that are not synthesised into a single transcendent object without contradictions. Instead, the result is a complex space of relationships,

[1] "In this context, the space is conceived as a compositional material, which means that it is essentially a space of relationships." (Vaggione, 1998b, p. 154)

which requires an approach aimed at reducing the ontic complexity of its components while preserving its particular epistemic complexity. This composable space is a place of relations that gives rise to emergences, which, following Vaggione, are the result of a *stratified construction of carefully articulated interactions*. These composable spaces—specific to each work—may also be viewed from a historical perspective, where the epistemic tensions within these experimental contexts express deeper ontological mutations of the composable itself.

Approaching musical composition presents a complex challenge—one that lies at the heart of this research. To express, through external means, what is embodied within each work is a paradoxical act: a translation into language of something that does not operate as language, even if certain affinities can be traced in its processes of construction and materialisation. Decoding what is specific to music using symbols—whether words, images, or recordings—implies a transfer of meaning that is always unstable, a layered metonymy without the guarantee of resolution. It is something that can only ever be approached partially, situated within a context, and tentatively connected to broader networks of human activity.

Everything that forms or surrounds artistic practice—whether directly or indirectly—can serve as a point of entry for questioning the objects it produces and the subjects it implicates. When I speak, write, or reflect on composition, I frequently turn to the term *the composable*, derived from Horacio Vaggione's notion of *the composable space*, a spatio-temporal entity through which to think musical creation. The strength of Vaggione's concept lies in its capacity to foreground materiality, representation, and temporality within the act of composing—while drawing from a wide array of influences, including object-oriented programming, phenomenology, and cognitive science, among others.

In this sense, reflecting on composition means engaging with a practice that is both situated and speculative, material and conceptual, and irreducibly plural in its logic and outcomes. The composable emerges not as a static category but as a dynamic site of epistemic negotiation, a terrain where heterogeneous modes of knowing and doing converge without necessarily resolving their tensions. To write about composition is thus to trace its shifting contours, to attend to how each work configures its own space of emergence—its own logic of construction, resistance, and articulation. What I propose is not a theory of composition but a way of inhabiting its complexity: to think and compose from within a space that remains in flux, a space whose very instability becomes a condition for thought.

Mapping Theory and Artistic Methods

Theoretical Frame

In this theoretical framework, I explore the composable as a space where technological apparatuses, musical practices, and experiments intersect. Composition, rather than a mere structuring of material, emerges through dynamic interactions between technical, conceptual, and performative elements. Drawing from Benjamin (2012, original 1936) and Sédès (2013), I examine how musicians' engagement with technology transforms modes of listening, producing, and thinking music.

Central to this inquiry is the apparatus conceived not simply as a technical system but as a networked dispositive that shapes musical creation. As Sédès' analysis of the electric guitar illustrates, modular instruments redefine aesthetic possibilities through their appropriations. This principle extends to the multidimensional sound diffusion setups I employ, where instruments, transducers, and spatial configurations actively shape the compositional process.

Following Lachenmann (2009a), I consider composition to be inseparable from the construction of its instrumentarium. The composable space is not simply an arrangement of sounds but an ecology of tools, gestures, and constraints that produce musical thought. This perspective aligns with Varela's (1996) enactive cognition, which posits knowledge as an emergent property of embodied interaction. Musical structures arise not from fixed abstractions but through the situated interplay of material, perception, and action.

Vaggione's multi-scale approach (2007, 2010) further informs this study, framing musical time as a stratified phenomenon where micro, meso, and macro levels emerge relationally rather than hierarchically. The composable is the site where these temporal scales interact, producing granular morphologies and large-scale musical structures through articulated networks of sound objects and figures.

Ultimately, I position composition as an epistemic act, embedded in the material conditions of sound production and the cognitive processes of the musician. By framing the composable as an experimental field, I propose a model that embraces multiplicity, instability, and interaction, situating composition not merely as the organisation of sound but as a mode of inquiry into the sonic world.

The Composable as a Space for Experimentation

In this section, I explore the composable as a space of experimentation, situating it within an epistemological framework inspired by Hans-Jörg Rheinberger's (1997b) studies on experimental systems in scientific research. My intention is not to conflate artistic and scientific practices but to examine how knowledge is generated in composition through processes that, while distinct from scientific inquiry, share certain structural affinities. In music-making, knowledge does not reside in a fixed body of theoretical concepts but emerges dynamically through interactions between material, conceptual, and representational elements. The composable, in this sense, functions as an experimental system—an evolving site where technical objects and epistemic things interact, shaping and being shaped by artistic problematisation and inquiry.

At the centre of this exploration is the dialectical relationship between what is known and what remains uncertain, a dynamic common to both scientific and artistic experimentation. Rheinberger's concepts of epistemic things and technical objects provide a useful lens through which to consider this interplay in composition. While technical objects—such as instruments, tools, and established techniques—offer stability and structure, epistemic things remain undefined, emergent, and subject to transformation. The boundary between these categories is fluid, shifting in response to compositional inquiry.

Experimentation in composition takes place within spaces of representation, where musical ideas are inscribed, transformed, and articulated in material forms. Just as scientific experiments generate traces that contribute to knowledge production, composition involves notational, sonic, and symbolic inscriptions that do not merely document pre-existing knowledge but actively shape new musical thought. These graphemic materials serve as generative elements, structuring the emergence of ideas through iterative processes of exploration and refinement.

A key concern in this study is the interplay between acquired and emergent knowledge in compositional practice. While composition necessarily draws upon prior knowledge—technical, theoretical, and historical—it also fosters new forms of understanding through recursive experimentation. The composable is thus inherently future-oriented, a space not simply for the application of established techniques but for the unfolding of unforeseen possibilities. This continuous negotiation between knowledge and discovery places composition within an epistemological field that resists classification within conventional disciplinary frameworks.

By framing the composable as an experimental system, I propose a way of thinking about musical knowledge that foregrounds its contingent, processual nature. Composition, like scientific inquiry, is not a linear sequence of predetermined actions but a network of interrelated gestures, decisions, and transformations. Its experimental nature is embedded not only in the materials and techniques it employs but also in the very structure of its knowledge production. Rather than applying scientific epistemology to artistic practice, I reflect on how experimentation itself operates as a fundamental mode of inquiry in music-making.

This exploration ultimately aims to establish a space of comparability between artistic and scientific knowledge production while respecting their irreducible differences. In doing so, I seek to highlight how composition functions as an investigative practice—one that navigates material constraints and conceptual uncertainties to generate new forms of knowledge through its experimental processes.

Multidimensional Dispositives

In this chapter, I explore the multidimensionality of sound within the composable space, examining how spatial configurations and hybrid instruments shape compositional knowledge. My inquiry focuses on the interplay between materiality and abstraction in music-making, considering how spatialised dispositives—assemblages of acoustic instruments, electronic elements, and transducers—transform musical production and listening, generating new epistemic and aesthetic frameworks.

At the core of this investigation is the multidimensional sonic dispositive, a dynamic system where sound-producing objects interact within a compositional framework. Beyond a technical arrangement, it is a site of experimentation where musical ideas materialise through the negotiation of acoustic, electronic, and spatial elements. In works such as *Mutante/Amniótica* and *Contraccolpo*, I examine how hybridising acoustic instruments with electronic transduction systems expands the possibilities of instrumental writing, allowing sound to be projected, filtered, and spatialised in ways that challenge conventional approaches. My process is grounded in empirical exploration, where the selection and arrangement of microphones, transducers, and speakers are integral to the formation of compositional structures.

Space is a crucial component of this inquiry. Sound is not passively diffused but actively shaped by its environment, from the resonance of an instrument's body to large-scale site-specific configurations. In *Les sons ne sont pas des hommes*, for example, the vineyard setting at Villa Medici became an active element of the compositional process, merging natural and synthetic sonic ecologies to create an immersive, nonlinear soundscape.

This perspective aligns with the works of Hugo Morales, Carola Bauckholt, and Daniel Zea, who similarly explore the interaction of material objects, electronic processing, and performative action. Their approaches, whether through structural couplings of acoustic and transduced sound, spatialised mimicry of natural environments, or audiovisual performative dispositives, reinforce the idea that compositional space is not fixed but constantly reshaped through experimentation.

Ultimately, this study positions composition as an experimental practice where knowledge emerges through engagement with material and spatial mediations. The composable is not merely a framework for structuring sound but a site of interaction—between objects, spaces, and listeners—where artistic and epistemic processes unfold through sonic exploration.

Symbolic Granulation

In this chapter, I explore symbolic granulation as a compositional method, investigating how digital and analogue audio processes are translated into instrumental writing. My approach operates within a granular paradigm, viewing musical time as a multi-scalar, non-linear, and recursive phenomenon. Rather than working directly with audio signals, I apply the principles of granular synthesis to the symbolic domain, fragmenting notated musical material into discrete units—grains—that are then manipulated, reorganised, and recombined through compositional strategies and algorithmic processes. This enables the creation of emergent and complex sound textures from seemingly simple musical materials.

I contextualise this approach within a historical lineage, from Wiener's *energy grains* and Gabor's *acoustic quanta* (1947) to Xenakis 'stochastic models (1960) and Curtis Roads 'granular synthesis. Xenakis 'application of probabilistic structures to instrumental composition remains central to my own practice, where symbolic granulation serves as a bridge between digital processing and notation.

Within this historical and theoretical framework, I analyse my own compositional practice, beginning with *Mutante/Amniótica* (2018), a work for double bass, electronics, and a multi-dimensional sound apparatus. I focus on the granular-based techniques that shaped its instrumental writing, particularly the use of sampling and other granular-based operations. The central challenge was to create instrumental morphologies capable of circulating across multiple temporal scales while maintaining coherence within the electronic sound diffusion system. My research process involved extensive collaboration with the double bassist Charlotte Testu, leading to the development of reference figures that served as the basis for granular manipulations. These figures were designed to be malleable, allowing for micro-articulation and transformation through progressive shifts in the reading window, a technique akin to the granular synthesis parameter of grain size modulation.

A similar approach is evident in my more recent work, *Neon Frog* (2024), where I extend these methods by incorporating phasing and sampling techniques. Here, instrumental figures undergo progressive transformations, shifting from noisy to resonant timbres as they are repeatedly deconstructed and reassembled through symbolic granulation. The work's formal structure emerges from an interplay of iterative cycles, phase shifting, and non-linear accumulations of material, generating a continuously reconfiguring texture. I outline the global processes that structure these transformations while also detailing the local operations—pitch filtering, micro-variations, and shifting strategies—that ensure a fluid yet unpredictable evolution of sound.

I situate my approach within a broader compositional discourse, engaging with Bernard Lang's systematic looping, Bryn Harrison's recursive temporal structures, and Laure M. Hiendl's score-sampling techniques. While these works explore iterative processes, my focus lies in the interaction between symbolic and acoustic domains, where digital paradigms are not merely imitated but reinterpreted as expressive tools for musical form.

While these works share a focus on iterative processes and the reconfiguration of sonic material, my own approach places particular emphasis on the interaction between symbolic and acoustic domains. My method does not simply seek to imitate digital audio processes in instrumental writing but rather explores the expressive potential of this translation, situating symbolic granulation as a tool for generating emergent musical forms. I view the compositional process as a continuous negotiation between structure and contingency, where global formal processes set the framework but local decisions introduce variability and openness.

Ultimately, this chapter articulates a compositional perspective in which musical time is approached as a fluid and multi-scalar entity, shaped by the interaction between granular methodologies and the evolving properties of instrumental and electronic sound. Symbolic granulation emerges not as a rigid system but as a flexible and exploratory method—one that invites both precision and unpredictability, structure and emergence.

Sonic Translation

In this chapter, I examine sonic translation as a compositional methodology, exploring how non-musical phenomena are transposed into the sonic domain. My approach considers this translation process not as a simple mapping of data onto musical parameters but as an act of artistic transformation that negotiates between the real and the imaginary, the concrete and the abstract. Sonic translation allows me to reframe the act of composition as a process of mediation, in which diverse materials—visual, textual, environmental, or conceptual—are rendered audible through a series of operational strategies. Rather than merely representing external phenomena, this approach interrogates how translation itself conditions musical form and listening.

I begin by contextualising sonic translation within a broader artistic and theoretical framework. This practice extends beyond music, intersecting with disciplines such as visual art, literature, and data sonification, while remaining rooted in the compositional concerns of mapping, transcription, and mimesis. The relationship between sound and meaning is central to this discussion: how does a sonic gesture retain traces of its source material, and at what point does it become autonomous? This tension between representation and abstraction runs through all the works analysed in this chapter.

My own compositions serve as a primary site of investigation. In *Trans-étude #4: Intérieur/Extérieur* (2022), I explore the translation of urban soundscapes into instrumental writing and electronic sound. Developed in collaboration with tuba player Jack Adler-McKean, this piece originates from field recordings made by the performer in his immediate surroundings, which then become the basis for instrumental imitation and transformation. The work oscillates between direct sonic references and abstracted forms, investigating the thresholds at which a sound ceases to signify its original source and begins to function as musical material. The process unfolds across multiple stages, including field recording, cataloguing, mimetic transcription, and abstraction through compositional operations such as looping, filtering, and spectral manipulation. Each version of the piece emerges from its specific recording context, rendering the work inherently site-responsive.

A different approach is explored in *Neon Frog* (2024), where sonic translation operates across a continuum of natural and artificial sound worlds. Here, I integrate recordings of South American frogs and toads with satellite transmissions, creating a sonic network that juxtaposes biological and technological signals. The process involves various degrees of translation, ranging from high-fidelity transcription to instrumental analogy, where selected sonic features—timbre, envelope, rhythmic behaviour—serve as points of departure for new instrumental morphologies. Rather than functioning as mere sonic representations, these translations generate emergent textures that blur the boundary between imitation and invention. By continuously reconfiguring the relationship between the original sound and its instrumental transformation, *Neon Frog* constructs a fluid interplay between sonic realism and abstraction.

I situate this approach within a broader discourse, engaging with composers such as Joanna Bailie, Alberto Bernal, and Carola Bauckholt, whose works interrogate the boundaries between recorded sound and instrumental translation. Their varied methodologies—from mimetic transcription to audiovisual mapping—highlight the unstable nature of sonic representation.

Across these different approaches, a common theme emerges: sonic translation is not simply a technique but a means of questioning the act of listening itself. By positioning sound as both a trace of external reality and a constructed musical artefact, these works challenge conventional notions of musical materiality. My own explorations in this domain are driven by a desire to navigate this ambiguous terrain, where sound operates simultaneously as representation and abstraction, memory and invention.

Ultimately, sonic translation emerges as a way of rethinking composition as a space of negotiation between materiality and meaning. By framing sound as both trace and invention, I position composition as an act of mediation, attuned to the shifting relationships between listening, transformation, and the compositional imagination.

Feedback

In this chapter, I have explored audio feedback—and more precisely, Larsen tones—as both compositional material and performative phenomenon. I have intended to retrace a lineage of artistic practices that, from their earliest appearances, sought to engage with feedback not merely as a technical artefact but as a sound matter capable of shaping compositional spaces. Grounded in a material perspective, I aimed to observe how the physical, environmental, and technological conditions that give rise to feedback simultaneously redefine the modes of listening, composing, and performing.

My inquiry traces its historical and experimental uses from early rock musicians to figures such as Cage, Lucier, and Collins—who centred feedback within his compositional discourse. Collins's *Pea Soup* was particularly influential, demonstrating how feedback transforms the acoustic space into an active compositional agent.

This research extends to hybridised instruments, where feedback systems reshape performative and sonic interactions. Works by Lupone, Di Scipio, and Pauly highlight how feedback destabilises conventional instrumental roles, a principle that guided my own explorations. In *Fabulae*, *Allegretto: Dynamogramme*, and *Mutante*, I developed feedback-based instruments—Feed-Tom, Feed-Sax, and Feed-Timpani—where performers modulate sound through gesture, space, and electronic mediation.

Yet it was in *Campo amniótico* (2021) that I confronted the question that had haunted me throughout this journey: how to compose with the unpredictable? How do we engage with a phenomenon that, by its very nature, escapes control? For the first time, I decided to centre the entire compositional process around a self-regulated negative feedback system. Long periods of experimentation led me to conceive hybrid instruments—coupled cylindrical tubes and microphones—and a dispositive where the performers' gestures become acts of negotiation with the system rather than exercises of control.

In *Campo amniótico*, performers do not embody mastery but rather inhabit a space of vigilance and constant recalibration. I was fascinated by the way the system forced them into new forms of agency, requiring them to abandon learnt reflexes and embrace a mode of performance grounded in presence, awareness, and a shared vulnerability with the system itself. What emerged was a form of listening and acting that redefined the performer's role: no longer a transmitter of written instructions, but a mediator within a fragile sonic ecosystem.

This work also allowed me to think about musical time differently. The unpredictable latency of the feedback system generated a floating temporality, irreducible to metric precision, while the fixed timeline of the synthetic voices introduced another, opposing temporal layer. The mirror-like form I conceived—an arch of accumulation and rarefaction—sought to hold these two temporalities together, without resolving their tension.

What ultimately interests me in all these experiences is the way feedback, as a material, constantly resists reification. Each performance becomes a unique negotiation, a re-actualisation of the piece in response to the space, the bodies, the machines, and the contingent conditions of the moment. Larsen tones cease to be mere sonic by-products and become, instead, emergent sound objects—composed emergencies that inhabit the work as its most fragile and vital core.

Through this chapter, I have tried to delineate not only a technical but also a poetic field, where feedback systems invite us to rethink the very act of composing: composing not on the material but with the material, allowing sound, technology, and bodies to co-construct the compositional space.

Research Aims and Methods

Research Aims

This dissertation examines the mutations of *composable spaces* in my artistic practice as a composer over nearly a decade, from 2016 to 2024. My primary aim is to explore how these spaces—each specific to a singular compositional act—emerge, evolve, and transform under conditions of epistemic and methodological tension. The central hypothesis is that such mutations are generated through the interaction of multiple, overlapping artistic methods, which interrelate, feedback, and often coexist in a state of productive contradiction. These interactions constitute a dynamic field of forces in which actions, decisions, and emergent phenomena operate as catalysts within the compositional process.

Central to this research is an understanding of the *composable* not as a fixed category, but as an evolving space shaped by experimental methods, aesthetic choices, and conceptual reconfigurations. Knowledge is conceptualised in this context as an epiphenomenon—one that emerges through practice, reflecting the tensions between a priori frameworks and emergent understandings. These tensions are not only epistemic but ontological: they point to shifting modes of being, doing, and making that unfold within and through the composable.

The entanglements I trace in this dissertation are shaped by two distinct yet interwoven conceptions of musical time. One positions sound as an acoustic phenomenon, using digital signal processing (DSP) as both a model and operational strategy. The other introduces questions of meaning, representation, and translation into the act of composition, foregrounding the socio-cultural dimensions of sound. The tension between these approaches—between sound as material and sound as sign—frames many of the experiments I undertake.

The artistic aim of this research is to continually expand, evolve, and challenge the composable. This goal is pursued through a sustained process of iterative problematisation across diverse artistic methods, strategies, and operations. Each work created and analysed in the research process emerges from a unique configuration of composable space, informed by singular contexts, local conditions, and specific assemblages of instruments, media, and conceptual frameworks.

Although knowledge is certainly a thread running through this investigation, my central concern lies with the compositional methods themselves—their diversity, their tensions, and their capacity to act as both catalysts and traces of mutation. Thus, rather than pursuing a theory of knowledge, I explore the *mutation of the composable* as an evolving logic of artistic practice. The thesis is structured around this inquiry, identifying and addressing specific artistic methodologies and the ways in which they shape, reconfigure, or destabilise composable space over time.

Iterative Problematisation as a Research Method

This thesis is based on the investigation of how composable spaces, understood as dynamic and evolving fields of artistic interaction, mutate over time through processes characterised by epistemic and methodological tension. The central hypothesis guiding this inquiry is that such mutations arise from the interplay of diverse artistic methods that converge, diverge, and feedback into one another across multiple compositional contexts. These interactions are not neutral or additive; rather, they activate a productive field of contradiction and transformation, resulting in singular compositional outcomes that resist homogenisation.

I employ a methodological strategy I call *iterative problematisation* to address this complexity. This approach proposes a recursive mode of inquiry, in which a subject—be it an artistic method, a technical object or a compositional set of operations—is repeatedly revisited, reframed, and reactivated across different contexts, rather than seeking to fix definitive concepts or define techniques. I isolate specific techniques or strategies within individual works, tracing their behaviour under localised conditions, and later drawing out broader patterns of divergence or convergence, rather than attempting to resolve or synthesise different methods into a total system. This deepens my understanding of how compositional strategies operate, mutate, and generate new forms of musical thought over time.

The notion of problematisation is drawn from Michel Foucault's philosophical work, which he retrospectively identified as the leitmotif of his research: "The notion common to all the work that I have done since *Histoire de la folie* is that of problematisation" (Foucault, 1998, p. 257, as cited in De Assis, 2013, p. 162). He adds, "one always finds what is essential after the event; the most general things are those that appear last. It is the ransom and reward for all work in which theoretical questions are elaborated on the basis of a particular empirical field" (Foucault, 1998, p. 257). This perspective reflects how my compositional enquiries unfold: not from theoretical models applied in advance, but through situated, empirical engagement with questions that arise through artistic practice.

The following table compares works, methods, and theoretical concepts.

Table 1, Comparative table of works, methods, and theoretical concepts

Personal Work	**Art Method / Subject of Inquiry**	**Theoretical Concepts**	**Referenced works**
Mutante/ Amniótica	Multidimensional dispositives, Symbolic Granulation, Hybrid Instruments	Apparatus, Multi-scale, Multi-local, Granular Paradigm, Figure, Interaction, Non-linear temporality	*Doppelbelichtung, Waïra, Tonewood II, Repetitions in extended time, Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden*
Les sons ne sont pas des hommes	Multidimensional dispositives, Site-specific sound installation, Environmental sound integration	Apparatus, Emergence, Sound ecology, Situated listening, Sonic materialism, Site-specific sound, Referentiality	*Doppelbelichtung, Waïra, Tonewood II*
Contraccolpo	Multidimensional dispositives, Symbolic Granulation, Hybrid Instruments	Apparatus, Multi-scale, Multi-local, Granular Paradigm, Figure, Interaction, Enaction, Non-linear temporality, Embodied interaction	*Doppelbelichtung, Waïra, Tonewood II*
Neon Frog	Symbolic Granulation, Sonic Translation, Hybrid Instruments, Open-data composition	Multi-scale, Multi-local, Granular Paradigm, Figure, Interaction, Enaction, Emergence, Representation and abstraction, Referentiality, Non-linear temporality, Embodied interaction	*Repetitions in extended time, Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden, Trains, Impossible Translations, Doppelbelichtung, Lichtung*
Trans-étude #4: Intérieur/ Extérieur	Sonic Translation, Site-specific sound	Representation and abstraction, Referentiality, Sound ecology, Situated listening, Sonic materialism, Site-specific sound	*Trains, Impossible Translations, Doppelbelichtung, Lichtung*
Fabulae	Instrumental Feedback, Multidimensional dispositives, Symbolic Granulation, Hybrid Instruments, Audio-visual, Open-data composition	Enaction, Emergence, Apparatus, Multi-scale, Multi-local, Granular Paradigm, Figure, Interaction, Non-linear temporality,	*Pea Soup, Feed-drum, Feedback, Modes of Interference, Threshing Floor*

		Embodied interaction, Material agency, Performative emergence	
Allegretto : Dynamogramme	Instrumental Feedback (Feed-Sax), Multidimensional dispositives, Symbolic Granulation, Hybrid Instruments	Enaction, Emergence, Apparatus, Multi-scale, Multi-local, Granular Paradigm, Figure, Interaction, Non-linear temporality, Embodied interaction, Performative emergence	*Pea Soup, Feed-drum, Feedback, Modes of Interference, Threshing Floor*
Cada trozo/ cada ganglio	Instrumental Feedback (Feed-Timpani), Symbolic Granulation, Hybrid Instruments, Gestural modulation, Audio-visual, Open-data composition	Enaction, Emergence, Interaction, Multi-scale, Multi-local, Granular Paradigm, Figure, Embodied interaction, Material agency, Performative emergence	*Pea Soup, Feed-drum, Feedback, Modes of Interference, Threshing Floor*
Mutante	Instrumental Feedback (Feed-Timpani), Hybrid Instruments, Open-data composition	Enaction, Emergence, Interaction, Embodied interaction, Material agency, Performative emergence	*Pea Soup, Feed-drum, Feedback, Modes of Interference, Threshing Floor*
Campo amniótico	Instrumental Feedback, Hybrid Instruments, Multidimensional dispositives, Self-regulated feedback systems, Performer-system negotiation	Enaction, Emergence, Interaction, Post-human agency, Embodied interaction, Performer-agency, Performative emergence, Technoperformative agency	*Pea Soup, Feed-drum, Feedback, Modes of Interference, Threshing Floor*

According to Foucault, problematisation "doesn't mean representation of a preexisting object, nor the creation by discourse of an object that doesn't exist. It is the totality of discursive or non-discursive practices that introduces something into the play of true and false and constitutes it as an object for thought" (Foucault, 1998, p. 257, as cited in De Assis, 2013, p. 162). De Assis expands this idea by stating: "Problematisation has, therefore, to do with 'objects, 'with things that are archaeologically retraced and transmuted from 'neutral objects 'into 'objects for thought'" (De Assis, p. 162). Crucially, he proposes a shift from a retrospective to a projective mode of thinking: "a mode that, rather than aiming to retrieve what things are, searches for new ways of productively exposing them. That is to say, a mode that, instead of critically looking into the past, creatively projects things into the future" (De Assis, p. 162).

In this thesis, *iterative problematisation* functions in both archaeological and projective ways. I return to specific artistic methods—such as *feedback*, *symbolic granulation*, *sonic translation*, or *multidimensional dispositives*—across different works and conceptual frames. These returns are not repetitions but situated engagements, each iteration reframing the subject under new epistemic, material, and aesthetic conditions. For instance, feedback is explored in *Fabulae*, *Allegretto: Dynamogramme*, *Mutante*, *Cada trozo/cada ganglio*, and *Campo amniótico*, where it materialises distinct relations between performer, system, and space. Sometimes stabilised by physical gesture, sometimes left open to systemic fluctuation, or digitally shaped, feedback reveals itself as a method that resists fixation.

Similarly, *sonic translation* is revisited across *Trans-étude #4: Intérieur/Extérieur* and *Neon Frog*, each time shifting the terms of the relationship between sound and referent, from field recording to abstraction, from environmental inscription to situated listening. *Symbolic granulation*, first introduced in *Mutante/Amniótica* as a translation of DSP principles into instrumental writing, evolves in *Neon Frog* through techniques of sampling, phasing, and iterative recomposition. These operations are informed by theoretical readings (Xenakis, Curtis Roads, Bernard Lang), but their role is not to justify practice. Rather, theory, technique, and material experimentation are co-constructive, participating equally in the shaping of composable space.

This methodology unfolds through three interconnected modes: artistic experimentation, comparative analysis, and theoretical articulation. Each subject is investigated through concrete compositional practice, through juxtaposition with other works—such as Collins's *Pea Soup*, Bauckholt's *Doppelbelichtung*, Zea's *Waïra*—and through engagement with conceptual frameworks (Vaggione, Rheinberger, Foucault, De Assis). The aim is not to stabilise meaning but to inhabit complexity—to understand how methods generate epistemic tensions, produce emergent forms, and contribute to the ongoing mutation of composable space.

Iterative problematisation thus functions not only as a conceptual lens but as the operative research method of this thesis. It enables a sustained and dynamic approach to understanding how compositional strategies behave over time, how they evolve concerning materials, technologies, and environments, and how knowledge emerges from within the very act of composition. In this sense, the composable is not simply a domain of musical production but a field of inquiry—a space of recursive experimentation where thought and sound evolve together.

Chapter 1. Theoretical Frame

Apparatuses

Anne Sédès (2013, p. 11), borrowing a term from Walter Benjamin, poses a key question: how can a reflection on the notion of apparatus help us to renew our approaches to the subjects of study and to musical facts?

Benjamin (2012) depicts cinema as a system and describes the relationship between the apparatuses (camera, microphones, lights, etc.) and the different agents (actors, film and production teams, audience, experts, etc.) by evoking their points of view, as well as the socio-economic constraints imposed by the political and cultural context of an era.[2] Sédès underlines the importance, in the text of Benjamin, of the reflection on the apparatus and "how the technological mutations, in interaction with the time, transform the art, our manners of making and perceiving" the music. The ways in which musicians appropriate objects created by these technological mutations transform our forms of listening, producing and thinking music.

> Around 1900, mechanised reproduction had reached a standard where it not only began to make the works of art of the past its object and to transform by the same token their action, but also reached an autonomous situation among the artistic processes. For the study of this standard, nothing is more revealing than the way in which its two different manifestations -reproduction of the work of art and cinematographic art- were reflected on art in its traditional form. (Benjamin, 2012, p. 25)

Sédès evokes as a completed example of the phenomenon, the importance of the electric guitar in the construction of the sound of pop music and how it has, "according to the appropriations by the musicians, by making appear the multiplicity of its aesthetic identities has, according to the expression of Jean-Louis Deotte, fashioned the era" (Sédès, 2013, p. 2). This example is not insignificant, the

[2] Benjamin's text more broadly addresses the singular *hic et nunc* of the artwork—its unique presence in time and space, or what he terms its *aura*—and its loss in the context of the mass reproduction of artworks.

electric guitar being also the perfect example of a modular instrument,[3] of a device that can be connected to other devices, of a networked device that refers us to a multiplicity of studio practices, from electroacoustic music to commercial music:

> The electric guitar is no longer a musical instrument in the traditional sense. It is a modular instrument, a networked piece of equipment, made of a solid body guitar, equipped with microphones, connected to an amplifier that will add possibilities of transformation and processing of the sound. Effect pedals will finally complete the electroacoustic processing chain. Nowadays, this chain can integrate the means of digital audio processing. (Sédès, 2013, p. 2)

The aesthetics of a time thus emerge through the various modes of interaction between the equipment, on the one hand, and the artist, the technician, the expert, the listener, etc., on the other.

Since my approach is primarily concerned with the analysis of practice and oriented toward operational aims, I focus my reflection on my relationship with the apparatuses. I do so by tracing the genesis of the composable spaces in works that employ multidimensional sound diffusion setups, such as *Contraccolpo*, *Mutante/Amniótica*, and *Les sons ne sont pas des hommes*. The apparatuses at work and our modes of interaction with them, as well as the set of operations and variables that we produce in a given work environment and the conceptual tools to formalise it, integrate and delimit this composable space, its instruments and its buttons.

Sédès offers an example of the interaction between equipment and artist within the experimental music studio, clearly illustrating how this relationship reveals the composable spaces through which works can be created. She then extends this model of music production to include instrumental music. Citing Helmut Lachenmann, Sédès recalls that to compose is to reflect on one's tools, to define one's instrument, and to allow oneself to act. In other words, composition involves thinking about one's working environment, defining the composable space, and engaging with it through interaction. For Lachenmann, this also includes the aesthetic apparatus:

> The instrumentarium, both theoretical and practical, traditional or recently developed, i.e. the musical instruments with their characteristic construction and the performance techniques derived from them, including the current concept; beyond that, also all the technical means, tools, conceptual devices, working techniques developed and exploited within our conception and practice of music, as well as the institutions and markets concerned within society. (Lachenmann, 2009a, pp. 69-70)

[3] This line of thought provided a valuable point of departure for analysing the central role played by the modular instrument—formed through the coupling of a double bass and eight transducers—featured on stage in my work *Mutante/Amniótica*.

Thinking about the devices and the ways in which the musician interacts with them within a given composable space and within the totality of the aesthetic apparatus is a fundamental step in approaching a relevant exhibition of how I have composed with a multi-dimensional dispositive.[4] This is all the more true if we consider the existing imbrication between technical and technological objects, knowledge, and practices in the context of creation. Under this angle, it is easy to highlight the multiplicity of points of access to approach the practice of these types of dispositives and the multiplicity of possible interactions emerging within them, as much in the stages of genesis of the work as inside the composable space that is at its origin.

Benjamin points out that critical moments of technological change produce visible effects only if they are reflected in the birth of a new artistic form (of production), which he calls a *modification of the technical level*:

> The history of every art form has critical periods, when it tends to produce effects that can only be achieved effortlessly after a modification of the technical level, i.e. by a new art form. (Benjamin, 2012, p. 45)

However, this shift at the technical level can no longer be understood solely as the emergence of a new art form. What the technical and technological mutations—directly or indirectly affecting the sonic and visual arts (including their modes of reproduction)—have produced is a new substrate for the emergence of hybridisations between practices and disciplines, and for the formation of new couplings. In the context of the subject at hand, this transformation of the technical level is manifested in the multiplicity of equipment integrated within dispositives. It is also reflected in the hybridisation of practices and the forms of knowledge mobilised—ranging from mixed music and low-fi aesthetics to new lutherie, hybrid/modular instruments, sound art, and DIY cultures.

I appropriate both the notion of a "modification of the technical level" and the concept of the apparatus within my epistemological reflection, positioning the conception and design of the sonic dispositive as a central compositional act.

[4] As a concept, and depending on the various disciplines that employ it, the notion of *dispositive* can refer to both material, physical objects and immaterial, symbolic constructs. To narrow the semantic field addressed in this dissertation, I will generally use the term *dispositive* to designate a set of physical elements forming a mechanism, machine, or apparatus. I will also consider it as a networked system, whose components may themselves function as devices. A central aspect of my working hypothesis is to approach and define the *dispositive* as a compositional act. I will not engage with the Foucauldian sense of the term, which relates to the concept of governability within his theory of biopolitics. While this interpretation has had a significant influence across various disciplines, the breadth of references it entails exceeds the scope of this study.

Enaction

According to the computational paradigm that dominated the emerging cognitive sciences during the first decades of the post-war period (1950–1980)—and upon which early developments in artificial intelligence (AI) were based—knowledge was thought to operate through the manipulation of discrete symbols according to logical rules. In its initial phase, AI sought to solve general problems by emulating the intelligence of high-level experts, under the assumption that such an approach would address the core mechanisms of cognition. Gradually, however, this path was reversed: attention shifted to the analysis of more ordinary tasks—even those performed by simple organisms—and it became apparent that traditional computational strategies were insufficient to account for them.

In response, new foundational approaches have emerged, proposing that cognitive processes should be understood in terms of how meaning arises within the living organism. These approaches suggest that cognition—including abstract thought—is grounded in the organism's concrete activity, particularly within the dynamics of sensorimotor coupling. As Varela stated:

> The world is not something that is given to us: it is something that we participate in according to the way we move, touch, breathe and eat. This is what I call cognition as enaction, because enaction connotes this production through concrete manipulation. (Varela, 2004, p. 24)

In another work (1993), Varela continues to emphasise that sensorimotor processes are inseparable from cognition, arguing that the relationship between perception and action should not be understood as a simple input-output circuit connected in a merely contingent manner. He summarises an initial account—what he terms the *enactive approach to cognition*—through two interrelated principles:

> 1) perception consists of actions guided by perception; 2) cognitive structures emerge from recurrent sensory-motor patterns that allow action to be guided by perception. (Varela, 1993, p. 285)

Unlike the computationalist perspective, which understands perception in terms of representing a world with predefined attributes, the enactive approach examines how the perceiving subject guides their actions within specific contexts and situations. In this theory, the focus is not on how a subject retrieves data from a world independent of themselves, but on identifying "the common principles or relevant connections between the sensory and motor systems that explain how action can be guided by perception in a world dependent on the perceiving subject."

In the enactive approach, the perceiving subject constitutes reality, which is not a given. This does not imply that reality is "created" at will, but rather that what appears as a relevant world to the perceiving subject is inseparable from the subject's own structural organisation. According to this approach, the cognitive structures familiar to human beings emerge from the recurrence of sensory-motor patterns, which allow action to be guided by perception. This thesis accounts for the emergence of "lower"-level cognitive events. To address "higher" cognitive levels—those involving the significant conceptual structures of cognition—Varela draws on Lakoff's (1983) thesis concerning their dual origin:

> 1) the structured nature of bodily experience; 2) our imaginative ability to make projections to conceptual structures from certain well-structured aspects of bodily and interactive experience. (Varela, 2004, p. 34)

Our capacities for abstraction thus arise from an empirical substrate formed by these embodied sensorimotor structures. According to Varela, these empirical structures of knowledge that originate in action-guided perception "motivate" conceptual understanding and rational thought.

> Since we have said that perception and action are embodied in sensory-motor processes (which are self-organizing), (...) it is natural to postulate that cognitive structures emerge from the recurrent patterns of sensory-motor activity. In each case, it is important to see not that experience strictly determines conceptual structures and ways of thinking, but that it both enables and limits conceptual understanding in many domains of cognition. (Varela, 2004, p. 34)

Emergence

The multi-scale approach proposed by Horacio Vaggione - which I will discuss later in this chapter and which is central to our theoretical framework - postulates the possibility of a coupling between various time scales, and between various types of temporalities. Vaggione (2008) situates the specificity of this approach in the creation of a multiplicity of convergences between these scales of *simultaneous vectorisations*. At the same time, he describes the musical sound as a compound emerging from an intrinsically unstable situation, far from equilibrium, possessing a complex and "highly stratified structure, made of clumped moments, like a yarrow"[5] (Vaggione, 2008, p. 166). As we shall see later, Vaggione consistently observes that these scales are never predefined and that their very definition constitutes a compositional act in itself. The determination of these scales takes place within the specific framework of the composable space posited in each

[5] Vaggione often refers to the complex sound object as a laminated object. The image of the yarrow serves as a recurring metaphor within Vaggione's conceptual framework.

instance. This means that, within a musical work, all temporal scales and levels—whether micro, meso, or macro—emerge through the compositional process

> In a multi-scale approach, all the levels are emergent, because they are intertwined, manifesting themselves from a reciprocity concerning all the relations in play in the compositional network. (Vaggione, 2008, p. 166)

Vaggione situates what is commonly referred to as form—or more precisely, "macro-form"—within the various orders of temporal magnitude present in a work. In this approach, it is understood as just another level (or stratum): a complex morphological entity that can be approached in the same way as all others. The macro-form, therefore, is also emergent. This point is crucial, as it reflects a particular temporal mode of the compositional process and serves as a conceptual thread throughout this research.

> One could thus by no means consider the macro-form as something predefined, nor resulting from the 'material' nor constituting a 'higher' level to which all the others would be inferred. (The macro-form is the) place of an emergence. (Vaggione, 2008, p. 166)

Vaggione considers the role of emergence in thought and musical practice as an organising force. He sets aside the central notion of functionality as traditionally embedded in tonal systems and places this reorientation at the core of his compositional approach (2008, p. 167). Drawing on the emergence of electroacoustic music and the use of highly stratified processes, he proposes a logic of emergence as an alternative to a logic of functionality.

> The state of things to be composed is no longer underpinned by a pre-established hierarchy of degrees of attraction, which constituted the framework on which a musical figuration would acquire its meaning. It is rather manifested, in the perspective of the network and the emergence, by a stratified set of temporal scales which is itself composable, and not pre-established. (Vaggione, 2008, p. 167)

But this substitution of functionalism by a logic of "making emerge" does not imply the negation of the idea of function, but rather its redefinition on grounds other than those of tonality. This shift entails, as Vaggione explains through the words of D. Charles, "a change of function of the function" (Charles, 1978, cited in Vaggione, 2008, p. 168).

Starting from the definition of sound as a complex and dynamic event whose attributes are not only parameters but emergences, he considers that each structural level, each morphological dimension as well as each temporal scale "is constituted by a movement of generalisation of the properties of each component" (2008, p. 168). Vaggione (2008, p. 168) thus defines the composable as the place of these emergences:

> The composable is the articulable: it is the place of emergences, but these do not constitute phenomena 'found' or provoked by a kind of stacking of elementary processes, but the fact of a stratified construction of carefully articulated interactions - composed. (Vaggione, 2008, p. 168)

The Problems of Representation

Vaggione, a close reader of Varela, articulates with notable precision the intersections between the enactive approach and the problems of representation. As previously mentioned, Varela places the notion of structural coupling of sensorimotor schemas at the heart of enaction, using it to explain the emergence of cognitive structures. The emphasis on this notion allows cognition to be understood as an activity aimed at "making a non-predefined world emerge" (Vaggione, 2008, p. 160). According to Varela (1989, p. 92), "only a predefined world can be represented." The condition for something to emerge, therefore, would be, in Varela's terms, to operate "without representation."

But what does it mean, for us as musicians, to "work without representations"? While we may aspire to the non-predetermined world of a musical work, we nonetheless rely on representation to conceive, compose, and bring a piece into being. Vaggione, who addresses this question primarily within the domain of computer science, draws on several authors who have proposed critiques of representation—most often as alternatives to classical cognitivism—including Flores, Brooks, Winograd, Bouveresse, Dreyfus, Chapman, and Wegner. He offers a starting point for considering this issue in relation to musical practice. Any attempt to approach this problem from a compositional perspective must inevitably grapple with the place of the human within systems of representation—with the role we play, both as producers and as situated agents, within the structures that enable and constrain how we make music and meaning.

> One could summarise the common element of the various avatars of this critique of representation in a terminology close to both hermeneutics and systemics, in the following way: a situated existence can only manifest itself in interaction (in reciprocity, asymmetry, incompleteness, and so on), and not in the fixation and predictability of a closed system. (Vaggione, 2008, p. 161)

The condition for actions oriented towards emergence necessarily implies a critique of representation. For Vaggione, this critique must resist any formalist reduction that treats representations as fundamental substances—that is, any attempt to hypostasise them—since such reductions obstruct the very possibility of emergence. What is required, rather, is "abandoning what Winograd calls 'classical rationality'," and moving away from the "compression of reality by and in the calculation" (Vaggione, 2008, p. 162). We must decisively move beyond the black box paradigm (Ashby, 1956, p. 86, cited in Scholte, 2016, p. 619) proposed by First-Order Cybernetics (Wiener, McCulloch, Pitts, Bateson), in order to make room for true interactivity. In contrast to the closed logic of computational axioms, Vaggione (2008, p. 161) argues for a necessary formal incompleteness as a precondition for any genuine emergence.

> In the case of the critique of representation, on the contrary, what is put forward is the fact that representations have no intrinsic reality: they are only tools that point to a contextual emergence, corresponding to a situation, or, as Varela says, to a structural coupling. (Vaggione, 2008, p. 161)

The representations—the tools to represent—convened for the musical creation become operative in the action. The emergence of the work (and of its composable space) within the structural coupling between sound and symbol is therefore contextual, not predefined. Our notation systems require an ambiguity that allows us to create functions that are an integral part of what we want to compose, of our composable space. This ambiguity, this "fuzzy" aspect of the system, is the attribute that allows us to access - through a flexible symbolic system that facilitates interaction with the composer - the composable. The objective of the representations of the music is not to create tools to affirm, to re-present, "an already existing information," but, as well says Vaggione (2010, p. 52), to "create a fact that is irreducible to this information."

> As for the operative representations that we use in music, (...) we are in a very different case from that of cognitivist representationalism, because these operative representations are tools created (constructed) in order to reach a morphological field of action, and not in order to re-present or trans-code mental processes, nor in order to elaborate models (formalisations) of the 'world'. (Vaggione, 2010, p. 53)

From this perspective, Vaggione proposes a form of contextual emergence that encompasses "the representational system, its present instantiation, and the composer himself" (2010, p. 54). There is no essential separation between composing sounds, defining a relevant system of operative representations, and composing the work itself. The genesis, creation, and implementation of the instruments that constitute our composable space are inseparable from the genesis of the work.

A Multi-Scale Approach to Musical Time

From the late 1980s to the end of the 1990s, Vaggione wrote extensively on the concept of a multi-scale approach to time in musical composition. At the heart of his thinking lies an operative distinction—one intended to be directly useful for the composer's engagement with the act of making—between two major orders of temporal scale, both in terms of perception and within musical culture: those pertaining to micro-time and those relating to macro-time. These temporalities are conceived as stratified entities, their magnitudes comprising a multiplicity of levels. However, these levels cannot be regarded as fixed data—"as instances of a predefined hierarchy" (Vaggione, 2010, p. 46)—to be inhabited like an empty, prefigured space. On the contrary, their very definition constitutes a compositional act. These scales are, in this sense, themselves composable.

> As for the temporal scales on which musical operations can be performed, we can postulate all the scales we want, because the way in which temporal scales are defined is already an operative choice, a compositional act. (Vaggione, 2007, pp. 156-157)

In instrumental and vocal music, the threshold separating two temporal dimensions is marked by the note—the fundamental symbolic unit of our tradition. Macro-time encompasses all scales that extend beyond the note, including the various levels of formal articulation that range from the local to the global. Conversely, the scales that extend inward belong to micro-time—a domain in which we locate non-notatable phenomena related to performance: agogics (the micro-articulation of sounds), timbral shifts, and other subtle expressive gestures.[6]

In drawing this distinction, Vaggione suggests that the difference between macro- and micro-time is not one of nature or content, but of scale. This distinction becomes operationally significant when delineating the fields of action between acoustics and electronics: the latter, for Vaggione, grants the composer access to micro-time, making it as composable as macro-time.[7] Thus, we may conceive of both domains as situated within the composable, where interactions and articulations can be imagined and constructed across scales—without erasing the threshold between them, but by engaging it through a shift in perspective.

In the field of electronic music, the lower perceptual threshold of micro-time can be situated within durations ranging from approximately 100 to 50 milliseconds. However, this estimation must be approached with caution, as such thresholds are context-dependent and must be understood within a specific morphological framework. In the case of granular synthesis, for instance, a cluster of samples

[6] "Where conventional musical notation no longer applies, because the order of magnitude of its symbols cannot be applied to the field of micro-phenomena of sound (micro-phenomena that are potentially present, however, in the music that this notation denotes), there begins, below the notes, the domain of micro-time." (Vaggione, 2010, p. 48)

[7] For Vaggione (1998c, p. 189), the composition of micro-time in the instrumental domain can only be achieved secondarily: "The timbre - the sound articulated at the level of micro-time - does indeed constitute this impossibility of writing, (...) musicians have of course realised this many times: what it is not possible to write directly, can be achieved by ricochet. There is a link between transposition, registration and intensity that makes it possible, by means of macroscopic writing alone, to act on the field of spectral energy."

within this temporal range is not perceived as a sequence of discrete events but rather as a texture—exhibiting its own emergent properties. This aligns with what Di Scipio (1998) describes as a “second-order sound” in his analysis of Xenakis’ electroacoustic music.

Vaggione insists that defining boundaries between temporal scales does not entail erasing their differences or dissolving the thresholds that separate them. Thinking of micro and macro temporalities within the same composable space does not imply their homogenisation—each scale remains irreducible. Their capacity for coupling and interaction is vast, but transitions between them cannot occur through simple transpositions of material. Despite his early interest in fractal approaches to music, Vaggione maintains that the only meaningful relationships between these temporal scales are non-linear.

I would further stress that the definition of temporal scales must be situated within the specific multi-scale framework posited by each composition. This approach is equally applicable to instrumental music: it becomes a matter of defining the operational levels being addressed, the classes of operations that can be applied, and the types of interaction that may emerge among them.

In an interview with Osvaldo Budón (2007, pp. 110–11), Vaggione summarises the multi-scale approach as follows:

> The pure Euclidean space (...) was the framework for classical linear operations such as term-to-term transpositions. But it has to be relativised if we want to integrate different temporal dimensions (...), in a multi-scale compositional network. In this way, we can take up the challenge of electroacoustic music by allowing all the singularities that manifest themselves at all temporal scales to emerge as products of interaction between multiple dimensions.
>
> We can sum up this situation in terms of a double articulation. On the one hand, as long as the different temporal levels present in a musical process are interacting, morphological characteristics can circulate from one level to another. On the other hand, the establishment of such a circulation can only take place on the condition that we assume that this circulation cannot, in any case, be strictly linear. (...). Thus relations - (...) - are to be defined through their content of interaction which, unlike a linear one-to-one relationship, does not exclude fractures, distortions and disjunctions between temporal levels. (Vaggione, as cited in Budon, 2007, pp. 110–111)

A Multi-Local Approach to Musical Time

As I have already pointed out—and as Vaggione consistently emphasises—temporal scales exist only in relation to an operational framework and are defined accordingly. This relativity allows the composer to move between these scales from any chosen point, disregarding their relative distances, in any direction and at any moment. Regarding this point, Vaggione (2010, p. 51) states: "At each level, everything depends on the precise definition of the (postulated) time scale in which we (temporarily) fix our 'windowing', our operating frame of reference."

All temporal levels—whether micro, meso,[8] or macro—can be conceived according to distinct operational plans. Furthermore, each level—which does not exist a priori, but must instead be composed—can be constructed through different and parallel processes. Radically contrasting operations may even converge within a single object, which circulates them, encapsulated, across various scales within a given composable space. This is why Vaggione (2010, p. 51) asserts that any "deliberately multi-scale-oriented process is always 'multi-local'."

A granular paradigm for musical time

The beginnings of the granular sound synthesis techniques used in computer-assisted electroacoustic music composition can be traced back to the work of physicist Dennis Gabor between 1946 and 1947. He presented the idea of applying quantum physics methods to the description of sound signals and explained the limitations of describing sound using Fourier analysis. Gabor proposed reducing Fourier's method to cells in a mathematical context, which led to the emergence of the concept of the "sliding window" in the 1960s. In music, we might mention the pioneering experiments of Iannis Xenakis in pieces such as *Concret PH* (1958) and *Analogique A* et *B* (1958-59).

This synthesis technique allows complex sounds to be generated using a flow of micro-samples, or grains, of variable density. Granular synthesis corresponds to a corpuscular type of description of the sound phenomenon that complements the wave-like description that has prevailed for a long time and may even incorporate it.[9] The perception of the resulting sounds generated by these granular synthesis techniques can vary according to a density threshold that we place, as an indication, at 20 events per second. From one side of this boundary to the other, we move from perceiving distinct individual entities to perceiving global textures, approaching the continuous character of waveforms.

Vaggione points out that, as soon as sound is conceived as a flow of grains rather than as a continuous waveform, a new morphological field becomes available to the

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[8] *Meso-time* refers to a set of temporal scales situated between micro- and macro-time, occupying a plane that encompasses the symbolic domain of score-based music: the musical note.

[9] "This is why the granular approach could be considered as a valid mode of generation for all sound, because it incorporates the wave aspect as one state of affairs among others: a laminar state (of any duration) obtained from flows of grains." (Vaggione, 2008, p. 170)

composer. This shift grants access to micro-temporal scales with a high degree of resolution—at a *morphophoric*[10] level, at the level of the grains themselves. It thus becomes possible to define an unlimited number of micro-scales by acting directly on the attributes of these grains: their duration, amplitude envelope, spectral content, spatial position, and more. Such manipulations allow for the emergence of complex morphologies and highly differentiated granular textures, whose identities may be either stable or dynamically evolving.[11]

> The interest of the granular approach for musical composition, then, lies in the possibility of carrying out a symbolic treatment operating on a micro-time scale. And, by extension of the principle, to work with morphological entities of all sizes, fragmenting them, agglutinating them and projecting them everywhere in the composable. (Vaggione, 2008, p. 171)

Again, following Vaggione, I refer here to a granular approach to musical time—one that enables intervention at both micro-temporal scales (via synthesis) and at meso- and macro-temporal scales (in both electronics and instrumental music). This is not to suggest that these dimensions can be treated as equivalent: the specific affordances of acoustic instruments cannot be simply equated with the possibilities enabled by electronics. Rather, it is precisely this asymmetry that mixed music seeks to engage with. The challenge—and the compositional task—is to establish a common vectorisation between these temporal dimensions, not by erasing their differences, but by activating them as points of tension and resonance within the composable space.

In the field of instrumental music, a heightened awareness of the morphological substratum of sound—upon which notational operations are carried out—has already found its way into compositional practice. This has fostered a more immediate relationship between sound and symbol (the note), supported by a focus on timbre as a structural element and on perceptual aspects of listening. Concurrently, access to the microscopic phenomena of sound, enabled by technological tools, has allowed composers to engage—albeit indirectly—with the

[10] In this context, morphophoric refers to the property of small-scale sonic units (such as grains in granular synthesis) to carry or convey morphological information. A morphophoric grain is not just a unit of sound, but one that encapsulates a dynamic form, however minimal: an envelope, a spectral curve, a spatial trajectory. The morphophoric level is where shape and function converge at micro-time scales, allowing for the emergence of higher-level temporal or textural structures through the behaviour and organisation of these grains. **"Morpho-"** comes from *morphology*, meaning form or shape, and **"-phoric"** comes from the Greek *phoros*, meaning "bearing" or "carrying."

[11] Agostino Di Scipio (1994, p. 206) proposes a description of the emergent properties of complex sounds according to the rules of *Morphostasis* (conservation of a stable identity) or *Morphogenesis* (dynamic behaviour).

domain of micro-time traditionally reserved for performers. As Vaggione (2007, p. 125) notes, the possibility opened up by this temporal approach is to achieve:

> A relative expansion of syntactic operations that are properly compositional, i.e. explicitly included in the system of representations (notations) of the work. In this sense, we can speak of 'instrumental granularity', because the figurative agglutinations of the score (always macroscopic, (...), because situated at the level of the 'note', above the 'horizon line' of micro-time) correspond structurally with numerical granularity (Vaggione, 2007, p. 125)

The practice of electroacoustic music in the studio—the interaction with analogue and digital equipment, access to techniques of sound description, analysis, and synthesis, as well as the use of algorithmic computation to generate sound and musical structures—has had, and continues to have, a considerable impact on the instrumental music of several generations of composers. Various techniques derived from electroacoustic practice have served as sources of inspiration for imagining models that can be applied to instrumental writing. I would like to mention a few paradigmatic cases:

- The music of sound masses organised according to stochastic principles by Iannis Xenakis.
- Helmut Lachenmann's *musique concrète instrumentale*.
- The works of Gérard Grisey and Tristan Murail, in which instrumental writing inspired by additive synthesis or other frequency-domain synthesis techniques is developed.

In general terms, this macroscopic granular approach can be situated alongside other approaches to instrumental music that draw inspiration from paradigms and/or techniques rooted in electroacoustic music—what we might call forms of 'instrumental synthesis', such as those developed by Grisey and Murail. However, my focus is not on the resulting forms or techniques per se—whether in the creation of complex sounds emerging from textured masses, structured timbres, or stretched and orchestrated spectra. Rather, my interest lies in the phenomenon of categorical transfer: the migration of conceptual models from the domain of digital synthesis into the realm of instrumental composition.

The task—reimagined with each new work within this approach—is to devise ways of effecting this transfer when applying operations inspired by granular synthesis to the figures and objects of instrumental music. Within this particular temporal framework, I generally conceive a given instrumental figure or object—defined by specific morphological characteristics—as if it were a sound object stored in a memory buffer. This reference figure never appears in its original form during the unfolding of the piece; what is heard are the various outcomes of the operations performed on it—its instantiated versions. This mirrors how, in granular synthesis, a recorded sound may be re-synthesised through streams of grains without ever being presented in its initial, unaltered state. Moreover, even though time is inscribed within the morphology of the figure, I must imagine it outside of time in order to carry out the operations I intend—displacing it from temporal continuity to enable its transformation.

The instrumental granular approach I am proposing—one that engages not only with timbre and sound morphology but also operates at the symbolic level—is primarily oriented towards temporal operations: instantiated sampling and the shifting of the reference window through which this sampling occurs. This focus does not exclude other operations drawn from the granular paradigm, such as those involving event density, timbre, dynamic envelope, and frequency—all of which are intrinsically linked to temporal behaviour. These time-oriented operations may concern both meso-structures (i.e. the sampling of figures, their placement and aggregation below the threshold at which they are perceived as discrete entities) and complex instrumental sounds—emergent sonic forms or global state changes produced either through the interaction of multiple instruments or by a single instrument capable of generating flows of micro-events at the relevant temporal scales.

I will explore this issue in greater depth through the analysis of various works, outlining the operations performed and the interactions generated within these composable spaces in Chapter 4, which focuses on symbolic granulation methods.

The Sound Object in the Composable Space

The Schaefferian (1966) sound object is conceived as opaque, closed, and self-contained. In contrast, for Vaggione (1995, p. 35), the sound object—essentially digital—is transparent and open: it enables direct compositional intervention by granting access to its internal structure:

> When we say that an object is transparent, we mean that this object not only shows itself, as a closed unit, but that it is capable, essentially, of showing its methods and its code. This remains valid even in the case of work on sampled natural sounds: these will not be 'found objects' insofar as their digital definition will allow multiple rewritings, through multiple modes of representation, and thereby integrate them into a general strategy of composition comprising networks of symbolically determined operations. (Vaggione, 1995, p. 35)

The multitude of potential morphologies encompassed by the digital object—when compared to the note, a permutable syntactic unit suited to combinatorial approaches—constitutes a significant asset for a multi-scale approach to mixed composition. According to Vaggione, the digital sound object offers a rich morphological reservoir: it is at once discrete and multiple, composed yet open, interactive and manipulable. As Sédès (2007, p. 91) describes it, it is a 'multiple unit'.

> The object, as I see it, is an operative category, that is to say a technical concept forged for the purpose of finding a mediation criterion that could encompass different temporal levels in a plural entity but with defined edges, and hence manipulable within a network. (Vaggione, 2003a, p. 99)

Given its constituent attributes, the sound object plays a central role in the compositional process within the approach considered here. Its morphological richness positions it at the intersection of multiple temporal scales, enabling it to mediate between them. Moreover, the sound object is context-sensitive: it can shift function depending on the compositional environment in which it is situated. Analogously, its internal components may also assume different functions according to the temporal scale in which they are inscribed.

Vaggione's notion of object is borrowed from computer science and is inspired by object-oriented languages. Vaggione assigns it three constituent attributes: Closure (encapsulation), Inheritance and Polymorphism. Bonnardi and Svindinski explain this topic as follows:

> Encapsulation corresponds to the notion of **closure**: a linkage of a set of properties and behaviours for the purpose of creating an object. **Inheritance** generally refers to any relationship between a set and a subset (a class and a subclass) of objects. Finally, **polymorphism** allows objects to be manipulated in such a way that, when receiving identical messages, they can produce entirely different results depending on the choices made during instantiation. (Bonnardi and Svindinski, 2015, p. 2)

As far as I am concerned, the digital (and acoustic) objects that I create in the act of composing are complex, layered, and hybrid. They encompass not only multiple temporal dimensions but also a range of distinctive morphological attributes. Such objects may include contrasting sonic regions—ranging from noise to referential material, whether historicist or concrete/mimetic (that is, the appropriation or imitation of non-musical sound sources).

The objects I conceive are capable of supporting multiple operations, but also of carrying within them traces or sedimentations of practices originally inscribed in their referential components. They embody a transductive appropriation of their attributes and/or the original protocols that shaped them. Their constituent properties can be hybridised; their encapsulation can bring into play a heterogeneous set of behaviours and attributes—sometimes disparate, yet always retaining a degree of morphological coherence that allows for transformation and manipulation.

Those components that carry a historical or semantic charge (such as voices, speeches, or sounds linked to daily life and specific actions) also bear their own temporalities, practices, and meanings. These features coexist and interact with other components—also objects, but of a different level or internal constitution—to produce an identifiable multiplicity: a well-defined plurality that is therefore open to composition. Within their internal organisation, the component-objects of these object-networks generally hold functions. Depending on the scale of the object and the temporal level in play (or from the perspective of a given context in action), these functions may shift over time.

In the plurality of their internal composition, the objects I conceive are capable of inhabiting multiple temporalities, depending on their scale of reference. Those that perception recognises as signifying units—or that generate a self-referential effect of meaning—are composed of networks of objects and figures. These are deployed within the meso- and macro-temporal structures of a work's composable space. However, more complex and stratified objects may also encompass granular textures: sounds whose emergent properties result from manipulations at the level of micro-time. If the constitutive richness of the sound object encompasses a multiplicity of temporalities, supports multiple operations, and gives rise to numerous interactions, it is its operative transparency that renders it both composable and manipulable within a network.

The Figure in the Composable Space

Another notion developed by Vaggione is that of the figure. More usually associated with the fields of instrumental writing (pure or mixed), but sometimes also applicable to electronic sounds (concrete, transformed or synthesised), it has attributes approaching that of the object: a morphological profile that is well defined but allows for various manipulations; a capacity to be instantiated and to circulate in networks "in order to produce multiple figurations" (Sédès, 2007, p. 92).

From a historicist and comparative perspective, we can draw parallels with the notions of motif and theme, given their capacity to articulate with other elements and to generate formal content—particularly in contexts where no strict duality between form and material is maintained. Much like the object, the figure serves to mediate between temporal scales; both categories are indispensable for engaging with multi-dimensional musical time. Vaggione (1998a, pp. 98–99) considers that "a figure can be considered as the product of singular articulations, conveying morphological properties, on which various operations can be performed." He suggests coupling it with the concept of the object, which serves as a category that allows figures to be embedded and circulated within a network of compositional operations.

The Network in the Composable Space

A third operative category of significant interest in establishing a syntax for the multiscale approach to composition, which is mostly used in conjunction with the two terms just defined, is that of network.

> We would then be justified in positing a multi-scale network concept: a network is composed of objects, but each object within a network is also, in itself, a network. Within the limits of the temporal scales accessible to us, every network of objects is composed of objects that are themselves networks. Naturally, these networks are not 'low-level'; however, they are capable of receiving and transmitting granularities of all sizes. (Vaggione 2008, p. 157)

This notion is closely linked to that of object, their essential difference being in terms of levels: the network delimits a higher one. In this way, the network is capable of encompassing every possible type of interaction and relationship between sets (and subsets) of objects. For Vaggione, this notion should also be understood as an assembly of multiple ways of representation: partition (itself a multi-symbolic network), patch, graphical function, script, etc. An important feature to note is the absence of hierarchy between its components, none of which is subordinate to another, each retaining its own power and defining features. In the network, there is a plurality of objects that can be linked together by a plurality of ramifications. This condition endows the network with the capacity to be recomposable, which according to Vaggione (2003a, p. 114) "represents any state of a mobile situation," and also endows its components with a functional mobility that is constitutive.

Interactions in the Composable Space

For Vaggione, the development of the concept of interaction appears as a response to the constraints imposed by linear programming—the operational framework within which much of twentieth-century algorithmic music developed, as exemplified in certain phases of the work of composers such as Xenakis or König. Once an algorithm had been designed and specific data input, the computer would generate the piece, with the composer intervening only at the end of the process, and solely to modify the results. As a result, the interaction between compositional action and algorithmic calculation was minimal.

Vaggione therefore proposes a shift towards "a plurality of diverse operations, rather than a single algorithm" (Vaggione, 2003a, p. 97). This alternative calls for the development of an interaction-oriented approach to this plurality. The composer can thus intervene directly—through writing or manual manipulation, according to

Vaggione (2000, p. 102)—creating a space of convergence between craft and formalisation.

> The emergence of an approach articulated around the concept of generalised interaction (internal to the work) allows us today to envisage both the existence of possible passages between disjoint dimensions of time and the nature of the non-linearities that result from their interactions. (Vaggione 2000, p. 102)

Formalisation is therefore not generalisable but localised—“regional” (Vaggione, 2003a, p. 79). This partial overlay of formalisation across the work allows other aspects to retain a degree of ambiguity, an indeterminacy from which the composer may draw creative advantage. Craft and formalisation are not in opposition; rather, they can be articulated together to open a fertile field of interaction. Consequently, for interaction between its components to occur, the composable space of a work must remain formally incomplete. Such incompleteness is a necessary condition for the emergence of any interactive situation of which compositional processes are a part. Moreover, the interaction between craft and formalisation also reflects a broader interplay between local and global levels. In this approach, algorithmic calculation belongs to the global domain, while direct operations—writing or manual manipulation—function at the local level.

> A local writing action can be integrated into an algorithmic process, just as, symmetrically, the product of an algorithmic process can be transformed locally by a direct writing action. (Vaggione, 1996, p. 24)

The breakdown of mediation between levels—following the abandonment of the tonal apparatus (between form and content, between the work and the harmonic language of tonality, between phrases, sections, and movements)—has led composers from several generations to privilege “sometimes the local (as in serialism) and sometimes the global (composition of masses or textures), and to pose the passage from one to the other in terms of ‘deduction’” (Solomos, 2007, p. 41). Vaggione proposes rethinking these mediations in terms of interactions, while simultaneously levelling the hierarchy between the two by granting them equal status as dimensions of the composable.

Composable Space

The notions just discussed—object, figure, network, and interaction—are intimately linked to that of the composable space, a central concept in the reflection underpinning this work. This notion has also been extensively developed by Horacio Vaggione. Following Carvalho (2010, p. 52), the composable space may be defined as the assembly of a network of objects forming an operational whole. It is shaped both by its content—the materials employed—and by the internal relationships between its components. This space is already part of the compositional material, and its definition constitutes a compositional act in itself:

> Space is conceived as a compositional material, which means that it is essentially a space of relationships. (Vaggione, 1998b, p. 154)

It is therefore a space of relationships composed in order to create a work—a space of relationships that is expressed through the work itself. It constitutes both the material and the context of a musical work; it is the space in which that context is brought into being. This space is interactive, open, and mobile—dynamic and multiple. It cannot be reduced to formal operations reproducible in series or conceived within a theoretical vacuum. It must be engaged with, inhabited anew each time, and defined on each occasion in relation to its particularities—its 'instruments' and its 'controllers'.

> Therefore, what is to be composed is not only an arrangement of surface atomic entities, but also the multi-stratum context in which the notes are placed. (Vaggione in Budon, 2007, p. 104)

It is a space composed of networks of objects and figures, operations and interactions, apparatuses and instruments, multiple strata, and—most importantly—diverse temporal scales, inscribed at the levels of micro-, meso-, or macro-time.
The particularity of the composable spaces within mixed music—the domain that concerns us most directly—lies in the convergence of these temporal scales: between the granular (sub-symbolic) and that which can be expressed through symbols, such as notes. These convergences, which Vaggione refers to as *vectorisations*, are essential. For the composer, however, the very principle of mixity must be understood as an operative notion which—like the compositional act, the networks of objects, and the operations that bind them—must be situated within the composable space. It must encompass:

> The postulate of a possible convergence, of a common vectorisation. This of course implies the inclusion of instrumental sounds in the morphological field where spatial articulations are played out - composed (...). The challenge of mixed music is to achieve integration. (...) However, this does not happen automatically. In order to achieve this integration, the music itself must be thought of as a fully-fledged part of the composable field. (Vaggione, 1998b, p. 165)

Chapter 2. The Composable as a Space for Experimentation

I describe experimental systems as exteriorized spaces of imagination
-Hans-Jörg Rheinberger, *Forming and Being Informed*

Introduction

In this chapter, I aim to offer a different perspective on musical composition and Vaggione's notion of composable space by engaging with Hans-Jörg Rheinberger's epistemological and historical approach to scientific practice—particularly his concept of experimental systems. This perspective will focus on knowledge as a central issue in experimental practice, drawing on Rheinberger's epistemological approach and applying it to the subject of my thesis, which explores tension as a catalyst for the successive transformations of the composable spaces within my artistic work. My purpose is to identify a field of potential comparisons between two activities whose objectives, practices, and methods of experimentation cannot be homologated. In recognising these irreconcilable differences, I will draw parallels and contrasts to examine knowledge through experimental practice in musical composition, informed by Rheinberger's ideas.

Composable spaces and *experimental systems* are sites of experimentation and articulation. Both Vaggione (1998) and Rheinberger (1997b) identify entities that integrate time and space while articulating matter and concepts. They emphasise the role of the interaction between known objects and things in the process of becoming, the importance of representing and inscribing the material traces of experimentation, and the function of material symbols as active agents in the praxis.

Composable spaces and *experimental systems* are future-oriented devices, machines for generating questions that facilitate the concatenation of practice across localised but interconnected spatio-temporalities. Both are the products of a historical and cultural context, created by two personalities with a vast cultivated background. They base their knowledge not on an intellectual genealogy but rather on an intricate network of diverse authors from outside their fields of expertise. The two concepts describe complex, dynamic, and evolving phenomena, even if the objectives and practices of their respective fields—science and the arts—remain fundamentally incommensurable. Creating musical works of art is an intricate process that, much like scientific practice, demands research and experimentation, as well as prior and emergent knowledge. My intention is to reflect on the contingent nature of knowledge as a complex phenomenon by situating knowledge within the practice of experimental composition.

To this end, I will first introduce some key notions of Rheinberger's thought. Next, I will establish a comparative framework between art and science to explore the problem of knowledge based on the differences and parallels between them. Finally, I will address the question of knowledge in musical composition through experimentation and iterative problematisation. I will approach it through a "philosophy of epistemological detail", following Bachelard (1966, pp. 12, 14), as cited in Rheinberger (1997a, S246).

Experimental Systems

In this section, I will provide a concise overview of the key issues in Rheinberger's theory of experimental systems for knowledge production in scientific research. These concepts are inscribed in a vast network that draws on the history of biology, epistemology, philosophy, the sociology of science and technology, philosophy of language, psychoanalysis, semiology, and semiotic. [12] As a historian and philosopher of science, he introduced the idea of examining how scientific research is carried out and how knowledge is generated. Rheinberger's work provides a nuanced understanding of how experimental practices contribute to scientific knowledge, emphasising research practices' dynamic and evolving nature. I will approach some of the most important subjects in Rheinberger's theory by exploring:

- The notions of epistemic things and technical objects, extensively theorised by Gilbert Simondon and developed in Bruno Latour's Actor-Network Theory.
- The role of representation in the production of scientific knowledge.
- The complexity of experimental research processes.

[12] "I frequently refer to a series of French-speaking philosophers, scientists, and historians of science, from Gaston Bachelard, Georges Canguilhem, Michel Foucault, Louis Althusser, Jacques Lacan, and Jacques Derrida to Michel Serres and Bruno Latour; from Claude Bernard to François Jacob, Isabelle Stengers, and Ilya Prigogine. To speak of a series here is not to imply a genealogy. Such a genealogy does not exist. What exists is a finespun network of demarcation lines." (Rheinberger, 1997b, pp. 21–22)

- The significance of material and technical components in generating knowledge.
- The inherently dynamic nature of scientific inquiry.
- The irreducible interconnection between physical apparatuses, theoretical frameworks, and the methodologies that guide experimentation.

Epistemic Complexity of Experimental Systems

A significant part of the work of Rheinberger explores the role of experimentation in biology from a historical perspective, highlighting the importance of complexity in the research process. In his seminal work *Towards a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Rheinberger, 1997b), he develops a key concept for the evolution of epistemological science: experimental systems. Rheinberger aims to integrate the emerging phenomena within complex systems into our understanding of the scientific research process, underlining their unpredictable nature. He describes the non-linear character of experimental research, its multi-layered organisation, and the dynamic of constant feedback between their various components. It highlights the inherently open-ended character of a process that allows for the emergence of unexpected events and the generation of surprises, rather than producing data that confirms pre-existing hypotheses. In his essay *Experimental Complexity in Biology: Some Epistemological and Historical Remarks* (1997a), Rheinberger emphasises the contextual and localised character of the production of scientific knowledge. Quoting Gaston Bachelard, he states the necessity to counterpose a "philosophy of epistemological detail (…) on an epistemological level" to what Bachelard himself calls the "*integral* philosophy of philosophers" (Rheinberger, S246). In sum, the author explains the complex interconnections between the material and the conceptual in experimental research, and how knowledge is generated through a dynamic and contingent interaction of practices, materials, and epistemic objectives. For Rheinberger, complexity and unpredictability are inherent to scientific experimentation. In this essay, the author declares the need to reduce complexity while maintaining essential components, providing a framework for examining the "epistemic complexity" embedded in both biological and artificial systems. The author states that "experimental systems are machines for reducing complexity, but to escape triviality, they must remain connected to the complexity of an 'epistemic horizon'" (Rheinberger, S247). According to Rheinberger, to produce knowledge in a context in which practice and theory are in constant interaction, "ontic complexity has to be reduced to make experimental research possible, this very complexity epistemically retained in (…) an experimental landscape, in which new connections and disconnections can happen at any time, and where the boundaries of a scientific object continually fluctuate" (Rheinberger, S 247).

Experimental Systems as Spaces of Construction

For Rheinberger, experimental systems are spaces of construction—sites of material operations in the process of being defined, enabling the investigation of possible and contingent phenomena. Within these spaces, objects are not merely discovered; they are brought into being. However, these objects aren't purely natural or entirely man-made. Instead, they are *epistemic things*, shaped by and deeply connected to the experimental process itself. Experimental systems are essential, practical tools that scientists use to carry out research in a controlled and manageable way. It is in this sense that the author claims, following William Bechtel and Robert Richardson, the need for "decomposition" and "localization" (as cited in Rheinberger, 1997b, p. 28), the necessity of operating a reduction on the research objects' ontic complexity, to delimit controllable territories, "the smallest integral working units of research" (Rheinberger, p. 28). In his words, "experimental systems constitute integral, locally manageable, functional units of scientific research. It is through them that particular scientific objects —epistemic things in my terminology— gain prominence in a wider field of epistemic cultures and practices" (Rheinberger, 1997a, S246). Rheinberger denies, contrary to the above-mentioned "*integral* philosophy of philosophers," that these *units of scientific research*, oriented by epistemological detail, could be a "limitation for empirical knowledge" (Rheinberger, S246). The specific aspects and intricacies of practice, rather than restricting our understanding, are essential foundations that enable and facilitate the attainment of scientific knowledge. These spaces of knowledge construction facilitate the emergence of singularities at particular moments framed by praxis. "Novelties are always the result of spatiotemporal singularities. Experimental systems are precisely the arrangements that allow scientists to create epistemic spatiotemporal singularities" (Rheinberger, S247).

Experimentation does not concern the representation of fixed or stable conditions. Rather, experimental systems serve as environments in which the unknown is anticipated, and where one engages with the emergence of novel phenomena, elements that inherently resist full formalisation. **"**The (…) experimental scientist deals with systems of experiments that usually are not well defined and do not provide clear answers" (Rheinberger, 1997b, p. 28). Experiments do not solely serve to confirm existing ideas; instead, they actively generate new knowledge by producing unforeseen results and raising fresh questions that further drive the research process: "They are not simply experimental devices that generate answers; experimental systems are vehicles for materializing questions" (Rheinberger, p. 28). On the same page of his book, the author describes the inherent uncertainty in these experimental systems, which are "systems of manipulation designed to give unknown answers to questions that the experimenter is not yet able clearly to ask" (Rheinberger, p. 28).

Epistemic Things and Technical Objects

In Rheinberger's notion of experimental systems, two distinct but interconnected elements become apparent: the epistemic things and the technical objects. The first are "material entities or processes—physical structures, chemical reactions, biological functions—that constitute the object of inquiry" (Rheinberger 1997b, p. 28). These objects are characterised by a particular condition, their "irreducible vagueness" (Rheinberger 1997b, p. 28). As eminently paradoxical objects, these epistemic things "embody what one does not know yet," and hold the fragile position of "being absent in their experimental presence" (Rheinberger, p. 28). In other words, they could be concrete objects or phenomena existent in scientific research that are in the process of investigation. These objects hold the potential for knowledge, serving as catalysts for research by prompting questions about their properties, functions, or behaviours. They are ambiguous, defined in a dual nature that reunites materiality (e.g., molecules, proteins, enzymes) and epistemological function, because of their capacity to generate new knowledge in the research process.

In contrast to epistemic things, technical objects are instruments, tools, models, theorems, or methodologies that are stabilised and hold a confirmed function in the experimental system of a scientific researcher (e.g., a microscope). An epistemic thing could become a technical object once its properties are clearly defined and become part of a reproducible routine that helps the process of inquiry but does not generate new knowledge anymore. In this process of becoming technical objects, they engage in a "process of operational redefinition," a disposition of what we might call "experimental conditions [and] articulate themselves in a wider field of epistemic practices and material cultures" (Rheinberger 1997b, p. 29). The interconnection between epistemic things and technical objects within the experimental system is crucial for the creation of new knowledge and the stabilisation, or the materialisation of already acquired knowledge. At the moment of their coupling within this space of construction, there is an incompressible interrelation "between identity (the technical) and difference (the epistemic) in our processes of knowledge-acquisition" (Rheinberger, 2013, p. 207).

In contrast, their difference is established in the inherent state of indeterminacy of the epistemic thing and the defined character of the technical object[13] "within the given standards of purity and precision" (Rheinberger 1997b, p. 29). But this difference between the experimental conditions (technical objects), and these entities for generating knowledge that are the epistemic things, is based on how they are used, not how they are built. It is not possible to permanently separate the two

[13] "While the term 'object' carries some definiteness with it, there is something indefinite about 'thing'. (…) The choice of the notion of epistemic thing is tightly bound to this constitutive vagueness, while the choice of the notion of technical object is bound to its being more or less clearly delineated." (Rheinberger, 2013, p. 207)

within a system. Their distinction "is functional rather than structural" (Rheinberger, p. 30), it must be situated within the inquiry framework. Their operational functionality as either epistemic thing or technical object "depends on the place or 'node' it occupies in the experimental context" (Rheinberger, p. 30). For Rheinberger, there is an undetermined margin between these poles, but they are differentiated in the practice of the scientific researcher. Finally, their differentiation is of vital importance, because it "organizes the laboratory space (…) with its specialized sections on 'material methods (technical things), 'results' (halfway-hybrids) and 'discussion' (epistemic things)" (Rheinberger, p. 30).

Spaces of Representation

"Thus everything depended on the representation we formed of an invisible process and on the manner of its translation into visible effects" (François Jacob, as cited in Rheinberger 1997b, p. 102). The quotation from Jacob that opens this section is the epigraph of *Spaces of Representation*, the eighth chapter of Rheinberger's *Towards a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Given the "ambivalence" of this statement, the author raises the following questions: "Is the representation just a manner of rendering the invisible visible? Or is it a manner of translation, which (…) means converting signs into other signs, traces into other traces, concatenating traces? Is it a tracing game?" (Rheinberger, p. 102). Rheinberger thus leads us into a field where semiotic theory, nominalism, the philosophy of language, and the sociology of technology and sciences intersect. An arena where Peirce, Goodman, Derrida, Latour, and Woolgar converge. He explores closely through these lenses to state that the term representation "reveals itself to be polysemic" (Rheinberger, p. 103) and distinguishes three connotations. The first one is the "representation of something given (…), a representation 'of'," in the meaning of "analogies" or "symbols" after Pierce. The second one is the "representation 'as'," which refers to "models or simulations" and could be related to "Peirce's icons," and is designated as "an embodiment." He identifies the third connotation as an "experimental realisation," giving the example of a "chemist that produced or represented a particular substance in his or her laboratory," and is compared to "an index in Peirce's semiotic systems, i.e., a trace" (Rheinberger, p. 103). The three senses of the term representation constitute a continuum. The experimental space of scientific practice is defined "as a process in which traces are generated, displaced, and superposed," following these three meanings of representation. In this heterogeneous space, there is an interplay between symbolic systems (symbols, models) and material objects (i.e., substances or specimens). Rheinberger contests a "clear-cut dichotomy between theory and reality, between concept and object." (Rheinberger, p. 104). Steve Woolgar states that "representations and objects are inextricably interconnected; [objects] can only be 'known' through representations." (as cited in Rheinberger, p. 104). Producing epistemic things is "engaging in the potential endless production of traces, where the place of the referent is always already occupied by another trace." In sum, the space of representation is the epistemic and technical arena where objects become epistemic things in a continuous process of becoming.

Graphemes

Graphemes are the traces of materiality in the bounds of a given space of representation. In this way, it does not refer to its traditional linguistic definition (i.e., the smallest functional unit in a writing system).[14] Still, it is rather an epistemological term related to the materiality of scientific knowledge. The space of the graphematic is the space of the trace, the space of the experimental formulated using material signifiers. "A scientific object investigated in the framework of an experimental system (…) is (…) articulated from material traces, or graphemes within particular spaces of representation." (Rheinberger 1997b, p.105). In this sense, Rheinberger brings the question of signification into the field of the history of science and epistemology[15] by conceiving the grapheme as a material inscription.[16] As physical traces, graphemes are marks that scientists manipulate, interpret, rework, and theorise over, in a fundamentally metonymic and metaphoric space that gradually shapes the experimental process. These "graphematic articulations" exist as the "material forms of the epistemic things under investigation" (Rheinberger, p. 106). The graphemic material reveals, in Rheinberger's idea, the inscriptional nature of scientific work, where written signs, symbols, and diagrams—the graphemes— serve as mediators between scientists and the objects they study. These inscriptions are not just representations of knowledge; they play a crucial role in the discovery process. They serve as intermediaries in the ongoing dialogue between the unknown (the research subject) and the known (the background knowledge that scientists depend on). "The epistemic techniques through which it engenders its inscriptions lead, again and again, to unprecedented excesses that cannot be anticipated but appear only in the making." The representation within the experimental systems brings "epistemic things into existence." But this experimental representation process of creating graphemes is full of "uncertainty, fuzziness, and fugacity." This open-ended process "functions by permanently deconstructing its constructivist aspect: the New does not enter through the obvious door but through some fissure in the walls" (Rheinberger, p. 107).

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[14] For an exhaustive description of this term in the field of linguistics, see how Manfred Kohrt approaches it from a historical and theoretical perspective. In semiology, it could be related to the concept of Barthes' "unité syntagmatique" (syntagmatic unit) as a part of the system of signs in communication.

[15] "Spaces of representation are coordinates of signification." (1997b, p. 105)

[16] "Graphemes, in the first place, are material articulations of significant units." (1997b, p. 106)

In conclusion, it is crucial to stress that graphemes are intrinsically intertwined, and conceptually twisted together to a precise space of representation. “Graphemes and spaces of representation do not exist independently. They mutually engender each other. There is no representation space before an articulation of graphemes. And outside such a space, a particular graphematic trace remains without assignable meaning” (1997b, p. 105).

Knowledge in Science and Knowledge in Art

In this writing, I address the question of knowledge in musical composition by referring to concepts created to think about this issue in the context of scientific experimentation. Is it possible to equate scientific and artistic practices? In principle, it might seem obvious to point out the essential differences between the ways these two realms experiment. In Henk Borgdorff’s words: “As I have pointed out elsewhere[17] (…), an artistic experiment cannot be simply equated with a scientific experiment” (Borgdorff 2013, p. 115). Is it sufficient to mention experimental practice and empirical knowledge to establish a precise field of comparison between Art and Science? Can the problem of knowledge production in these two domains be approached through simple and univocal operations of analogy? It would seem naïve to answer the above question positively without ignoring the specificities of each of these practices.[18] However, by formulating the above question in this manner, my intention is not only to deny the possibility of a simple conceptual homologation between these two fields but rather to start locating more precisely where these differences in their ways of experimenting operate. Both scientific and artistic practices are concerned with the production of knowledge, but they operate in different regimes of materiality and discursivity. Science strives to formalise and stabilise what we know, whereas art frequently reveals the fluidity of signification and the contingent nature of experience. Despite these differences, both fields are inherently experimental, both are entangled in processes of discovery, intervention, and the making of meaning. The two encompass material practices and ways of representation—although, each in a different regime—through which the unknown is approached. One and the other are probing the boundaries between the known and the unknown, between objectivity and subjectivity, and between fact and fiction.

[17] Borgdorff, 2011, pp. 52–53.

[18] As Rheinberger states in his conversation with Michael Schwab: “It is very clear that there is no one-to-one homology between scientific and artistic activity—otherwise these two realms would collapse into each other anyway.” (2013, p. 207)

Knowledge as a Social Phenomenon

These two disciplines of human activity engender knowledge produced through material practices and manners of representation, albeit in diverse registers. Both are constructions that emerge from human and non-human actors' exchanges, and the knowledge they produce is the fruit of complex networks of social interactions.[19] Following Latour's ideas, we can state that knowledge is always the outcome of a collective process involving negotiations, translations, and forms of mediation (Latour, 2005). Both exist within negotiating networks involving instruments, experiments, funding, colleagues, and external establishments in an ongoing construction process. Artistic creation is shaped by interactions between artists, materials, institutions (like music schools, venues, orchestras, etc.), critics, and audiences. Art is not isolated from the world but part of a network where meaning and value are constantly negotiated.

Time and Historical Perspective

Both disciplines are inserted in a historical interweaving in which their instruments, theories, and material output have a sequential character. Rheinberger draws the art historian George Kubler's thoughts on artistic production materialised in temporal forms to highlight his historical perspective on science and scientific things. Rheinberger explores Kubler's "formal sequences" to introduce the particularities of the spatio-temporal organisation of his experimental systems. In assessing a possible comparison between the historical sciences of the two disciplines, he uses the following quotation (Rheinberger, 1997b, p.4) from Kubler: "The value of any rapprochement between the history of art and the history of science is to display the common traits of invention, change, and obsolescence that the material works of artists and scientists both share in time." Experimental systems in science follow a "rule of order" akin to the "formal sequences" (Rheinberger, p.4) found in art production. Scientists and artists are not solely concerned with recognising what already is, one and the other "turn more upon future possibilities, whose speculations and combinations obey an altogether different rule of order, described here as a linked progression of experiments composing a formal sequence"[20] (Rheinberger, p.80).

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[19] "All knowledge is social in that it must make use of forms that have evolved socially." (Dorschel, 2024, p. 6)

[20] Kubler, 1962, p. 85.

Intersections among Art, Science, and Technique

Art-making can use technical objects, stable objects materialised by scientific practice. Can some fields of science and technology also benefit from the knowledge embodied in artistic practice? Engendered by the latter in the research that any artist must carry out to produce works of art? Aren't there technical objects that were created in a complex network of actors that resulted from the confluence of epistemic things—and previous technical objects—coming from scientific, technical, and artistic practices? Doesn't a technical object such as a sound signal synthesis, control, and processing software like Max embody knowledge coming from scientific, technical, and artistic practice? Isn't it the stable materialisation of epistemic things coming from scientific, technical, and musical experimentation? Is it not artistic practice that ends up shaping specific technical objects through which we can know, and which we can use to produce works of art, but also new epistemic things?[21]

A Realm of Comparability

Rheinberger claims the necessity "to be aware of (…) irreducible differences while nevertheless working on a conceptual framework in which to talk about these differences and bring them into the realm of comparability" (Rheinberger 2013, p. 207). We must create a field of comparisons, starting from the differences already identified between both disciplines, while highlighting the few similarities already exposed. To consider how knowledge is created in artistic practice, specifically in a given musical work, and to explore the processes and conditions that contribute to its emergence. It was already stated that both disciplines evolve in a dynamic process based on experimental practice. Experiments develop in a given space where the material, the conceptual, and the representational interact. It happens in sequential forms, and in temporalities that are framed in historical practices. They produce a specific type of knowledge and are a complex social product that emerges from interacting networks between human and non-human actors. This already delimits the first possible field of comparison, even if the goals and methods of each discipline are different. As was already pointed out above, the aim is to create a realm of comparability considering their irreducible differences while enunciating their general similarities. For this purpose, to approach the question of knowledge in musical composition, a series of symbolic operations—of semantic and semiotic

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[21] When I was a young student at the Cursus for Composers at IRCAM in Paris, I had an enlightening exchange with the now-deceased Eric Daubresse (one of the professors of the pedagogical staff). In response to my concern that the format of a given software can influence and shape the process of composing a musical work, and my question about why this may happen, he answered: "It is ultimately the composer who establishes order and meaning in the use of a tool. Through their compositional practice and aesthetic intuitions, the composer determines the tool's current form."

order—are needed, which will allow us to identify the traces of experimentation in musical composition.

Is there any possibility of translation, of creating a metonymic chain to produce a sliding of meaning that allows us to think of the production of knowledge in musical composition from epistemology, from the analysis of scientific practice? The experimental practice of art needs to produce concrete symbols to create output. As Rheinberger states, referring to the same topic in his field of study, "Science, viewed from a semiotic perspective, does not escape the constitutive texture of the inner workings of any symbol system: metaphoricity and metonymicity. Its activity consists of producing, in a space of representation, material metaphors and metonymies." (Rheinberger 1997b, pp. 104, 105). But something happens within this mediation process. Bruno Latour uses the term 'distortion[22]' to refer to the use of theories of knowledge to approach politics, designating this use as 'political epistemology.' We can then observe that, in using notions of epistemology to think about the problem of knowledge in musical composition, an inevitable 'noise 'will be produced, a distortion in the chains of signifiers we use for this purpose. This phenomenon is, however, inherent to the conditions and constitutive of the forms in which human knowledge is produced within the metonymic sliding as it moves through different spaces of representation. In the next section of this writing, I will try to expose the question of knowledge in music and some particular forms of experimentation in the practice of composition by referring to Rheinberger's thoughts.

Knowledge through Experiments and Problematisation in Musical Composition

At the core of every composer's action is the ability to externalise imagination through experimental practices and to materialise knowledge through the creation of musical works. In this section, I will explore the aspects of knowledge and experimental practice in music composition through the lens of Rheinberger's epistemological thought. As previously stated in this chapter, I will address both phenomena by problematising the already exposed epistemological concepts from the perspective of an experimental contemporary music composer, using a detail-oriented approach rather than an integral one.

Firstly, I shall address the issue of epistemological complexity inherent in any musical work, and the ontological complexity of the objects that constitute the

[22] "I use the term "(political) epistemology" (…) to designate the distorting of theories of knowledge in order to rationalize politics but without respecting the procedures for coordination either of the sciences or of politics." (Latour, 2004, p. 241)

experimental space—which is an operational field—of composition. Secondly, I will elucidate the experimental, dynamic, and interactive nature of compositional practice; identify the framework of tension among the various types of knowledge involved in musical creative processes; and examine recurrent phenomena in the emergent process of musical knowledge production within experimental compositional practice.

I will then address a central theme of Rheinberger's thought as applied to my own practice: the interaction between technological objects and epistemic things. This interaction concerns the relationship between what materialises or reflects momentarily stabilised knowledge and what remains unexplored in the open field of artistic experimentation. Finally, I will explore a theme that is common yet of paramount importance to both scientific and artistic activities: representation. This includes the material symbols that constitute it and their role in the processes of creating musical knowledge and producing musical works.

Epistemic Complexity in Musical Works

"Are artworks or art practices capable of creating, articulating, and embodying knowledge and understanding?" (Borgdorff, 2013, p. 113). Contemporary and experimental musical works, as technological artefacts, embody complex epistemic processes. They reflect intricate knowledge creation and understanding mechanisms and are made of interconnected epistemic elements including instruments, theories, practices, graphemic material, and symbolic systems. Paulo de Assis states that musical works "are highly elaborated, complex semiotic artifacts with intricate operational functions. They are made of a variable, though normally large, number of constitutive parts that interact in non-trivial ways. (…). But they are also the products of invention and embed a rich array of interconnected knowledge encapsulating one or more operational principles." (De Assis, 2013, p. 155). Musical works involve the interplay of materials, practices, and conceptual frameworks that yield emergent outcomes not fully predictable or reducible to their elements. Just as scientific knowledge emerges from the interaction of various domains, composers often incorporate diverse inputs from different fields into their sophisticated mechanisms of musical knowledge-making.

Although their conception and creation inherently involve both a priori and emergent knowledge, musical works are also products of their time and specific contexts. We can draw a parallel between Rheinberger's concern about the role of historicity in scientific knowledge and how newly created musical knowledge is shaped by its cultural and historical context, regardless of the artist's consciousness. Musical works are made in a non-linear progression in which knowledge emerges from an experimental practice, as from an interweaving between context, materials, concepts, and representation.

Reducing Ontic Complexity

Like scientific inquiry, musical experimentation often requires reducing complexity to produce both knowledge and tangible outcomes. While experimenting, the composer must simplify the material and conceptual elements of her/his particular framework, reducing their ontic complexity to facilitate abstract musical operations. This enables the articulation of interacting sonic object networks, often across different time scales. As in science, this is a fundamental phenomenon in the music-making process. I will present two different concrete examples of this:

- In the first section of his work *Partiels,*[23] the French composer Gerard Grisey gave us a paradigmatic example of *instrumental synthesis* derived from electronic additive synthesis. In his orchestration of the spectrum of a low trombone's E note, Grisey omits information from both time and frequency domains. The composer eliminates spectral information, mainly micro-time scale phenomena (such as attack transients' high-frequency bands and rapid durations), even if his aesthetic approach is to radically stretch the time of the acoustic event from which he draws inspiration and data. Sound is a non-linear entity that changes dynamically across time, and timbre is determined by various complex components that happen at temporal scales that human perception can't perceive and that are synthesised in a single event. This particular case demonstrates the necessity of reducing the ontic complexity of the components of a given experimental framework. Grisey focuses on frequency and dynamics, largely disregarding micro-time phenomena that, even stretching temporal scales, are challenging to symbolise, impossible to play with acoustic instruments, and, thus, difficult to incorporate into compositional operations. Without this complexity reduction, the main compositional strategy of gradually including inharmonic partials on the orchestrated spectra would be musically irrelevant.

[23] https://www.youtube.com/watch?v=Mmw8M_e2x_8 (Accessed March 30, 2025).

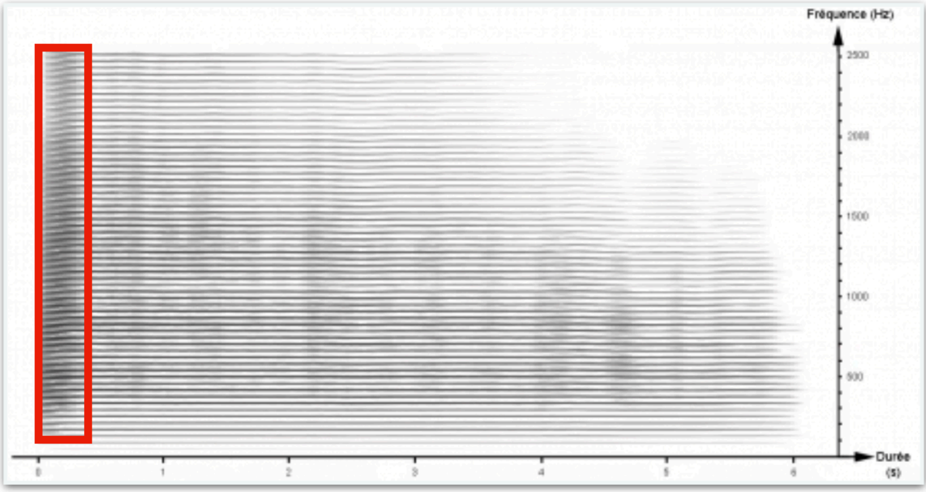

Figure 2.1, Spectrogram of a trombone's E2 sound
The highlighted zone corresponding to the transients' frequency bands omitted in Grisey's *instrumental synthesis*

- In my recent work, *Neon Frog* (2024),[24] I have produced various forms of what I call sonic translation of diverse phenomena, objects, and concepts as an artistic methodology that exploits the tension between two divergent visions of sound: sound as an acoustic phenomenon and sound as a cultural artefact resulting from complex social interactions. In the final sections of the piece, a recurrent field recording of South American frogs is transcribed for a sampled piano tuned in quarter tones, which gradually replaces the targeted sound. To accomplish this operation, I used a simple Partial Tracking patch made in the software Max. To make the transcription into the symbolic domain, i.e., the musical notes, effective in perceptual terms, I adjusted two basic parameters in the technical object used: the velocity threshold, which in the Midi system is equivalent to the parameter of the dynamics of a sound; and the number of peaks, or formants. By adjusting the values of these parameters, I filtered the number of partials of the sound to be transcribed to leave only those that sounded the loudest. In other words, I reduced the ontic complexity of the recorded sound object, the frogs, in the symbolic domain so that its transcription would concentrate on the formants, the most audible frequencies. In the following graphs, we see the same sound transcribed with two contrasting values in the velocity and peaks' numbers parameters and the consequent difference in the number of frequencies.

[24] https://soundcloud.com/fernando-garnero/nf-ext2 (Accessed March 30, 2025).

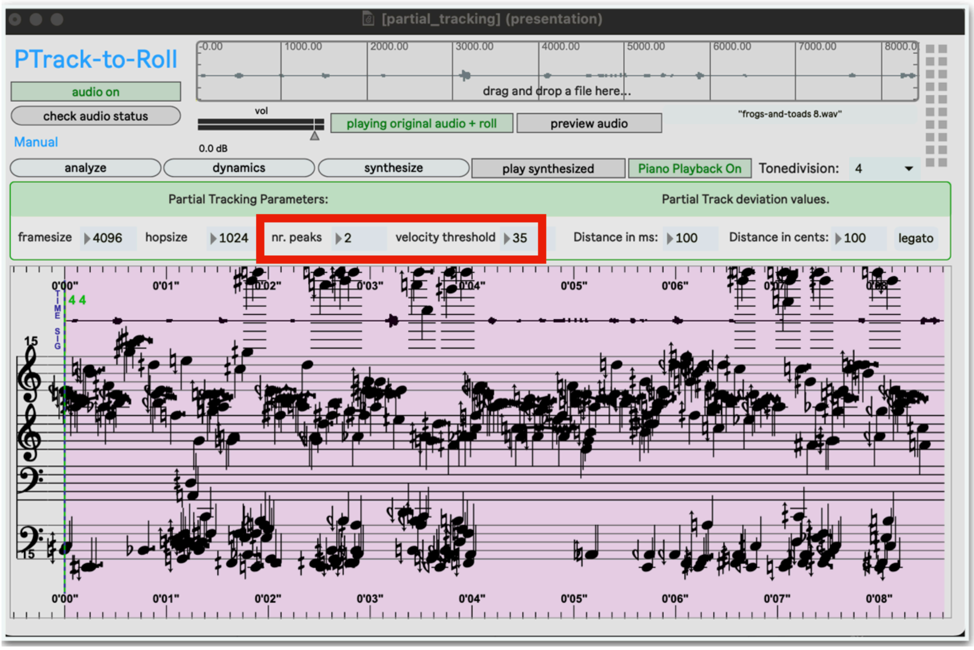

Figure 2.2, Partial tracking and symbolisation in a Max patch

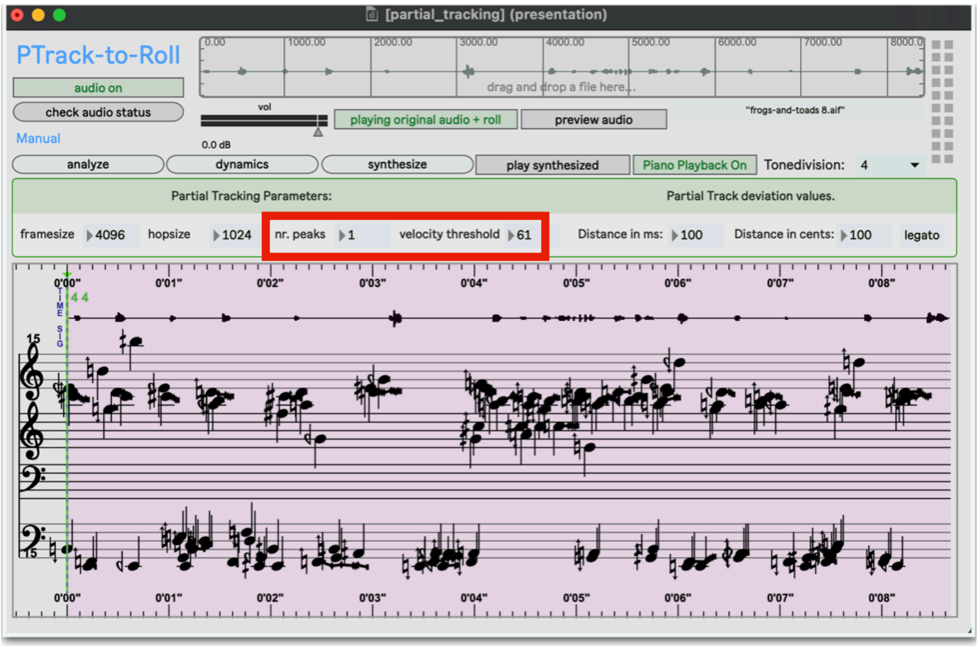

Figure 2.3, Partial tracking and symbolisation in a Max patch

Experimenting within a Composable Space

Experimentation—as a site of discovery— plays a major role in the ontogenesis of musical works. As a locus of experimentation, the composable is a vehicle for exteriorising musical imagination. Similar to scientific practice, the composable serves as an experimental space where material, conceptual, and representational elements interact in a non-linear manner. While influenced by historical and cultural contexts, composing new music involves both established knowledge and the emergence of new insights during the creative process. Composable spaces materialise inquiries, shaping new questions through experimentation.

The composable, as a space of articulation, has changing boundaries, regarding a situated practice. A practice that can involve moments of interplay within a community of actors, and moments of solitude in which a single actor engages in localised actions of experimentation. However, as was previously highlighted in this writing, scientific and musical practices operate within distinct realms of physical existence and conceptual discourse. It is not only a simple matter of having different production aims and subjects of inquiry; the sequential order of the operations over their internal components and the interplay among them makes it impossible to homologate their respective ways of experimentation.

Nonetheless, aware of their differences, we could adopt Rheinbergerian terminology to describe the composable as an experimental system, as the smallest integral working unit of musical composition, where technical objects and epistemic things interact in a space of representation formed with articulated material traces, with graphemes. A manner of "working on a conceptual framework in which to talk about these differences and bring them into the realm of comparability" (Rheinberger 2013, p. 207) is problematising these epistemological questions from the perspective of a contemporary music composer.

Acquired Knowledge vs. Emerging Knowledge

Andreas Dorschel asked himself: "What sort of knowledge *goes into* music, and what sort of knowledge *emerges* from it?" (2024, p.1). This question does not try to get a defined answer but rather describes a fuzzy terrain regarding the problem of knowledge's place in music. Defining the boundaries of one from the other is less useful than identifying the existence of a certain tension between two states of knowledge in the process of materialising musical output. "The tension between *a priori* existing knowledge and knowledge created by actors is a theme that has long preoccupied philosophers (Bachelard, 1953) and sociologists of science." (Latour, Woolgar 1996, p.178). Bruno Latour's quote sheds light on a problem that also exists in music; however, unlike other fields, few composers have theorised about it.

What role does the tension between acquired and emerging knowledge play within the experimental process of composing music? Defining the proper contours of knowledge created by singular actors becomes a difficult task, invention often emerges from iterative problematisation of previous compositional subjects of inquiry, whether this issue comes from the experience of others or a singular one. The tension between stabilised forms of interaction amongst acquired techniques and art methods in the process of becoming operates unexpectedly when particular components are relocated into a new context and framed in another space of experimentation. Changing the place of a technical object in the sequence of interplaying with the art method that the composer is shaping could lead to a redefinition of the subject under investigation itself. Iterating already-tested compositional operations under a different sound object or objects network could produce the emergence of something unforeseen. Utilising a different tool for experimenting with an already-known compositional operation could reassign the tool's utility and reshape a given art method. For this reason, but this time in and from the domain of musical composition, we join the already quoted affirmation of Rheinberger that the difference between a technical object and an epistemic thing is not structural but rather functional. Their status and value depend on the spatiotemporal singularity within the experimental space, in the place where we assigned them, and the moment we used them in the process of experimentation.

Interaction, Iteration, and the Emergence of the Unforeseen

The challenging task of defining and identifying musical knowledge is influenced by the inherent uncertainty of specific subjects of inquiry within an open-ended experimental process. In this process, intuition, improvisation, and serendipity play critical roles, and the distinctions between thinking and creating often blur. Following Rheinberger's approach, we examine the intricate question of knowledge in musical composition through the lens of "epistemological detail." Consequently, the concrete aspects of the relationship between music and knowledge, rather than abstract formalities, should be examined on a case-by-case basis.[25] However, we are establishing a conceptual framework to compare the differences and similarities between two distinct realms, each producing specific outcomes through experimental processes in which various types of knowledge converge. This framework allows us to use Rheinberger's concepts to approach this issue in musical composition.

In a composable space, we could already trace some recurrent phenomena, that take a distinct form regarding singular experiences:

[25] This issue will be addressed, either directly or tangentially, in the subsequent chapters, which present concrete cases linked to the central research framework of this dissertation, based on various works from my artistic production.

- Interaction between acquired knowledge (the composer's understanding of instruments, musical theory, music technology, music history, culture, previous experiments, etc.) and emerging knowledge in a process under constant tension.
- Interaction between *technical objects* and *epistemic things*, in the frame of a dialectical relationship.
- Interaction among material and conceptual elements within a space of representation.
- Iterative problematisation of art methods, musical techniques, compositional operations, and manners of articulating sound objects and networks.
- The emergence of novel phenomena that resist full formalisation and results from spatiotemporal singularities.

From the interactive and iterative process of localised experimentation, unforeseen outcomes could emerge, potentially leading to the development of art methods that exist under constant inquiry and redefinition. The composable is always situated and framed in sequential forms, where the boundaries concerning the emergence of new knowledge are not clearly defined from one experiment to another. In this sense, music experimentation is a future-oriented device, continuously producing new knowledge and understandings.

Technical Objects, Epistemic Things, and Composition

Within this comparative framework of experimentation, the tension between acquired and emergent knowledge must be understood as a symptom of the dialectical relationship between technical objects and epistemic things. This tension can introduce confusion when attempting to clearly distinguish one concept from the other. Rheinberger has already emphasised the dialectical nature of this relationship, establishing a difference in their functions that must be situated within the context of experimentation: "In *Toward a History of Epistemic Things* I wanted to convey the idea that the experimental process plays out a dialectic between epistemic things and technical objects, and that there exists a functional relationship between them rather than a substantial one" (Rheinberger, 2013, p. 203). In the context of the composable, this dialectical relationship could also, through the experimental process, lead to stabilised objects becoming challenging once again. Inversely, things under investigation could reach a point of stabilisation where no further knowledge can emerge from them. We can refer back to Rheinberger to draw a parallel on this issue, this time from the scientific perspective: "Epistemic things that have reached a certain point of clarification can be transformed into technical objects—and vice versa: technical objects can become epistemically problematic again. The technologies with which one works are normally used as black boxes; they can, however, be reopened and become things of epistemic interest" (Rheinberger, p. 203).

Knowing their dialectical relationship and functional differences, we can approach these crucial concepts from a musical perspective by situating them in a hypothetical experimental composition space. Unlike the inherent indeterminacy of epistemic things, technical objects are momentarily stable, reliable instruments that make musical investigation possible.[26] These well-established technologies are used to investigate artistic subjects and experiment with undefined musical ideas, intuitions, and methods. These entities, which aren't static, are considered material or conceptual tools of briefly stabilised musical knowledge. They shape the course of musical experiments and the kinds of knowledge that can be produced and help to delimit the space of the composable. Composers actively engage with instruments, tools, theories, and concepts, and these artefacts significantly influence the musical outcomes they produce. Their role is primarily instrumental—they help musicians interact with and manipulate the emerging knowledge, but they are not the focus of inquiry. Their design, capabilities, and limitations influence how composers interact with their subjects under investigation, their epistemic things. Composers don't simply use instruments passively; the instruments and tools themselves influence the type of music created, we could invoke Latour's ANT again and his own words: "Objects too Have Agency" (Latour 2005, p. 63).[27] The composer's relationship with musical matter is mediated by technical objects, and the entire compositional process can be viewed as an experiment. Musical matter is generated, manipulated, and refined based on interactions between the composers and the tools they use. In this sense, the physical place we invest in composing, the music studio, or the performance space parallels Rheinberger's laboratory.

To facilitate the problematisation of epistemological notions in Rheinberger's thinking from a composer's perspective, and as a means of bringing the conceptual framework of comparison closer to the realm of musical experimentation, I will provide some concrete, yet general examples of what we could identify as technical objects in compositional practice:[28]

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[26] However, as Akrich (2006, p. 159) states, its apprehension remains somewhat problematic: "The sociology of technology is faced with an object which, although clearly defined in its physical aspect, is no less curiously elusive: half-flesh, half-fish, we don't know by which end to take them. They always refer to an end, a use for which they are designed, at the same time as they are only an intermediary term in a long chain that associates people, products, tools, machines and currencies. Even when it comes to technical content, it's impossible to bring it into perfect focus, to replace an image with ill-defined contours with a simultaneous and detached vision of the object and the 'background 'against which it is set."

[27] "In addition to 'determining' and serving as a 'back-drop for human action', things might authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid, and so on." (Latour 2005, p. 72)

[28] This list doesn't pretend to be exhaustive but aims to illustrate the diverse range of technical objects that can be encountered in compositional practice.

- Some examples of material-technical objects are: acoustic musical instruments (including prepared or modified); electric instruments (synthesisers, electric guitars); analogical sound processors (electric guitar pedals, tapes machines, modular synthesizers); hybrid instruments (e.g., cello coupled with transducers or a percussive instrument played with automatised devices with solenoids commanded by microcontrollers); digital tools (software, hardware, signal processors). Some examples of immaterial-technical objects are: tuning systems; theories applied for the analysis or synthesis of sound signals (like the Fourier transform and Gabor transform); specific techniques of sound signals analysis and synthesis (Fourier Analysis, Spectral Analysis, Frequency Domain Analysis, Additive Synthesis, Granular synthesis); sound signal synthesis as models for instrumental synthesis techniques of acoustic writing (e.g., Additive, Spectral or Granular) for creating frequency, duration, rhythm, timber, formal and orchestration compositional operations; sample-based, analogical or digital sound editing and manipulating techniques as models for instrumental writing (symbolic or instrumental granulation, looping, sampling, chop and mix); algorithmic compositional techniques.

Epistemic things are the elusive, sometimes still uncertain, sonic or audiovisual materials, abstractions, intuitions, or ideas composers try to grasp, manipulate, and explore.[29] In composed music, sound itself[30] often functions as the "epistemic thing." Composers engage with sounds, instruments, electronic processes, concepts, or abstractions[31] in ways that seek to uncover novelty, much like scientists explore the unknown properties of new material. These musical matters in a process of becoming, can be thought of as epistemic things because they are not fully understood or predictable in their initial stages, and facilitate the emergence of new understandings. Composition becomes a process of experimentation, discovery, and learning, where interacting with the material leads to unforeseen outcomes.

However, more than one epistemic thing could be investigated in the composable space of a given musical work. This diversity underscores the unique nature of compositional practice, where various elements and their interactions can be explored simultaneously. In my singular practice with the composable space, scale changes may also occur within experiments, producing diverse epistemic things' inquiries in the same experimental space. In the dynamic music-making process, I can operate locally within different time scales and manipulate various levels of musical matter's meaning. On a small scale, I can perform operations of

[29] They are as well, art methods or compositional strategies, operations and techniques being iteratively problematised and leading to renewed musical inquiry.

[30] In my artistic practice, an example is a complex sound phenomenon as feed-back.

[31] In my personal practice it may include as well non artistic or extra-musical phenomena triggering musical experimentation.

decomposition and localisation of sonic matter and musical operations under it, much like scientists do, within the experimental process. On a larger scale, these operations could relate to a personal artistic method or a particular formal approach to musical matter within the context of a given work, involving more intricate actions upon object networks rather than focusing on single phenomena.

Representing in the Composable

Drawing a parallel with Rheinberger's concept, we could state that in the composable, the spaces of representation are the symbolic and material frameworks through which sounds are articulated, organised, and manipulated. They may include, for example, musical notation symbols, digital audio workstations, sound synthesis devices, and music-oriented algorithmic software. Additionally, sound diffusion setups and performance spaces could also be integral components. Like scientific representations (e.g., graphs or diagrams), these musical representations are not passive reflections of an external reality (such as pre-existing formal structures) but generative tools.[32] They allow composers to manipulate, transform, and create new sonic phenomena. As in experimental science, where materiality and representation are often indistinct, composed music also exhibits an *inextricable interconnection* between sound and representation. "Anything represented, any referent, as soon as we try to get hold of it, (…) as soon we try to shift it from subsidiary to focal awareness, is itself turned into a representation" (Rheinberger 1997b, p.104).

The interaction between material systems (such as instruments, electronics, and sound-producing objects) and symbolic systems (including notation, graphics, and conceptual frameworks) shapes musical outcomes within these spaces. For example, in electroacoustic or digital music, a composer might employ abstract sound synthesis techniques that relate directly to material conditions like signal processing. Nonetheless, the interplay between the material and their conceptual frameworks and poetics ultimately shapes the final form of their works.

In musical composition, representing is not merely a descriptive action; it generates knowledge[33] and musical output inserted in a dynamic chain of experiments, moulding the future of musical composition and artistic inquiry, as it is conditioned with past representations that influenced works and musical knowledge.[34] Spaces of representation within the composable have an evolving and paradoxical nature; they

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[32] "Representation *is* 'eventuation' (it is about intervention, invention, and the creation of events)." (Rheinberger 1997b, p.108)

[33] "All representation is production/reproduction, and the 'eventuation' of epistemic things is distinguished by lack of reference to prototypes." (Rheinberger, p.108)

[34] For example, the legacy of Serialism has significantly influenced algorithmic approaches in computer music.

are determined by historical knowledge while operating with contingency and are crafted by cultural context while exploring the unpredictable aspects of musical creation. These generative tools for representing serve composers to navigate the dynamic process of discovery, much as scientists do in the laboratory. They are the locus where inscriptions are made to generate and preserve material traces through different stages of musical experimentation.

Composing with Sonic Graphemes

As in Rheinberger's notion of *grapheme*, we could approach representational units of sound and musical objects or operations as material traces left in the experimental process of composing. Similar to how graphemes in scientific experiments serve as physical traces (like inscriptions or recordings) that contribute to knowledge development, graphemic material in music composition can be seen as the notational symbols (sound recordings, sonograms, chunks of code, designs, drawings) or other material artefacts created during the compositional process. These notations serve as intermediaries between the composer's conceptual world and the realised musical output. Analogous to Rheinberger's argument that graphemic material mediates between acquired and emerged knowledge in science, composers employ symbolic systems to explore musical possibilities that may not yet be fully articulated. These graphemic elements are crucial for navigating uncertainties while composing musical works. Composition, as an investigative endeavour, hinges upon the physical embodiment of ideas through graphemic inscriptions, which function as active agents in the making-music process. In these instances, the graphemes—whether they are sketches, improvisational recordings, unusual graphic signs, or hybrids of linguistic and non-linguistic symbols—form the foundation for generating new musical knowledge and outcomes. Composers engage with technological tools that produce material traces—schemes, digital manipulations of sound, raw audio data manipulated digitally, or digital graphs—which act as exploratory components in the compositional process. These materials are not merely representations of sound; they function as integral components of the creative process, shaping and guiding the direction and evolution of the composition.

However, these representational entities deal with the inherent contingency of experimentation; graphemes, as material traces of sound (whether notated, recorded, or electronically generated), are provisional, evolving artefacts that can change from one composable space to the next. Various performance contexts, instruments, or technologies can lead to vastly different results from the same compositional graphemes. In sum, these musical graphemes are not fixed entities[35] but rather dynamic elements that can be adapted, interpreted, and transformed over time.[36]

Experiments for Problematising Things and Thoughts

This exploration of the composable through the lens of Rheinberger's epistemological framework underscores the crucial role of experimentation in artistic inquiry. In musical composition, as in science, a dynamic interplay between sedimented knowledge and practice occurs, where the unknown is continually probed and from which new knowledge emerges. Central to this inquiry is the conception of composable spaces as experimental systems, which opens a new perspective on the former by highlighting the importance of materiality, representation, and the composer's role as both creator and investigator. By examining the role of graphemic material and the dialectical interplay between epistemic and technical objects, we can open a new perspective on understanding the composable spaces and identify the driving tension between stable and emerging musical knowledge within it. Ultimately, this comparative approach reveals an interconnection between art and science through experimental practice, despite their irreducible differences regarding materiality, discursivity, and teleology.

At the heart of this writing lies the thorny question of the epistemological status of art, whose profound approach extends beyond the limits of our domain of practice-oriented artistic research. Unlike scientific research, which relies on clearly defined research questions, methods, and justifications, art is inherently polysemic and resists definitive interpretation. However, art can still function as a site of research, where knowledge and understanding emerge through artistic practices and artworks themselves. In artistic research, artworks and practices can serve as both technical tools and epistemic things that generate new knowledge. Artworks are seen as *epistemic things*—hybrid objects or events that provoke new understanding through

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[35] As in psychoanalysis, we cannot have stable semiotic reference units in music. Symbols are contingent, sliding, and never fully fixed; they exist in "a game of changing traces." Symbols acquire meaning when situated within chains of other symbols, embedded in specific contexts, localised within particular practices, and inscribed within networks that contribute to the materialisation of musical outcomes.

[36] The notation in written scores used in Western music since the 18th century has remained relatively the same over the centuries. However, even this key aspect of classical music, which also serves as a symbolic mediation system between musical actors, has been revealed to be flexible and unstable. Since the post-World War II musical experience, we have access to many examples of this fluidity of symbols in the score domain. As a technical object of representation, their stabilisation is momentary, regardless of their sustainability over long periods. "In their transiently stable forms (note: of representational objects), they may act as embodiments of concepts, as 'reified theorems', to use Bachelard's expression." (Rheinberger 1997b, p. 107)

their inherent indeterminacy. Our approach to this intricate question of the epistemological status of art ends here; it is only a tangential reference to this complex issue, which serves as the deeper framework for our discussion. Responding to the challenge of foregrounding this topic from our field of practice-oriented artistic research is an initial proposal to open future discussions that concern us as a collective.

A more modest proposition in theoretical terms, but one of significant operational interest for our research field, would be to map the iterative problematisation of things and thoughts across situated cases of artistic experimentation and musical artworks. This could be achieved by localising singular problematised things and thoughts across different artistic experiments and artworks. Additionally, this would involve exploring and articulating the material traces of this iterative problematisation across diverse artistic experiments and artworks. This approach would provide us with the invaluable opportunity to investigate how the iterative problematisation of things and thoughts evolves and shapes the development of concrete composable spaces over time. This would merit the opening of a new, considerably extensive, yet undoubtedly fertile discussion.

Chapter 3. Multidimensional Dispositives

An Introduction to Multidimensionality

This chapter presents and discusses works that exemplify the concept of multidimensionality within the composable space. In this context, the spatial dimensions of sound within the composable are of paramount importance: encompassing the physical, actual, and virtual space; the spatial relationships among sound-producing objects—such as instruments, speakers, and transducers; and operations on sound space as an integral component of the compositional process.

A central notion for this exploration is that of the multidimensional sonic dispositive, a set of objects designed to produce and diffuse sound. It refers to a physical apparatus that integrates various devices for this purpose. The dispositive must include at least two distinct devices to conform to this definition, which may encompass instruments and/or objects for sound production, such as speakers, microphones, transducers or couplings that result in hybrid instruments. Abstract questions about art-making can be addressed anew by positing artistic concerns on a material plane, offering a renewed perspective on the historical approach in which musical ideas often dictate our engagement with pre-existing materials.

For this discussion, I will examine works using multi-dimensional dispositives, their relationship to artistic output, and their unique approaches to shaping and defining specific composable spaces. Each case study highlights a distinct perspective, showcasing particular spatial arrangements, distinctive methods of integrating dimensions, diverse devices or instruments constituting the dispositive, and specific interactions between materiality and abstraction.

Firstly, I examine my work *Mutante/Amniótica* (2018), for double bass and electronics, in which the sonic dispositive plays a pivotal role. In addition to the amplified instrument and eight surrounding loudspeakers, this piece features a modular hybrid created by coupling the double bass with transducers on stage, thus integrating electronic sound within the acoustic instrument.

Secondly, I address my 2020 site-specific installation *Les sons ne sont pas des hommes*, a site-specific sound installation conceived for the vineyards of the Villa Médicis' historical gardens. This eight-channel fixed media composition synthesises on-site recordings of the exhibition site with synthetic sounds, archival samples, and excerpts from previous works.

Lastly, I discuss my work *Contraccolpo* (2020), written for two hybrid instruments and electronics. In this piece, one instrument combines a condenser microphone with a snare drum and various objects, while the other incorporates a woofer into a saxophone's bell, which acts as a filter for the incoming electronic sound.

In addition to these works, I discuss three works by other composers as part of an introductory review of the state of the art. Comparing their approaches to multi-dimensional setups with my own sheds light on past decisions, facilitates the articulation of new questions related to this subject, and potentially opens new avenues for artistic exploration.

Tonewood II by Hugo Morales

Tonewood II was composed between 2014 and 2015. This piece was conceived for five resonant instruments of varying sizes. At its premiere in 2015, the instruments included guitar, violin, viola, cello, and double bass. These resonant cases are set into vibration by a tactile transducer moving along the back of the instrument. Each instrument contains a DPA microphone inside its resonance box, which amplifies the sound through a stereophonic loudspeaker system. The transducers scan the back of the instrument according to a pattern that defines axes (which may be pressure nodes or antinodes) and delimits possible paths between them at different speeds. These positions result in different incoming signal filters. The performers also each have an analogue volume pedal; their playing actions are limited to its operation and to the movements of the transducer on the instrument. The first dimension of the dispositive at work in this piece is thus a modular instrument made up of five hybrids created by coupling a series of components (tactile transducer, resonant instrument, volume pedal, and the device producing the input signal). The second dimension is formed by the microphone/loudspeaker pair and its control devices (mixing desk or sound card).

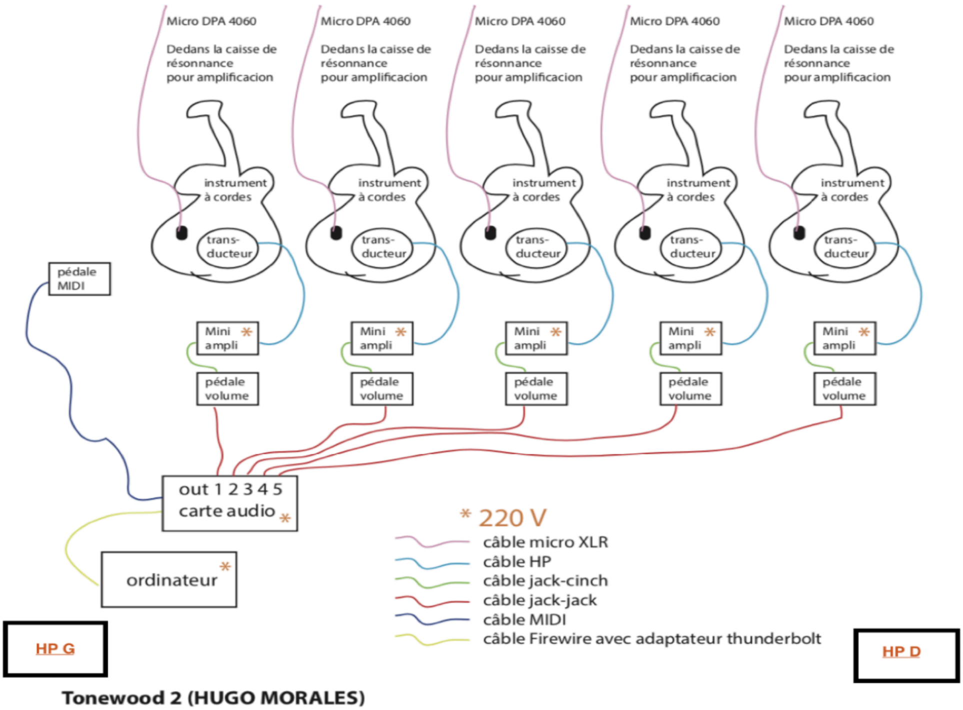


Figure 3.1, Tonewood II *Dispositive*

The instrument and the transducer are structurally coupled to produce a device designed to resonate and filter electronic sound. *Tonewood II* thus reverses the traditional relationship between instrument and computer, with the instrument processing the digital signal rather than the computer processing the acoustic sound. This hybrid instrument also delimits a small field of limited operations within the composable.

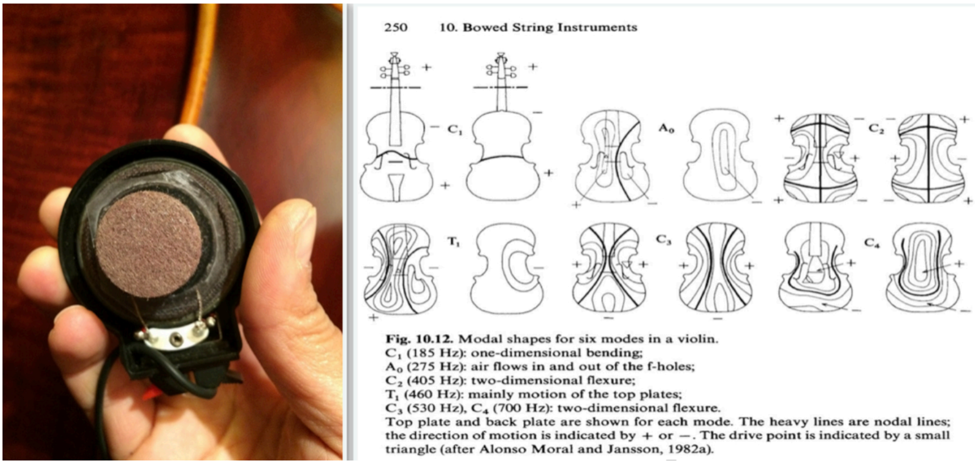


Figure 3.2, A transducer & Resonance modes of a violin
Left: photo by © Hugo Morales. Right: Fletcher et al., 1998

In an interview I conducted with the composer, he explained that the limited sound material at the base is determined by the dispositive and the reduced range of actions that result from it. He also noted that his choice of sound material—oscillators, pulses, and white noise—reflects his desire to pay homage to the beginnings of electronic music. Morales also advocates for a 'pedagogical' approach to the sonic dispositive for the audience, in which the listener engages with the logic at play through the act of listening and seeing. They witness a theatrical 'testing' of the instrument by the transducer, led by instrumentalists whom he envisions as 'industrial machine operators.'

A Small Field of Operations

The musicians' actions are limited to controlling the volume with the pedal, the amount of pressure exerted by the transducer, the placement of the transducer on the surface, and the circular movements of variable amplitude to be performed at each indicated position. The actions are limited to controlling the volume with the pedal, the amount of pressure exerted by the transducer, placement of the transducer on the surface, and the circular movements of variable amplitude to be played at each indicated position. At the first level of articulation, we can easily delimit the sections contained in *Tonewood II* according to the instrumental actions to be performed. The first section deals with volume control (which is gradually phase-shifted between instruments), transducer pressure and circular movements over a singular position (whose amplitude gradually shifts in phase between instruments).

Speed and amplitude of movement are the only parameters in play, reducing the compositional operations to phase differences or coincidences among instruments. In the last section, the position of the transducers freeze to reveal 'accents' of circular movements of maximum amplitude with simultaneous maximum pressure, distributed among the instruments and over a relatively stretched temporality. *Tonewood II* ends with an almost cadential action: the multiplication of an identical gesture followed by a *decrescendo subito al niente*.

There are three parameters to control:

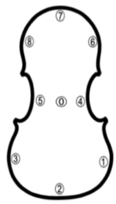
1. Duration/volume of the sound: controlled with the pedals. Four levels:
   - Off ○
   - Minimum *p*
   - Middle *f*
   - Full *fff*

2. Transducer pressure: resulting in a slight increment of pitch and is divided into:
   - Low pressure
   - Normal Pressure
   - Over Pressure ×

3. Spot on the instrument: each instrument (with the exception of the piano) is divided into 9 sections (as shown). Each of these sections is indicated with a number inside a circle. The piano however is simply divided into High, Middle and Low range.

   Circular Motion (center)

   - Super Narrow sn
   - Narrow n
   - Wide w
   - Super Wide sw



   - Small and medium instruments should rest vertically on the lap of the performer.
   - It is very important to always maintain the instrument straight. The cable connecting the transducer has to be attached by a strap to the wrist and arm of the performer.

Composed and commissioned by the Vortex Ensemble (CH)
Hugo Morales Murguia © 2015

Figure 3.3, *Tonewood II* Glossary and instructions. (Edited by the author, 2015)

A parallel layer of formal articulation is embedded in the structure of *Tonewood II*'s Max patch. Think of this second layer—superimposed on the one based on instrumental actions—as an input map: a map of the sounds that the transducers diffuse across the instrument's surfaces. The Max patch contains five modules for producing two types of sound: sawtooth waves or white noise. The single compositional operation is to vary the speed of the pulses generated by these sounds. Two modules are designed to produce sawtooth waves of different frequencies (325 Hz and 111 Hz).

A third sub-patch is designed to produce white noise. The remaining two *abstractions* handle operations concerning pulses, including assigning general or individual pulses, creating sub-divisions, and shifting among instruments. This involves changing from a generalised 80 BPM pulse to sub-divisions of a 100 BPM pulse. These pulsations are produced alternately by noise or by sawtooth waves.

This second level of articulation can be divided into three sections based on the events related to the sound and the operations performed by the patch. The first section uses only the oscillators at the two specified frequencies, starting with pulsed sounds and then transitioning to smooth sounds. The second section introduces noise and gradually fades out the sawtooth wave, accompanied by a simultaneous non-linear acceleration of the pulses and a gradual addition of varying speeds. The final section uses solely white noise with no pulsation.

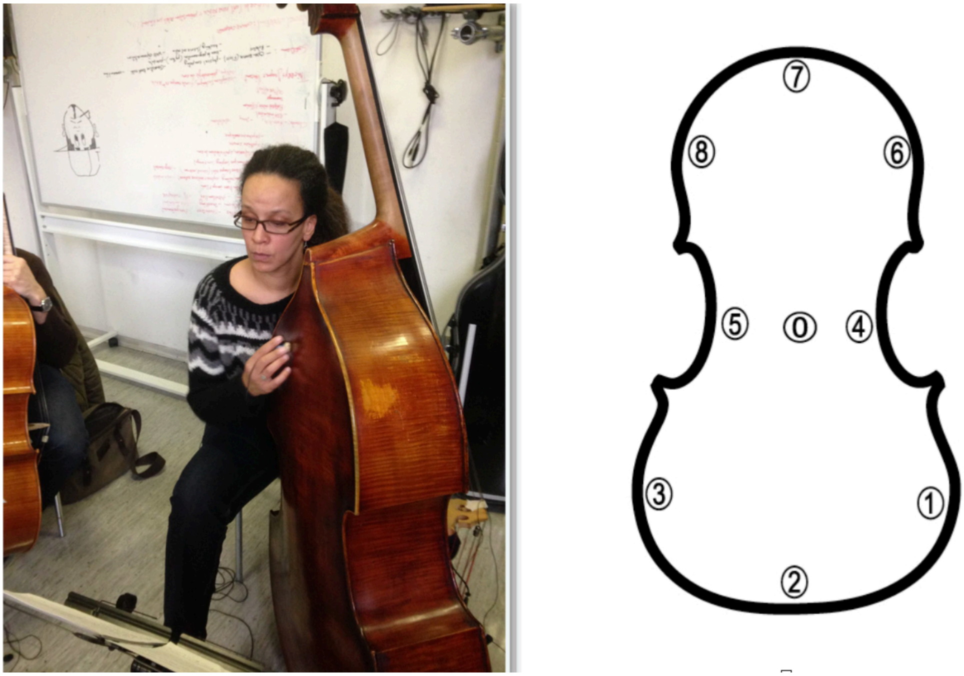


Figure 3.4, *Tonewood II* reference positions.
Left: Jocelyne Rudasigwa, former double bass player for ensemble Vortex, rehearsing (photo by © Hugo Morales). Right: Details of the reference zones for positioning and moving the tactile transducer on the surface of the instrument.

Exploring Actual Sound Space

Experimentation plays a key role in Morales 'approach to the composable. Testing, evaluating, and designing the dispositive—the physical apparatus—constitute the initial and most crucial stages of the composer's work. In *Tonewood II*, materiality profoundly shapes musical abstraction and scenic dramaturgy, defining a composable space reduced to a few components, with a limited set of compositional operations and a constrained domain of performers' actions.

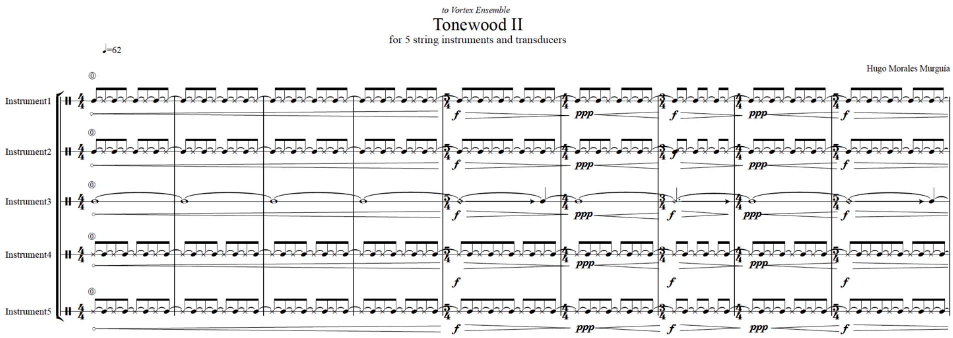


Figure 3.5, *Tonewood II*
Fragment of the first page of the score (© Hugo Morales, 2015)

The formal articulation of *Tonewood II* exploits Tonewood *II* formal articulation deploys the central components of its composable space: the position of the transducers (the 'strings' of the instrument) and their movement; the instrumental gestures (the 'discrete scale' of this piece); the very limited range of sounds chosen sounds; and the three types of operations performed on them: the volume control (via analogue pedals), the pulses (either one uniform speed for all five instruments or a superposition accommodating of up to five different speeds), and the filtering of the electrical signals emitted by the transducers through the instruments.

All actions occur in an almost linear process over three main sections, expressed by 14 events in the Max patch. These events globally range from sawtooth waves to white noise (with superimpositions, returns, etc.), and from pulsed sound (and noise) to sustained noise. Another parallel process culminates just before the end of the first section, where the volume remains at its maximum level. Each event in the patch delineates a precise field of action and operations, engaging one or two dimensions of the composable space, and excluding or 'freezing' others. In the *Tonewood* cycle, the composer pursued two main subjects of artistic inquiry: the investigation of forms of structural coupling to produce hybrid instruments, and the exploration of the *actual* space of sound (Solomos, 1998, pp. 211-224).[37] Both subjects are inextricably intertwined, establishing an experimental field in which certain technical objects (e.g., instruments, transducers, electronic signal generators) and epistemic things (e.g., structural coupling, actual space) interchange their operational functionality, depending on their position within the sequential forms of experimentation.

[37] Solomos makes a distinction between *actual* space (the physical environment where music is played and heard, involving measurable aspects like distance, reverberation, etc.) and *virtual* space (the subjective auditory perception created by sound spatialisation, timbre transformation and other techniques of sonic movement).

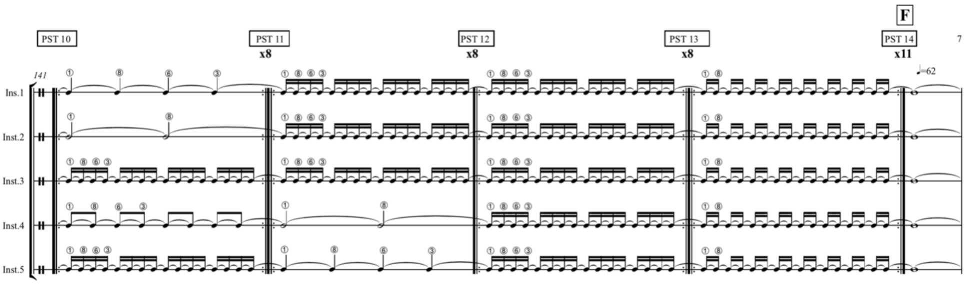


Figure 3.6, *Tonewood II*
Fragment of the last page of the score (© Hugo Morales, 2015)

The resonance of the body instrument and that of the hall are simultaneously ‘tested ’by the same sounds, diffused on the one hand by the transducers and on the other by the loudspeakers, with the DPA microphone acting as a mediator between the two dimensions. Thus, a unique listening experience emerges within a multiplied sound space. In a 2023 interview, the composer stated that one of his most important goals was “to give the listener the experience, through pulsations and filtering, of the two acoustic spaces at play: that of the resonant body and that of the hall,” the two forms of actual sound space at work in *Tonewood II*.

Carola Bauckholt’s *Doppelbelichtung* Dispositive

Writing on *Doppelbelichtung*, Van Eck (2017b) offers the following characterisation of Bauckholt’s work, highlighting its conceptual and technical interplay between imitation and transformation:

> Double exposure—the English translation of *Doppelbelichtung*—is the technique of taking two pictures on one frame of film. In this piece every sound seems to be a sonic double exposure of a violin and a bird: the violin imitates the bird sounds, which are in turn modified to resemble the violin. By transmitting these sounds through tactile transducers attached to violin corpuses hanging in the air, every bird recording acquires the spectral characteristics of a violin. The piece is a thoughtful conversation between these new creatures.

The dispositive conceived for *Doppelbelichtung* comprises four elements distributed in two complementary dimensions of its composable space. The first is the amplified violin, which imitates recordings of birdsong. In addition to the first, there are three components of the system designed to broadcast the twelve tracks of transformed bird song recordings: two loudspeakers on stage, placed to the left and right behind the violinist; five mini-loudspeakers: four in the auditorium (one of which is at floor level, number 4 in the illustration on the previous page), and a fifth on stage, facing the violinist, used as a monitor; and five violin-speakers (violins coupled with transducers) suspended from the ceiling: four in the auditorium and one on stage (number 5, which only reproduces a woodpecker song at its original speed).

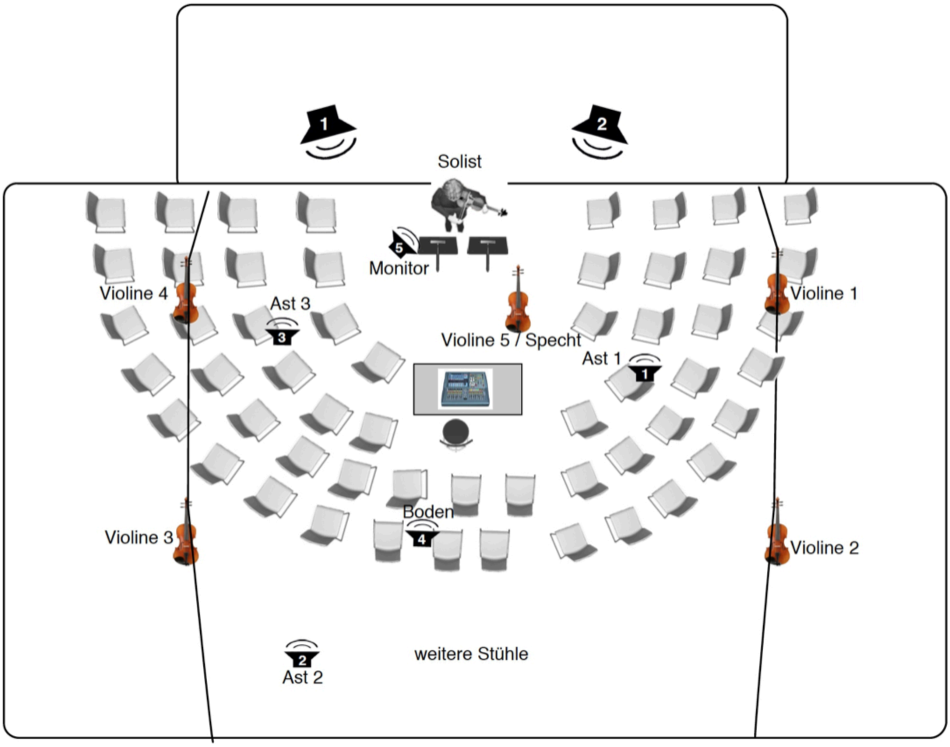


Figure 3.7, *Doppelbelichtung's* dispositive
In Van Eck (2017b)

Some of its components have a defined, invariable function in relation to the sound material and/or a specific operation:

- The loudspeakers placed on stage reproduce only the song of a thrush, always slowed down to between one- and two-fifths of its original speed.
- The mini-speaker on stage serves as a monitor for the violinist.
- The mini-speaker placed in the hall at floor level reproduces only the recording of a bird call at its original speed
- The violin/transducer pair placed on the stage reproduces only the song of a woodpecker at its original speed.

The appearance of these components, alone or combined with others in various configurations, acts as a formal articulator. Space and the way it is used are intimately linked to form. A description of the interactions between the diffusion apparatus and the instrument, the local parameters of each component (in terms of its location, material, temporality, and the operation performed), and the combinations given throughout the piece can help us to analyse the implementation of the composable space of this piece and its form. The various morpho-spatial configurations of the piece, in the order in which they appear, are as follows (always including the instrument played):

- Loudspeakers + Violins/Transducers 1 to 4 above the stage (reproducing the same bird song played by the violin with an infinitesimal phase difference - reverberation effect -, original speed).
- Violin/transducer on stage + mini-speakers (different songs from the same bird reproduced by the violin at their original speed), with a sub-group formed by the violin/transducer duo and mini-speaker 4 placed at ground level. During certain repetitions of this configuration, mini-speakers 1 and 2 alternately double or imitate the violin alternately.
- Multi-localised spatial polyphony, spread across the entire setup, creates a differentiated and complementary sound ecosystem. Each component reproduces a different song at its original speed, except for the loudspeakers on stage (which play slowed-down frost songs) and, at one point, violins/transducers 3, 4, and 6, which repeat the frost songs in slow motion. The relationship between the loudspeakers and the instrument changes, with the loudspeakers sometimes doubling or imitating the violin. The violin reproduces all the bird songs used in this work, including the frost song, at its original speed.
- Trios or duets formed by the violin and one or two of the mini-speakers (1 to 3) have a relationship that ranges from imitation or phase shifting to simple juxtaposition.

Other secondary configurations may occur but these are generally transitions or interpolations between the spatial sub-groups mentioned above.

Difference and Complementarity

The multidimensional *Doppelbelichtung*'s dispositive creates a differentiated and complementary space. A space where the movement of sound is not made by trajectories or global behaviours, but by the multiplicity of different sources that inhabit it, the localisation of specific types of sonic matter, and operations on them. The dispositive is both a part of and an expression of a composable space that contains multiple temporal scales, operations, composed interactions, and sound morphologies that emerge from the different couplings between its elements. This work presents a multi-dimensional space that articulates its emergent form through the interactions and localised couplings of its various components. Morpho-spatial events determine the sonic material of *Doppelbelichtung*, creating formal articulation as other sound parameters. Within its composable space, they constitute a central component of the artistic method employed during its composition.

The configuration of this setup is closer to that of *Mutante/Amniótica* (one of the works discussed in the following section) than to that of *Tonewood II*, primarily due to the presence of a solo amplified instrument combined with equipment that shapes a multi-dimensional sound space. However, the similarities end there, as each piece takes a radically different approach to spatialisation.

Bauckholt constructs a differentiated sound space by mixing loudspeakers and hybrids across multiple planes, whereas *Mutante/Amniótica* emphasises the contrast between two distinct dimensions. This contrast creates two distinct listening experiences: an immersive ('interior') experience within the auditorium and a frontal ('exterior') perspective from the stage. While *Doppelbelichtung* employs a diversified sound diffusion system, *Mutante/Amniótica* relies on alternation between these dimensions as a compositional strategy. Bauckholt composes a sonic ecosystem made up of multiple variations of restricted material. *Doppelbelichtung*'s composable space incorporates a variety of local configurations, which together form a large, diversified organism. Its components gradually hybridise: the violin imitates birdsong, and the birdsong is slowed down to approximate the sound of the violin.

My encounter with this work sparked a fruitful reflection on issues I had already been grappling with and opened up new avenues of exploration. Bauckholt's approach to the relationships between space, content and field of operation provided valuable insights that reshaped my perspective. By assigning immutable functions, precise temporalities and operational roles to specific components of the device within its composable space, I was able to conceptualise an articulated sonic spatio-temporal entity. This concept is based on a layered space in which certain elements maintain fixed spatial positions, combined with a circular sense of time, characterised by more or less regular temporal recurrences.

Waïra by Daniel Zea

The *waira* is an Andean aerophone instrument that produces sound using leaves, typically from maize but sometimes from other plants to produce sound. Its name comes from the Quechua word “wayra,” meaning “wind,” referring to the air required to produce its sound. Simple in construction, the waira consists of a folded or stretched leaf that vibrates when blown, generating its distinctive tone.

Traditionally used in ceremonial, festive and ritual contexts, the waira has both musical and symbolic significance associated with nature and the power of the wind. In ayahuasca rituals, only the shaman plays the waira, using it to bless the medicinal plant, introduce the music that initiates the ceremony, and conclude it with a “spiritual cleansing.”" This shamanic ritual and the movement of the waira's sound during the ceremony inspired Swiss visual artist Alexandre Joly's audiovisual installation and Colombian composer Daniel Zea's work 2020, which incorporates the instrument.

A Hybrid Dispositive: Installation and Sonic Setup

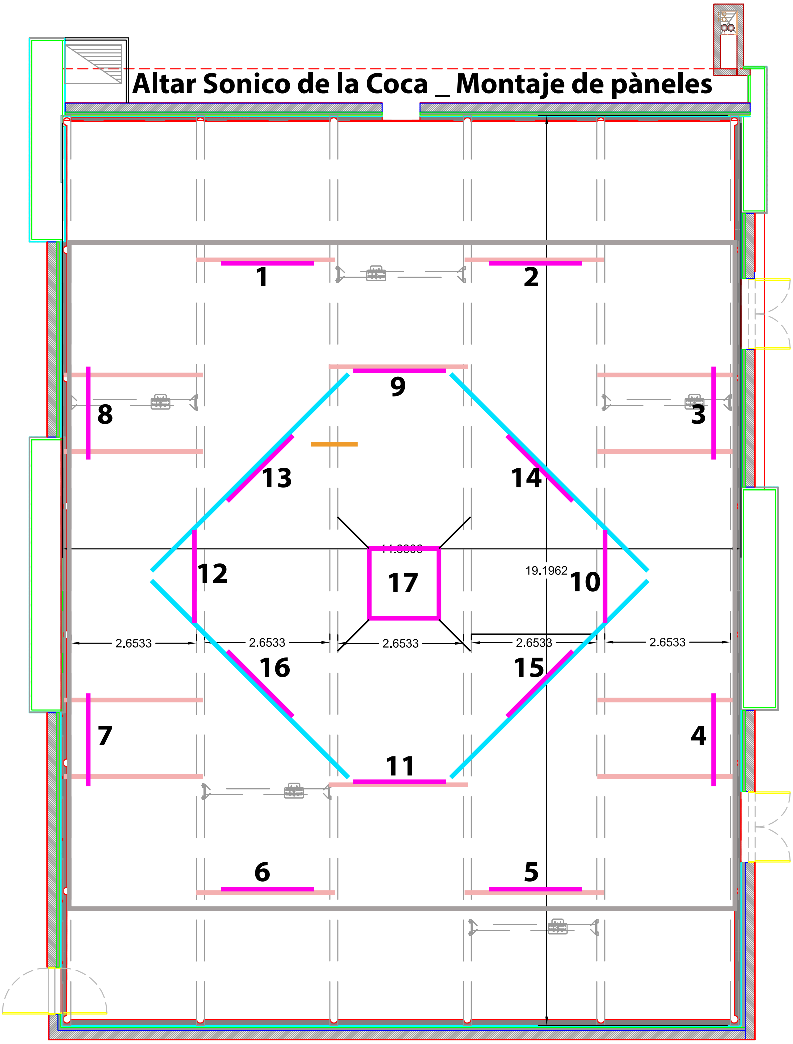
Joly's work for *Waïra* functions as both an audiovisual installation and a sound diffusion instrument. It is influenced by the coca leaf altars used by indigenous communities in the Andes who worship this plant. Its design dictates the stage arrangement of *Waïra*, a hybrid device comprising the 17 panels of Joly's work, two subwoofers and seven musicians who surround the audience, illuminated only by the devices that transmit information to them in real-time. The arrangement of the panels, suspended at different heights, creates a multi-dimensional acoustic environment by facilitating the diffusion of sound over several levels. This spatial configuration refers to the auditory experience of shamanic rituals involving ayahuasca, and is in line with the artists' intention (Zea, 2024) to create a "sonic exterior that projects the listener's introspection into the atmosphere of trance that Waïra wishes to convey.”

Joly's multi-dimensional dome consists of 17 resonance boxes, crafted from assembled spruce panels with a hollow interior just a few centimetres deep. Each module contains between sixty and one hundred piezoelectric membranes functioning as loudspeakers. These transducers are suspended from steel spikes using magnets and are interconnected by a network of copper wires and piano strings to facilitate audio signal propagation. Some resonance boxes feature sympathetic strings that produce distinctive sound radiation, while others incorporate piezoelectric transducers of various sizes, each tuned to its own resonant frequency. As Joly (2024) describes it, “This low-fi technology creates graphic compositions and draws inspiration from the construction of string and wind instruments, incorporating elements such as resonance holes, sympathetic strings, soundholes, and analogies to piano pegs, harmonium pulls, or guitar frets.”

Figure 3.8, *Waïra*'s dispositive
Photo of the first version of the installation created in 2020 at the *Théâtre du Galpon* in Geneva (© Alexander Joly)

Time and Space of an Audiovisual Ceremony

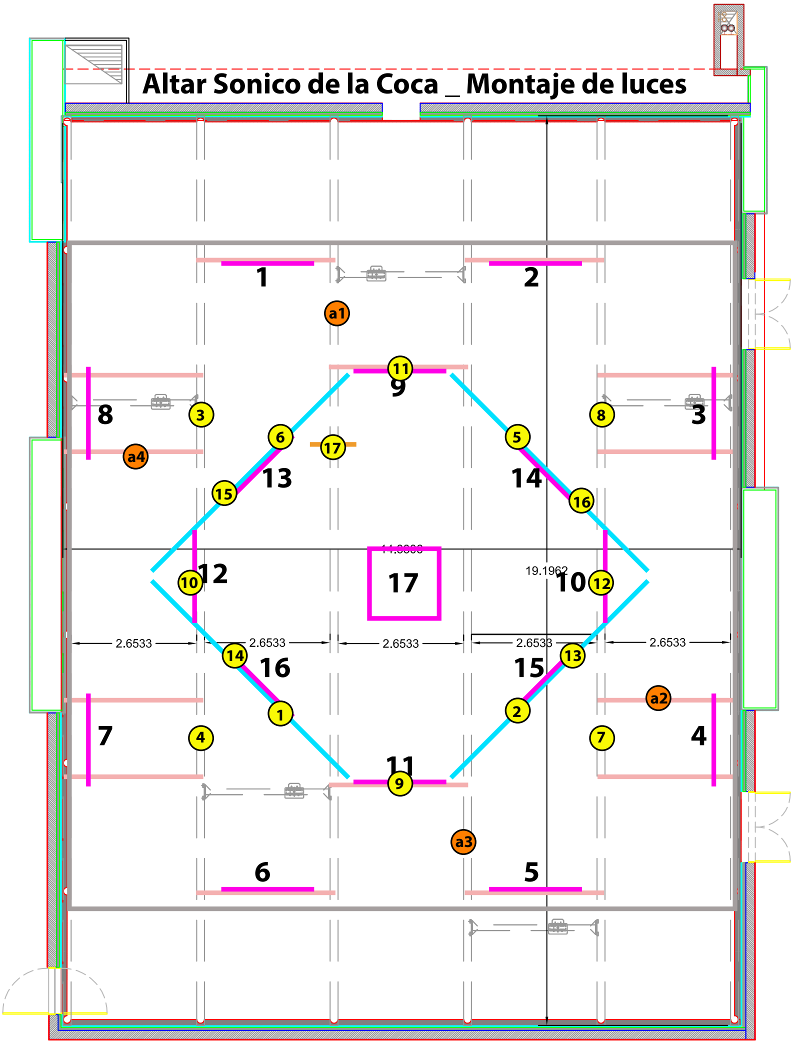
Music plays an omnipresent role during the Ayahuasca ritual, which is led by the shaman. As explained by Zea (2020), "Led by the shaman, the music does not stop throughout the night. Accompanied by his assistants, the healer creates a sound environment that promotes trance and accompanies the visions produced by the effects of ingesting sacred plants."



1 tubo de 1m de largo con sistema de fijacion a las vigas para luz panel 17
14 tubos de 3m de largo con sistema de fijacion a las vigas
4 tubos de 6m de largo con sistema de fijacion a las vigas con angulo 45º
16 paneles de madera negro mate 200 x 100 cms, suspendidos por guayas
1 panel central de 150 x 150 cms suspendido por guayas

Paneles 1-8 suspendidos a un metro del suelo
Paneles 9-12 suspendidos a 2,5 metros del suelo
Paneles 13-16 suspendidos a 4 metros del suelo
Panel 17 suspendido a 5,5 metros del suelo

Figure 3.9, *Waïra*
Left: Set-up of panels. From *Waïra*’s Rider, unpublished (© by Daniel Zea)



1 El numero de la luz corresponde al panel que alumbra. Segun la apertura las luces “profile” o “découpe” deben o no ser deportadas en altura. La idea es que unicamente el panel es iluminado y nada mas.

a3 En esta propuesta 4 zonas para cuatro altares diferentes cada uno con su luz

Figure 3.10, *Waïra*
Right: Set-up of lights. From *Waïra*’s Rider, unpublished. (© by Daniel Zea)

After Zea (2020) *Waïra*'s approach to sonic space and the overall management of musical time "replicates the form of the ritual." This is achieved through a stage setup in which "musicians, spatialised amidst a forest of small golden loudspeakers, serve as resonators and amplifiers of an enveloping harmony." The composer (2024) declares his intention to immerse the audience "in a mass of sound evolving at a deliberate pace to create a trance-like atmosphere for half an hour," using an automated lighting system to create reflections on the golden membranes of the piezo speakers in the darkness of the auditorium, thus "reinforcing the hallucinatory atmosphere of the work."

The work also aims to recreate the movements of auditory hallucinations experienced in a ritual trance state through a dual-tuning model inspired by the Doppler effect. Depending on their position, the instruments and electronics are tuned to 440 Hz and 432 Hz, respectively.

The *ritual* instrumentation includes percussion, chordophones, and aerophones of simple construction, often diatonic and favouring modal melodies. These characteristics guide the selection of additional instruments alongside those already present in the ensemble (violin, viola, cello, double bass, recorders, electric guitar, and percussion): Waira, Ngongo, Kalimba, and Saxonette. The Mixolydian mode of the Saxonette determines the frequencies of the low register within the spectra used for real-time additive and granular synthesis in the electronic part, as well as the harmonic field of the instrumental ensemble.

The general frequency domain of the entire work is structured around two meta-fundamental notes, G-D-G, exploiting an ambiguity between the Mixolydian mode notes and a spectral arrangement of frequencies that merges harmony and timbre. Consequently, just as the temporal articulation of the ritual influences the management of musical time, the modal characteristics of the ritual's music shape the harmonic system of the work.

The overall structure follows an almost symmetrical arc, inspired by the primary stages of the ritual. This arc is articulated through the distinct distribution of fundamental perceptual parameters across each macro-section. Harmony and timbre are globally organised by this formal arc, which presents in each macro-section three spectrums/modes (with fundamentals G-D-G), three spectral states (harmonic, inharmonic, harmonic), and three specific frequency registers (lower, upper, lower harmonics). This formal pattern also dictates the density of textures, instrumental actions, and the spatialisation of electronic sound and lighting. The behaviour of these components is concurrently regulated by LFOs (low-frequency oscillators), which explore an array of types and velocities of predetermined and random trajectories.

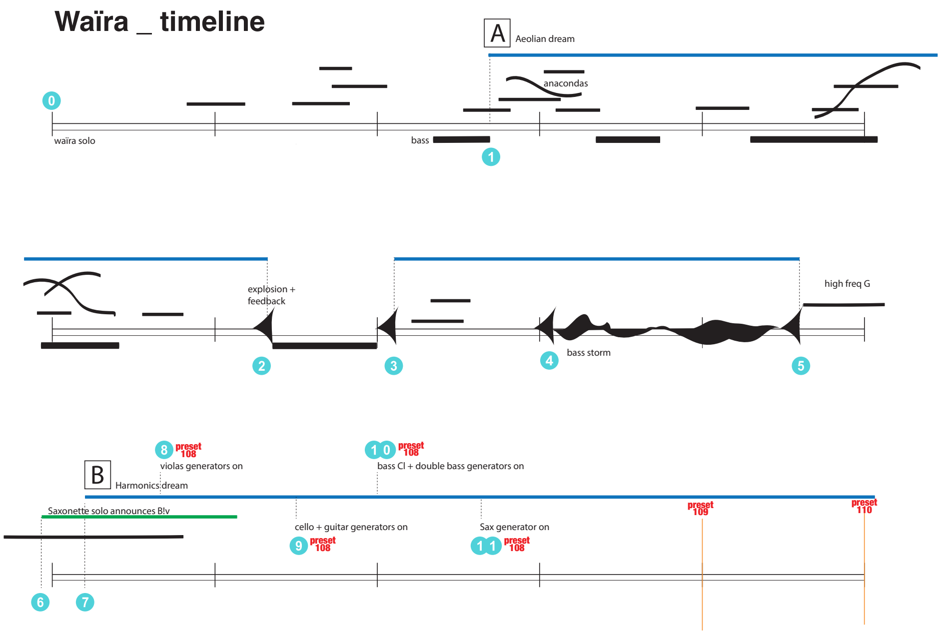


Figure 3.11, *Waïra*
First page of the score (Unpublished, © by Daniel Zea)

The quasi-deterministic approach of the global form, which orders specific moments, includes a contrasting element that allows for local emergent forms. This flexibility is enabled by a system that generates the synthesis of electronic sounds and a score for the performers in real-time. The additive synthesis generated in real-time determines the local harmonic field by assigning precise frequencies to the instruments, which are chosen at random—akin to the electronic part—among harmonics or partials of the spectrum within a precise register. Each temporal module contains a frequency register whose limits are progressively compressed, tracing an ascending line towards the high end of the given spectrum and then descending, following the predetermined arc shape to which we have previously alluded. The performers are also given flexible indications regarding the duration and morphology of the instrumental actions, allowing them a discrete margin of agency.

The dispositive conceived by Joly and Zea, combined with the real-time audio-visual generation system developed by the composer, creates a scenic and performative space for the artists, facilitating the realisation of the "hallucinatory, introspective, and ritualistic atmosphere" (Zea, 2024) modelled according to the temporalities of an ancestral ceremony envisioned by the creators.

Figure 3.12, *Waïra*'s panel
Detail of one of Alexander Joly's panels made or the 2024 Swiss performance of *Waïra* by the Vortex Ensemble at Festival *Les Amplitudes.* (Photo by © Alexander Joly)

Mutante/Amniótica (2018)

This section examines the genesis of *Mutante/Amniótica*'s dispositive, its role within the composable space, and its function within this work. It elaborates on the three dimensions of the dispositive—-the double bass, the on-stage double bass coupled with transducers and the speakers—-that emerged early in the developmental process of this work, outlining its components, significant attributes, shared elements, some initial spatial operations undertaken, and a description of the morphological fields of electronic sounds in this work. This section outlines the initial stages of the compositional process, beginning with a series of collaborative meetings with sound designer Daniel Zea during a three-stage residency at the cultural centre *l'Abri* in Geneva. It focuses on our experimentation with three specific areas of inquiry: the instrument/transducer coupling, the dispositive integrating both actual and virtual sound spaces, and sound spatialisation within this particular context. Furthermore, it details experiments with the technical objects involved and the progression of experiments before the premiere of *Mutante/Amniótica*.

This section highlights the concurrent strategies I employed to compose interactions among the various dimensions of the dispositive, the spatial composition, and sound spatialisation techniques, as well as the amplification of the double bass performed by the artist, which serves as another major component of this dispositive. Finally, it delineates its role within the composable space and its function within this work, detailing the localisation of sonic material within each dimension or its circulation among them.

***Mutante/Amniótica*'s Set-up**

Mutante/Amniótica was premiered on September 30, 2018, at the *Sala delle Colonne* of the Palace Ca 'Giustinian during the 62nd edition of the Venice Biennale's *Festival Internazionale di Musica Contemporanea*. The performance featured French double bassist Charlotte Testu and Colombian sound designer Daniel Zea on electronics. The work was commissioned by the Venice Biennale and co-produced by the Parisian CICM (MSH) and *l'Abri* in Geneva. This piece is part of a series I have composed in recent years, utilizing multi-dimensional dispositives. Some of these employ microphones, transducers, or loudspeakers coupled with acoustic instruments to form hybrid instruments or use instruments as resonators and acoustic filters.

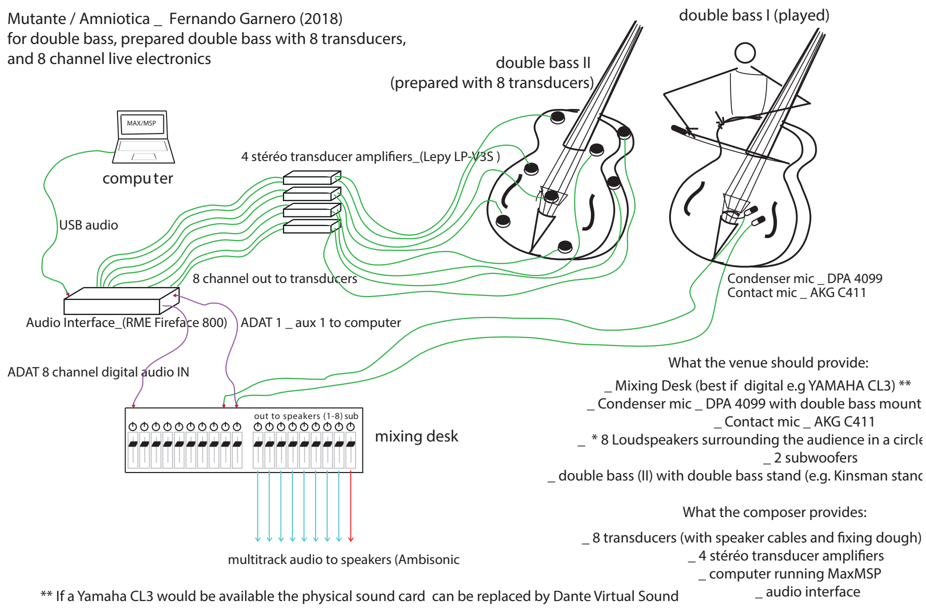


Figure 3.13, *Mutante/Amniótica*'s dispositive
Technical rider in the score (© BabelScores, 2018)

The dispositive created for this work consists of:

- A double bass, amplified with a DPA condenser microphone and a contact microphone. I will elaborate on the role of this dual amplification later in this chapter; however, it is not active throughout the entire piece. It represents one of three configurations used in *Mutante/Amniótica*. The double bassist is positioned stage right, from the audience's perspective.
- A second double bass mounted on a stand and connected to eight 10-watt transducers, which is positioned stage left from the audience's perspective. These transducers are affixed using a specialised adhesive designed for securing contact microphones to the resonance box. They are placed near or on the anti-nodes (the more resonant parts) and near or on the nodes of the instrument's body. The exact positioning should be reassessed each time, depending each instrument, according to the following distribution: three in front, three behind, and two on the sides—one per side, at varying heights. I will explain further in more detail when and why I chose this configuration.

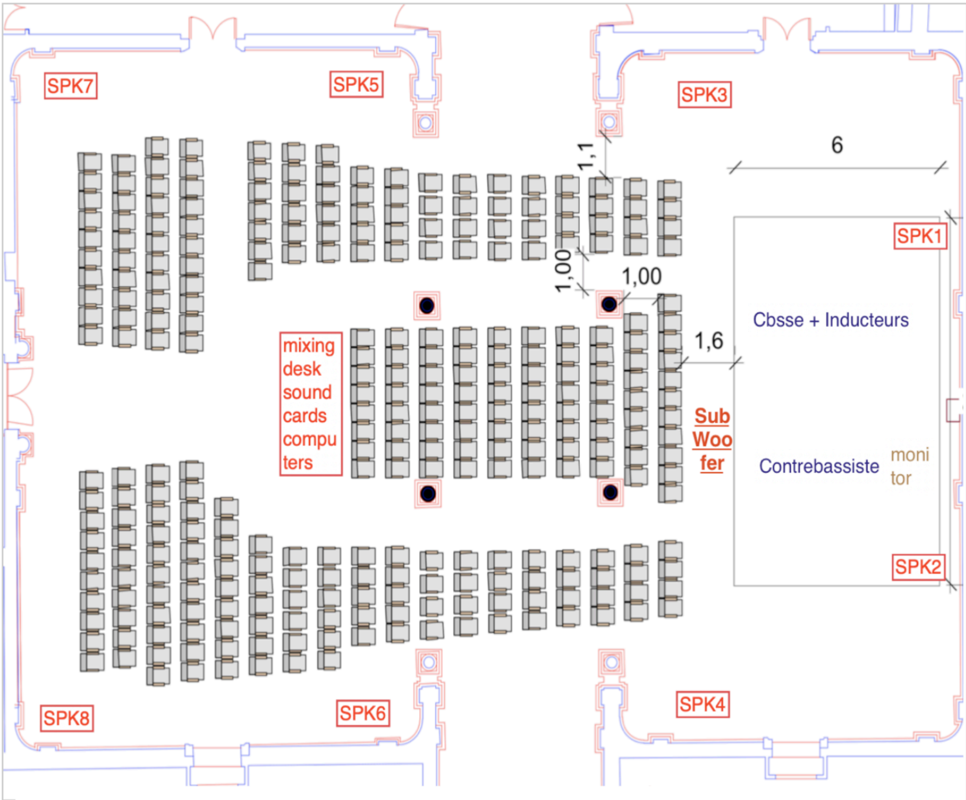


Figure 3.14, *Mutante/Amniótica's* speakers layout
Plan of loudspeaker layout in the space of the *Salle delle Colonne.*

This dispositive is completed by another component consisting of:

- Eight loudspeakers surround the stage and hall, with a subwoofer positioned in front of the stage.

Genesis of the Double Bass/Transducer Coupling Dimension in *Mutante/Amniótica's* Dispositive

I situate the genesis of the work's dispositive during initial meetings with the sound designer. I approached these meetings with an open mind, bringing an initial concept but remaining receptive to new questions and ideas that could arise from my initial intuitions, desires, and doubts, as well as my collaborator's proposals in response. Before my first meeting with Daniel Zea, I had already decided to use a multi-dimensional configuration. This expanded upon the original framework comprising double bass and electronics, which was the only constraint imposed by this commission. I envisioned this new component with equipment that would differ from, yet potentially complement, the loudspeaker's potential layout. It would be a modular apparatus designed to interact with these and integrate with other devices or instruments.

We had ample options to begin envisioning possible configurations for creating a multi-dimensional sound space that leveraged different couplings between instruments, loudspeakers, and microphones. In addition to the four loudspeakers available at the venue, we incorporated our computers, sound cards, four 10-watt and two 25-watt transducers, the three necessary mini-amplifiers, two microphones (one condenser and one dynamic cardioid), paste for attaching the transducers, and a double bass.

The first step involved scanning the instrument, focusing specifically on the resonance modes of the double bass. This was an empirical test, as a scientific analysis of resonance modes would be both costly and unnecessary for our purposes. This straightforward test entailed scanning the instrument's resonance box with a transducer while emitting **white, pink,** and **brown noise.** In this manner, we identified various nodes and antinodes, indicating areas of strong or weak resonance. We marked these positions with small pieces of glue paste.

Then, we experimented with families of sounds that had much smaller spectra to evaluate the instrument's response at these previously marked locations. Our goal was to define an empirical threshold of spectral conditions where no alteration in the transducer's position would yield a significant change in perceived timbre. These tests were designed to start delineating the boundaries of a possible range of sounds to be used. We also tested another series of sounds: **waves** (sinusoidal, square, triangular, rectangular, sawtooth), **samples** of various **orchestral *tutti*** moments (from Sergei Koussevitzky's *Double Bass Concerto, Op. 3*), and **stable granular textures** with contrasting densities. The selection of this type of sound is significant, as it aligns with my ongoing work over several years with complex hybrid objects that primarily consist of referenced sounds, noise, and instrumental/electronic sounds.

Figure 3.15, Experiments for creating an hybrid instrument
Testing the placement of transducers on a double bass. Photo by © Fernando Garnero

Upon completing this initial phase, we tested a configuration with the four 10-watt transducers attached to the resonance box of the double bass. The initial test informed the positions: one transducer was placed on a node and another on an antinode on the front of the instrument, with a similar layout on the back, all at varying heights. We experimented with several configurations within this "2+2" model framework.

We ultimately established two distinct approaches for sound diffusion through transducers:

- One approach assigns an independent voice to each transducer, and thereby localising the sounds.
- The other approach treats all the transducers as parts of a single device, focusing on the diffusion of sound based on its movement within this entire setup.

For the first approach, we developed an instrument using the Max software, creating a relatively simple patch. This patch permitted quick access to various sound types for listening and included a graphical interface that allowed us to swiftly assign dynamic envelopes and create variable metric cycles with minimal operations. This tool enabled us to rapidly model polymetric textures by coupling a distinct sound to each transducer. An abstraction in a sub-patch encapsulates the list of objects producing the available sounds: waves produced by low-frequency oscillators (LFOs); white, pink and brown noise; recorded samples (via the *sfplay~* object).

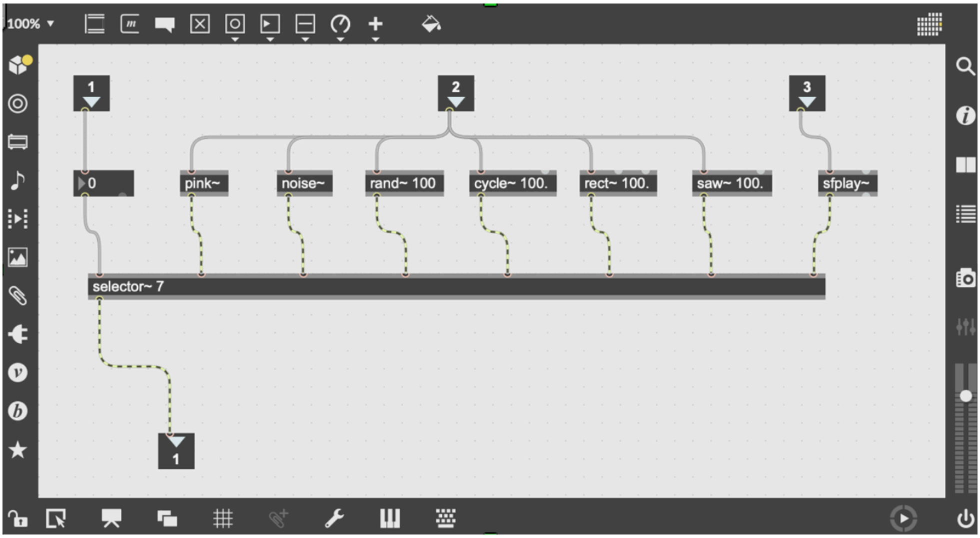


Figure 3.16, Testing localisation of sonic sources
Abstraction of the Max patch for testing sound diffusion through transducers resonating in a double-bass.

Cycle lengths and metrics are easily determined by assigning a time in milliseconds using the *metro* control object. The dynamic envelope of the played sound and the amount of silence per cycle can be directly drawn on the graphical interface of the *function* control object, enabling us to quickly explore a wide variety of configurations.

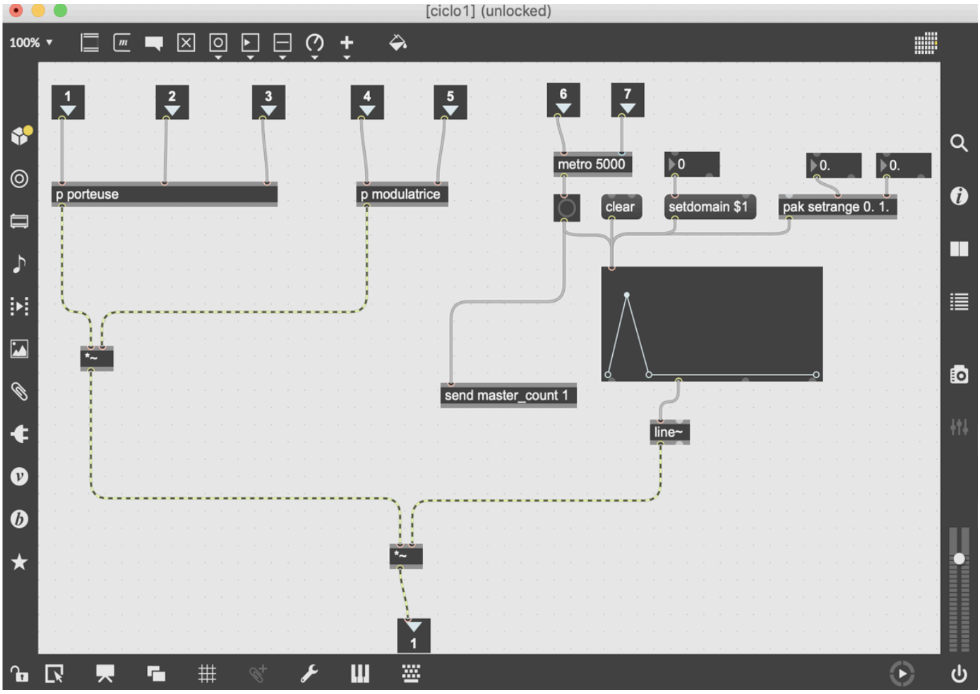


Figure 3.17, Shaping sound morphologies
Abstraction within the Max patch for length, metric and dynamic envelope assignation

We have also developed an optional amplitude modulation system to enable varied sound vibrato speeds. The nature and frequency of the modulating wave are determined within a separate abstraction, providing us with a selection of six distinct low-frequency oscillators (LFOs).

Ultimately, we expanded the initial module by a factor of eight to achieve the final transducer configuration. During testing, we integrated a system that enables automatic transitioning through various configurations after a predetermined number of cycles, which will be determined in one of the modules selected as a reference. The image on the subsequent page illustrates the first level of the patch, where it is possible to specify the type of sound source and its frequency (in the case of waves), the type and frequency of the modulating wave, and the cycle duration. Additionally, we developed an optional amplitude modulation system, primarily designed to provide different vibrato speeds to the sounds. The type and frequency of the modulating wave are determined in a separate abstraction, which also offers a selection of six different low-frequency oscillators (LFOs).

Finally, we expanded the initial module by a factor of eight to achieve the final transducer configuration. During testing, we incorporated a system that enables automatic transitioning through various configurations after a yet-to-be-determined number of cycles within a reference module. In the image below, the first level of the patch is illustrated, allowing for the specification of the type of sound source and its frequency (in the case of waves), as well as the type and frequency of the modulating wave, alongside the duration of the cycle.

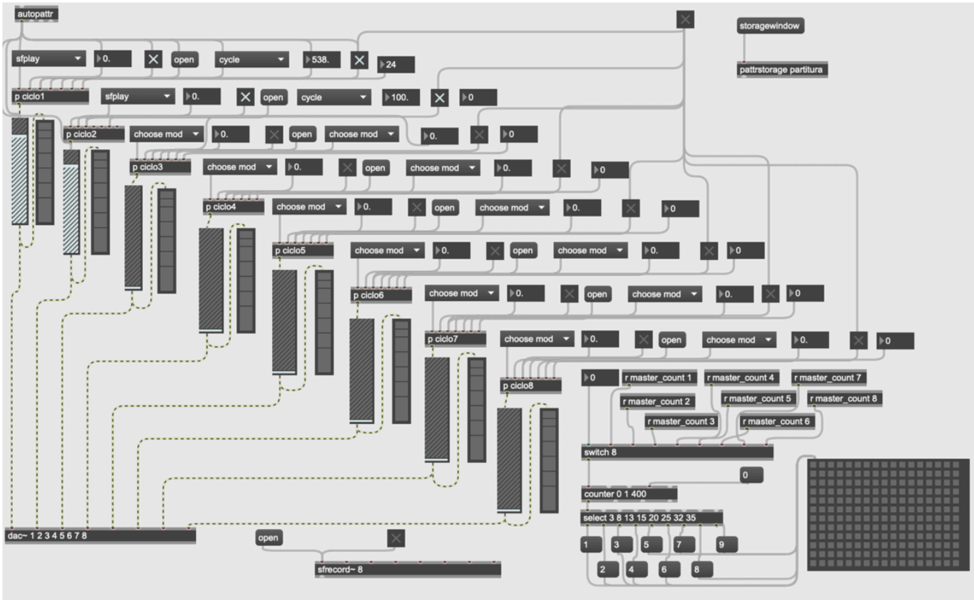


Figure 3.18, Amplitude Modulation and Source Configuration within the Max Patch
Abstraction within the Max patch for amplitude modulation, determination of cycle lengths, and configuration of sound sources for each transducer

The design of the instrument for the second approach—centered on the movement of sound within the dispositive—is aligned with the underlying methodology chosen for the virtual space of the loudspeakers, which I will elaborate on immediately afterwards. The instrument developed with Max is nearly identical in both contexts; however, its application yields different outcomes in each scenario.

In summary, the most significant outcomes of this initial stage of experimentation were:

- The development of a device for exploring the actual sound space and interacting with the virtual spatial dimension of the loudspeakers and the amplified acoustic instrument.
- The development of a transducer placement model for this device that considers the antinodes and nodes of the instrument's resonance box, distributing four

transducers in the front and four in the back of the instrument to construct a multi-layered sound diffusion system within this multidimensional dispositive.

- The establishment of two initial complementary approaches to sound diffusion through this instrument: the first approach assigns a voice to a transducer, enabling the perception of the source's location, while the second approach focuses on facilitating movement through the device.
- The widespread application of low-frequency oscillators (LFOs) for the control of sound spatialisation.
- The initial stages in constructing a morphological field for *Mutante/Amniótica*'s composable space through the definition of the primary electronic sound objects.

Speakers Dimension in *Mutante/Amniótica's* Dispositive

During this first three-day residency, we explored the issues surrounding loudspeaker diffusion systems, and its possible interactions with the on stage double-bass/loudspeaker. Initially, we correlated the modules of the sound diffusion system by testing different 4+4 loudspeaker arrangements in the space, following the model of the transducer placement on the double bass. This enabled me to identify the main questions concerning sound spatialisation in this dimension of the dispositive as follows: the distribution of loudspeakers in the space; the sound spatialisation system for this layout; an initial definition of the spatial morphologies at play; a preliminary definition of the types of relationships and possible interactions among dimensions; and a determination of the fundamental attributes of a sound source spatialisation tool based on these issues and the compositional approaches and envisioned strategies.

We investigated with Daniel Zea several sound spatialisation systems, including the fundamental approach of assigning a sound to a source designed for the counterpart dimension of the dispositive. Early in the process, we opted to concentrate on systems employing signal attenuation and source convolution algorithms. After evaluating various options, we resolved to implement Ambisonics systems. Subsequently, we conducted preliminary tests using the Max Ambisonics spatialisation objects developed by the Institute for Computer Music and Sound Technology (ICST) at the University of Zurich. This was undertaken to design an instrument that aligns with my approach to spatialisation and the compositional strategies under consideration.

After some experimentation and discussion, we have developed an initial approach to defining morphologies for sound spatialisation. This approach articulated our morphological field into three main categories: the first is defined according to a stratification model (localisable sound sources), the second is inspired by a wave-like paradigm (sound trajectories morphologies), and the third is based on a granular paradigm (including stable, directional, and aleatory spatial textures of variable density).

This initial definition of the field of spatial morphologies played a crucial role in shaping the conception of our digital tool. Equally influential was the consideration of the types of relationships and potential interactions anticipated between the two dimensions of the dispositive. To establish a comprehensive framework, I refined the options to three models: replication or juxtaposition, convolution, and the integration of the two dimensions into a single sound diffusion and spatialisation device. This definition facilitated the design of the final structure of our digital sound spatialisation tool.

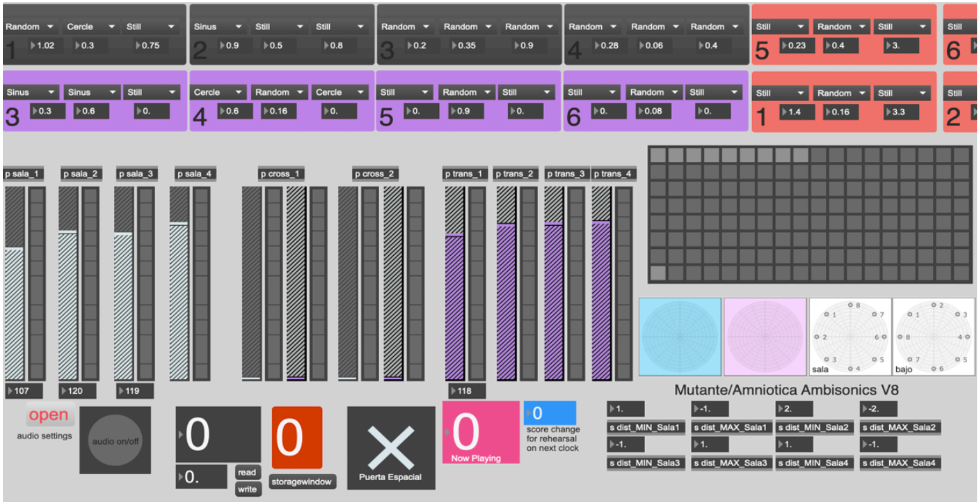


Figure 3.19, Spatialising sound among dimensions
The first level of *Mutante/Amniótica*'s real-time sound spatialisation Max patch realised with Daniel Zea

This experimental process facilitated the development of a general approach to sound space, driven by the necessity to operate multiple modules concurrently. It also enabled us to model our field of spatial morphologies according to specific behaviours, which are organised into the following categories: random movements (typically rapid and associated with granular textures), trajectories (wave-like morphologies), and stratifications or diffuse localisation (textures and spatial figures that move very slowly).

The initial level of this patch corresponds with my original definition of the field of spatial morphologies, allowing users to select behaviours and specify the values of spatialisation parameters—such as azimuth, distance, and elevation. These options include the stratified location of sonic sources (*sig~*), unidirectional circular trajectories (*cycle~*), bidirectional consecutive motion (*phasor~*), and random movements (*rand~*).

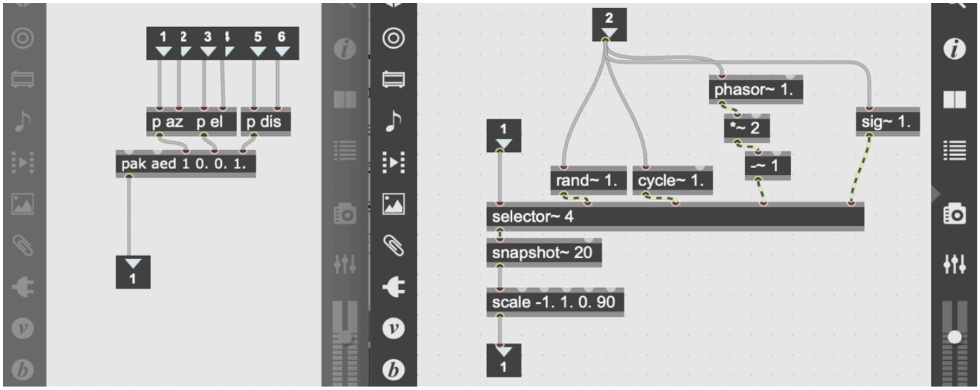


Figure 3.20, Shaping spatialisation with LFO
Abstractions within the Max patch encapsulating the spatialisation parameters controlled by Low-Frequency Oscillators

The architecture of this real-time sound spatialisation tool served as the foundational framework for the patch's final design, enabling each dimension to encompass up to four simultaneous behaviours. Integrating these elements has facilitated the implementation of one of the anticipated interactive models, which involves juxtaposing the two primary dimensions of the dispositive.

Dynamic Spatial Convolution among Two Dimensions

We have developed a spatial convolution module that facilitates cross-fade operations across two dimensions. This module comprises two components for each dimension, enabling interpolation across up to two concurrent spatial configurations. The underlying principle is straightforward: an interpolation occurs between two spatial configurations within each dimension, with adjustable speed. A primary consideration was to design an instrument capable of accommodating the disparities between the components of each dimension. The multi-dimensional dispositive is fundamentally based on these differences. However, at macro-structural levels, it occasionally operates as a unified entity, particularly towards the conclusion of the piece.

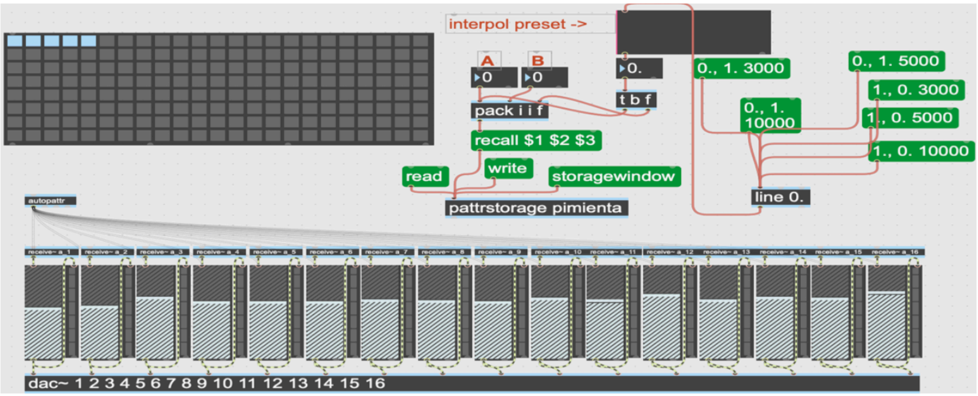


Figure 3.21, Spatialisation convolution
The first level of the sound spatialisation Max patch for testing spatial convolution

This dynamic spatial convolution tool was incorporated into the concert patch of the piece during one of the final stages of the composition process for *Mutante/Amniótica*. In our initial residency meetings, we identified this challenge and conceptualised an instrument to assist in modelling the musical scenarios envisioned in my workspace. This setup consists of two loudspeakers paired with four transducers, which are attached to various resonant cases—such as a violin, guitar, metal cases, and surfaces made of diverse materials. The tool developed is fundamentally straightforward: its primary function is to interpolate between two configurations at a determinable speed. This uncomplicated tool allowed for the rapid and efficient exploration of a vast array of spatial configurations, enabling the testing of speed variations based on factors such as instruments, materials of resonant boxes, distances, and, most importantly, the composition and morphology of the diffused sounds. This tool proved invaluable in composing transitions or passages between interpolated sections within these two dimensions. It was particularly crucial in defining shared or analogous objects and/or figures that generate convolutions at micro- and meso-temporal scales. The testing phases conducted with this instrument facilitated the identification of specific figures or objects possessing distinct morphological characteristics. These elements ultimately became central to the work, with their internal composition deemed particularly attractive or effective for the intended operations. This determination was made during the writing and composition process rather than in advance. The experiments conducted with this instrument at various stages of the compositional process contributed to the development of a contextual expertise, some aspects of which are unique to the compositional space of this work. This expertise was crucial during the writing stages, following its inherent logic. This logic emerged from the foundation created by the cumulative trials and evaluations performed with the instrument, as well as from subsequent reflections and ideas that surfaced throughout the creative process.

Intersecting Sound Morphologies

An initial characterisation of a common sound morphologies field for cross-fade and convolution operations emerged during this phase of experiments involving interactions between virtual and actual spaces. I applied identical spatial morphology configurations to a set of sounds, alternately diffusing them across multiple dimensions. Subsequently, I experimented with varying interpolation speeds, juxtaposition configurations, and replications incorporating phase differences. Through these methods, I gained insights into the transformation of loudspeaker space into timbre within this hybrid instrument. I observed how the movement of the sound source translated into changes in the spectral envelope and how a trajectory resulted in a *bisbigliando* effect. I chose to explore this relationship further. This understanding was generalised through the development of distinct components within the sonic material, with an emphasis on the intersections of objects, time scales, and morphological continuities that could link the diverse dimensions of *Mutante/Amniótica*'s dispositive.

The composable material, spanning multiple temporal scales at the intersection of the amplified double bass dimension and the loudspeaker dimension, comprises a superposition of interactive strata consisting of complementary cycles of varying durations. This space includes several networks of figures and objects that circulate across all structural levels, resulting in complex sand entities with emergent properties.

Conversely, the intersection formed by the amplified double bass and the second double bass coupled with transducers predominantly consists of a single network of objects and figures, with morphologies circulating across a limited number of temporal scales. The interactions between the amplified double bass and the hybrid instrument, created by coupling the second double bass with eight transducers, are transparent and readily perceptible. In contrast to the complexity of complementary cycles of object networks with varying durations that circulate across multiple temporal scales in the first intersection of components, the material of this second intersection comprises a superposition of polymetric cycles of a limited set of sound morphologies across a single temporal scale.

On Double-Bass Amplification

In collaboration with Daniel Zea, we experimented with various amplification configurations using the two available microphones, the DPA and the contact microphone. We maintained the approach of assigning a specific type of amplification to each intersection of the dispositive's components, with one emphasizing power and the other focusing on definition to accentuate the micro-phenomena associated with techniques that produce various noises or noisy sounds. However, following the initial rehearsals, while preserving this foundational configuration, we introduced instances of dual amplification at both dimensional intersections, thereby increasing the flexibility of the amplification system. I utilised the three possible configurations more liberally, still grounded in a fundamental principle of block assignment, a principle more rigorously observed in the intersection involving the amplified double bass and the double bass coupled with transducers.

Conceiving Electronic Morphologies

By the time I undertook the composition of the electronic part, I had already established the first structural definitions of *Mutante/Amniótica*'s composable space. The most significant aspect of this framework was the delineation of two primary intersections among the three principal components of the multi-dimensional dispositive: the instrument/transducer coupling with the amplified instrument and the amplified instrument with the speakers. This involved assigning a distinct morphological field to each intersection and culminating in a comprehensive configuration that unified the entire system into a singular sonic space. Each field, along with its common elements, was evaluated concerning the tension between techniques derived from granular and ondulatory paradigms. Consequently, this initial stage in composing the electronic part required a definition of the sound morphologies based on their association with two distinct planes:

- The first plane involved complex objects targeting orders of meso-structural temporal scales, which were composed of sounds with contrasting attributes. These sounds were categorised within the realms of noise, historical and cultural references, and electronic synthesis. The morphology of the sounds constituting these complex objects may share elements with instrumental figures, thereby creating a rich potential field for interaction. Such morphological correlations and interaction fields could be positioned as an acoustic "foreground" as they engage with similar magnitudes of temporal scales. This aligns with the temporal domain of sound closest to language, which Gérard Grisey referred to as "the time of language and breathing.“ (Grisey, 2008).
- The second plane included complex textures with stable, directional or chaotic emergent properties. These textures are predominantly created using various granular synthesis techniques and digital tools. Operating within the micro-time domain, they tend to have interactions with other electronic sound objects and instrumental figures that are less immediately perceivable. Shared elements, including sound sources and compositional operations, contribute to a unified morphological field. While the same operations may be applied, the resulting sonorities exhibit distinct morphologies across these different sonic strata.

After the tests that had already been conducted and the emergence of initial intuitions within a developing contextual knowledge, it became necessary to identify the initial challenges relating to the composition of electronic sound morphologies, specifically:

- What types of morphological attributes could define a relevant articulation for the morphological field of each intersection?
- What categories could be derived from this articulation?
- What sound morphologies or morphological attributes could become common elements of the two corresponding intersections within the composable space?
- What sound morphologies or morphological attributes might be the most effective for cross-fade and spatial convolution operations between the speakers and the instrument/transducer coupling dimensions?

I was thus able to formulate an initial definition of the morphological fields present in each intersection. For the intersection involving the loudspeakers, I established two distinct planes:

- The first was composed of a network of objects constituting a complex entity, encapsulated within a multi-track *buffer*. The derived morphologies would be deployed in meso-structural temporal scales, with their primary attributes described in the first morphological plane defined earlier.
- A second plane was composed of various strata of textures, to which sonorities conceived within the wave-based (ondulatory) paradigm could be added or omitted. I reduced the number of strata to three. The first consisted of continuous granular textures, derived from both instrumental and electronic foreground sources. The second comprised chaotic, noisy textures and wave-based chaotic sounds, produced using a custom-designed instrument capable of generating band-filtered feedback, alongside oscillators and additive synthesis. The third stratum featured sparse textures built from the superposition of irregular temporal cycles, primarily composed of very short noisy sounds, glitches, and brief granular sonorities derived from samples of attacks and noisy instrumental material.

As for the second dimension, the one that includes the pairing of the second double bass and the transducers, I also drew up two separate plans:

- A first plane comprises a network of objects including: waveforms and/or additive synthesis generated with LFOs; voice recording samples; white, pink, and brown noise; and dry, noisy percussive attacks—ultimately composed using physical modelling synthesis from percussion instruments.
- A second plane features a directional texture built from sonorities belonging to the same morphological categories as the first, though constructed through different processes. It also incorporates elements shared by both morphological planes.

Upon completing this initial stage of definition, I proceeded to edit, produce, and categorise sound samples, organising them into lists. These samples were intended for various applications, including different types of resynthesis, the formation of complex objects or networks of objects, and experimentation. Some of the samples within these folders became the “keys” of a virtual keyboard featuring various registers. The most significant electronic sounds were categorised based on whether they were:

- *Double bass samples* for processing or re-synthesising.
- *Recuperated sound samples:* fragments of speeches and segments from Koussevitzky’s Concerto, divided into three groups (tutti, soli and cadential moments).
- *Glitchy short sound samples*.
- *Noisy sound samples.*

Some Final Observations

The creation of this work has enabled the identification of compositional strategies for working with dispositives that integrate electronic sound devices, acoustic, and hybrid instruments. It has also clarified specific methods for composing with complex setups involving diverse equipment. Engaging with this variety of devices and instruments—across different temporal scales—demands a multi-scale and multi-local approach to composition.

The experimental process behind *Mutante/Amniótica* revealed how musical form can emerge from local interactions among sound objects, moving away from artistic methodologies based on a rigid distinction between form and content. This approach calls for “flexibility at the level of doing and not at the level of how” (Varela, 1996).

I consider the conception of the dispositive to be the first compositional act, and the experiments with it as the moment where the initial individuation occurs. Treated as an extended instrument from the outset, the dispositive is endowed with specific functions, ranges, and its own ‘extended techniques. ’By integrating its physical complexity and symbolic potential into the compositional process, the dispositive becomes a space of articulation—part of the composable.

Les sons ne sont pas des hommes (2020) & Contraccolpo (2020)

Introduction

This section explores the use of several multidimensional sonic dispositives in two recent compositions created during my 2020-2021 residency at the French Academy in Rome. I will first present the setup of the sound installation *Les sons ne sont pas des hommes* (2020), the specific context of its inception, the main musical ideas that underpinned its compositional process, its sonic material and the integral role of spatial operations in its development. Secondly, I will examine the series of experiments that culminated in the creation of the sonic dispositive employed in my work *Contraccolpo* (2020), present its distinctive setup, and finally discuss its implementation and the sonic material that comprises this composition.

Dispositive of *Les sons ne son pas des hommes* (2020)

Les sons ne sont pas des hommes is a site-specific sound installation conceived for the vineyards of the historic gardens of Villa Médicis, which premiered at the *Nuit Blanche/Notte Bianca* festival in October 2020. This eight-channel fixed media composition integrates recordings made on-site at the exhibition venue with synthetic sounds, recovered samples, and excerpts from previous works.

Figure 3.22, *Les sons ne sont pas des hommes*
A frame of the video realised by © Alexis Moreano-Banda (2020)

Created during the COVID-19 pandemic, the work was influenced by the unique circumstances of the time, shaping its creation, production, and subsequent exhibition to limited, rotating groups of listeners who were free to move along the internal pathways.

The vineyards of the Villa Medici, established in the mid-16th century, are located in two gardens known as the *Carrés*. The specific *Carré* used for this work features eight vineyards arranged in pairs, divided by small paths and a central clearing. The sound installation comprises eight arrays of nine piezo microspeakers each, powered by eight amplifiers and integrated into the structures supporting each row of vines; a 50-watt speaker and a subwoofer situated in the *Carré historique*'s central clearing, orientated toward the garden entrance; and a mixing console and computer running Max software for sound playback and real-time control of an ambisonic spatialisation system.

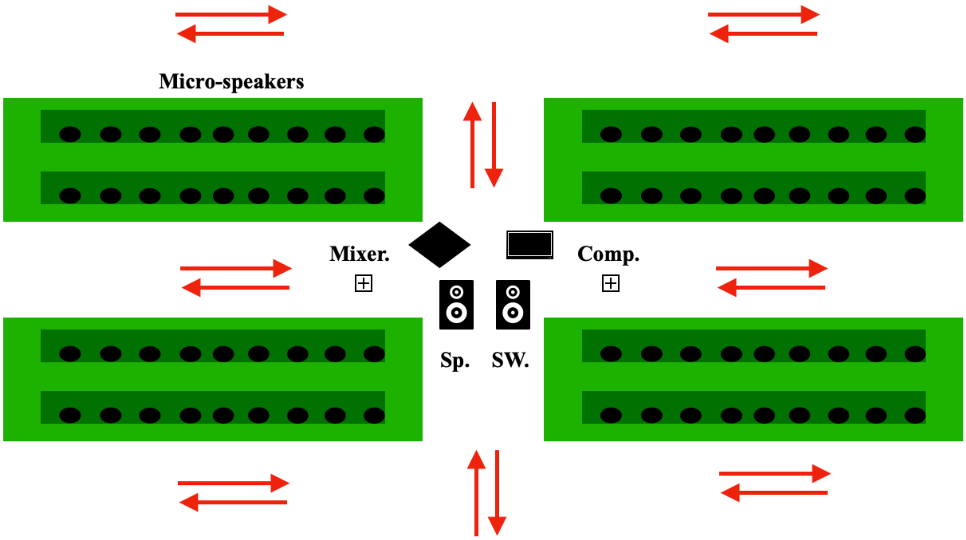


Figure 3.23, *Les sons ne sont pas des hommes*
A graphic of the dispositive © by Fernando Garnero

The exhibition took place in the first month of autumn, a time when the vines, having shed their fruit, still retained a significant amount of leaves in a range of autumnal colours. This setting provided partial camouflage for the installed micro-speaker arrays, which were arranged symmetrically along the rows of the vineyard.

About Sonic Context and Sound Material

Concurrent renovations near the vineyard added to the existing garden soundscape while composing and premiering this installation. The resulting overlap between construction and visitor schedules led me to integrate the construction sounds into the eight-channel fixed-media composition.

The primary objective was to develop a work that explored the interplay between the acoustic environment of the site during its conception and a hybrid composition that included musical morphologies derived from the existing ecosystem of sound and excerpts from previous compositions. This constructed soundscape, positioned at the nexus of the real, the imaginary, and the autobiographical, sought to establish a sonic continuum bridging representations of nature and culture.

The initial compositional process involved designing the sound installation's dispositive and making field recordings on-site. These recordings, captured from various positions and times of day within the vineyard, utilised directional microphones to isolate recurring sound phenomena—such as birdsong, construction noises, and workers' voices—while an omnidirectional microphone captured the overall sound environment from different listening points throughout the day.

Figure 3.24, *Les sons ne sont pas des hommes*
A frame of the video realised by © Alexis Moreano-Banda (2020)

After an extensive editing process, I conducted an initial categorisation of the collected sound material based on its duration (medium or short) and content (ambient sound or discrete sonic event/phenomenon). This categorised material was then supplemented with excerpts from earlier works (primarily short samples), synthetic sounds designed to morphologically resemble recurring sounds recorded *in situ* (notably birdsong, voices, and percussive noises), and digitally processed ambient sounds, primarily manipulated through granular synthesis.

This process led to the creation of several distinct sound layers, differentiated by their duration and morphology. The short-duration layer included samples derived from field recordings, morphologically similar synthetic sounds, and samples drawn from previous works. The medium-duration layer consisted of excerpts from unaltered or digitally modified field recordings of medium-length, excerpts from earlier works, and complex textures constructed from the aforementioned short samples. To generate these complex textures, I developed a sampler bank containing all these fragments and created a custom patch for algorithmic control. Using the AC Toolbox software developed by Paul Berg at the Sonology Lab in The Hague, I analysed a MIDI transcription of birdsong fragments recorded on-site to generate polyphonic textures from multiple superposed variations obtained with Markov chains. The pitches and rhythms of these textures governed the activation and onset of the samplers, which generated complex granular textures exhibiting behaviour analogous to that of a biological organism. I composed a twenty-minute electronic work conceived as a circular loop from this sonic material. The eight-channel fixed-media composition *Les sons ne sont pas des hommes* presents a constructed soundscape, devoid of any musical dramaturgy indicating a discursive progression, within which a clear beginning and end are indistinguishable once the listener is immersed.

Sound Spatialisation

This site-specific installation serves two key functions in the spatialisation of the sounds and textures that make up the eight-channel fixed media layers. Firstly, it acts as a defining parameter—much like dynamic envelope or rhythm—shaping the morphology of sound objects and textures composed of object networks. Secondly, it functions as a tool for articulating musical flow at meso- and macro-temporal scales, while also operating on emergent sound objects at micro-temporal levels, particularly in the case of complex granular textures.

For real-time spatialisation of sound sources, I employed a third-order Ambisonic system using object-based technology developed by ICST (University of Zurich) to create a Max patch. This patch controls the spatial behaviour of five distinct sound layers using low-frequency oscillators. Spatial behaviour is primarily determined by azimuth and distance, and secondarily by elevation.

Figure 3.25, *Les sons ne sont pas des hommes*
A frame of the video realised by © Alexis Moreano-Banda (2020)

Three families of spatial morphologies are defined to organise these behaviours:

- ***Localised Sounds.*** Sound objects within this family circulate on meso-temporal scales, providing local articulation within the musical flow. However, the superposition of these fixed, regularly repeating sound objects gives rise to an emergent network of objects that circulate on macro-temporal scales, exerting a global influence on the work's progression. This emergent network forms a spatio-temporal mosaic defined by the phase differences of its constituent objects, which are perceptually rich due to both their sound morphology and semantic connotations. This spatio-temporal morphological family is composed of samples representing extra-musical sonic realities, such as fragments of birdsong, tool sounds, human voices, and sirens, among others.
- ***Sounds with Specific Movements.*** This family consists of morphologically heterogeneous sound objects and textures of contrasting durations, which circulate across different time scales. The morpho-spatial behaviours encompass unidirectional, circular, and zig-zag movements, implemented using a phasor (a linear low-frequency oscillator operating as a ramp or sawtooth wave). They also include bi-directional circular movements controlled by a sinusoidal low-frequency oscillator. The speed of these movements varies considerably (from very fast to very slow), and incorporates both accelerations and decelerations. The sound objects and textures within this morpho-spatial family create intersections between the real, the imaginary, and the autobiographical, exploring a sonic continuum that bridges representations of culture and nature.

- ***Sounds with Random Movements.*** This family comprises granular polyphonic textures, exclusively constructed from short samples. Their movements and velocities are inherently unpredictable.

Contraccolpo (2020): Experiments with Noise

This work, commissioned by the Spanish ensemble Vertixe Sonora, was also composed during my residency in Rome, within the specific context of the COVID-19 pandemic. The project's genesis lay in the revision of a previous work, *Tête-Carrousel* (2016–2017), a composition for saxophone and percussion. *Tête-Carrousel* emerged from my explorations of a particular type of hybrid instrument, created through the structural coupling of microphones or loudspeakers with instruments or other objects. The instrumentation for *Tête-Carrousel* consisted of two modular instruments: Feed-Tom and Filter-Sax. Feed-Tom, which will be discussed in detail in the chapter on instrumental feedback, was originally conceived for my work *Fabulae* (2016) and results from the coupling of a tenor tom-tom, a contact microphone, a mobile woofer, and analogue pedals. Filter-Sax is created by coupling a saxophone with a woofer placed within its bell. From this earlier work, only the Filter-Sax component, the insights gained (though I considered the compositional experiments unsuccessful), and the impetus to continue investigating the musical and instrumental possibilities of coupled microphones/loudspeakers and instruments/objects ultimately persisted.

The composition of *Contraccolpo* began with the development of a focused experimental framework, addressing the less defined and inarticulate aspects of *Tête-Carrousel*. This framework was established through a two-step process. Initially, I identified two epistemic things: the generation of noise and its subsequent mechanical filtering. Subsequently, I selected the necessary technical objects to accomplish this research: a *Naint X-X* omnidirectional microphone, a woofer, instruments and other objects, and the electromechanical components required for sound production. This selection process culminated in the choice of the snare drum as the most versatile percussion instrument for investigating noise production with a contact microphone applied to various surfaces.

Figure 3.26, ***Microphone***
A photo of the omnidirectional condenser microphone *Naiant X-X* used in *Contraccolpo*

The initial phase of experimentation, which ultimately defined the configuration of the *Contraccolpo* multi-dimensional sound installation, was executed in two stages, each dedicated to one of the hybrid instruments.

- ***Microphone/Snare Drum & Objects.*** This phase focused on a series of experiments designed to produce varying qualities of noise using the microphone. These experiments explored different interactions—rubbing, pressing, tapping—between the microphone and various surfaces on the instrument and other objects, seeking to create contrasting sound textures. This process led to the development of a range of instrumental techniques, informed by considerations such as the resulting sound morphologies, ergonomic factors, and the articulatory capacity of each technique on a given material. Furthermore, different configurations for the production, control, and modification of the microphone's signal were tested, with particular attention paid to three key parameters: signal and dynamic envelope control (compression/limiting); spectral content manipulation (equalisation); and signal distortion.
- ***Filter-Sax***. This stage focused on experiments examining the mechanical filtering of the digital signal diffused through the instrument. The primary manipulation

involved altering the tube length, thereby affecting its resonance modes. Three woofers, each possessing distinct characteristics, were tested. A series of empirical tests using various fingerings was conducted to measure the instrument's response within each resonance mode, analyse the characteristics of frequency filtering, and investigate the phenomenon of "localised" spatialisation—defined by sound diffusion through the last open hole of each fingering. These tests also aimed to establish an appropriate method for re-amplification. The experimental design incorporated three distinct types of incoming signals, ranging from spectrally rich signals (white, pink, or brown noise) to spectrally sparse signals (recorded feedback from a Feed-Sax and the *Naiant X-X* microphone within a cardboard tube and human and synthetic voices).

Contraccolpo's Dispositive

The *Contraccolpo* multi-dimensional dispositive is designed as a flexible configuration, adaptable to the specific context and available materials. The construction guidelines are thus intentionally open to some variation. Although a Naint X-X microphone is the ideal choice, its discontinuation necessitates the use of a comparable analogue model. Instruments from the saxophone family are preferred (baritone, tenor, or alto), but other instruments may be used provided they meet the minimum requirements for a successful performance. The work premiered in Spain in 2021, performed by Vertixe Sonora using a baritone saxophone. Lucilin subsequently presented two versions (in Luxembourg and Sweden), one featuring a tenor saxophone and the other an alto saxophone. Future performances are planned for 2025–2026. Vortex (Switzerland) will perform two versions with bass clarinet (in Poland and Switzerland), and KNM (Germany) will perform two versions with contrabass clarinet (in Argentina and Germany).

For its premiere performance in Lugo, *Contraccolpo* employed a dispositive comprising a baritone saxophone with a woofer affixed to the opening of its bell. The woofer should fully encompass the bell's circumference, which typically measures between 15 and 20 cm in diameter, depending on the specific saxophone model. A woofer with a power rating of at least 100 W and a maximally wide frequency response is recommended for this instrument configuration.

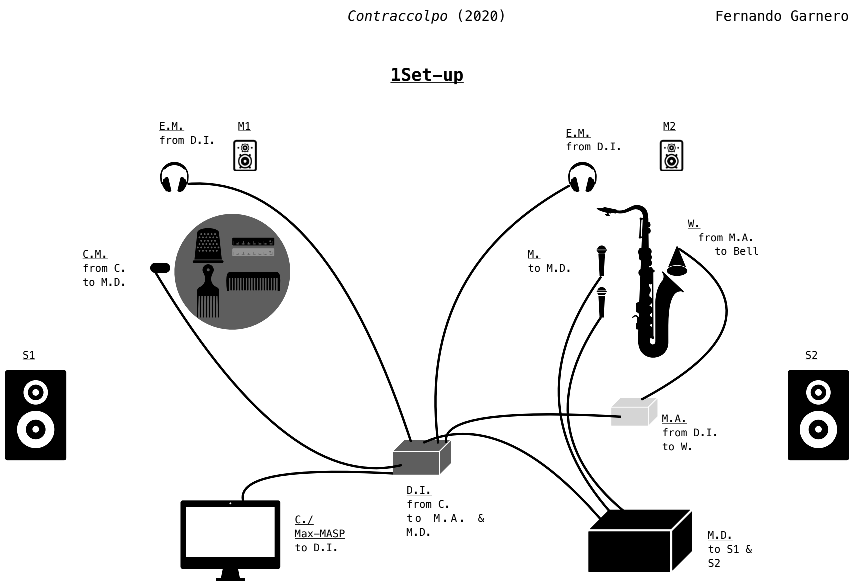


Figure 3.27, *Contraccolpo's* set-up
Rider incorporated in the unpublished score

The second performer's instrumentation consists of a snare drum, the previously mentioned microphone (or a suitable analogue alternative), and the following items, which are placed on the instrument's batter head: two buckle tapes, each approximately 10 cm in length (one soft and one hard); a hard brush; a 20 cm flexible metal ruler; and a small metal grid. For optimal performance, a second snare drum, inverted, is recommended to facilitate the specialised instrumental technique of rubbing the microphone against the snares.

The complete setup includes an amplifier, a mixing console or sound interface (phantom power is required), at least two directional microphones for the re-amplification of the Filter Sax (or any analogous instrument used), a MIDI pedal, two high-frequency in-ear monitors (for the click-track), two speakers positioned on stage, and two additional monitors (optional).

From Noise to Figure: Compositional Strategies in *Contraccolpo*

The compositional strategy guiding this work centred on establishing varying degrees of analogy between the sound morphologies produced by the installation's two components, each designed for distinct functions of sound production and filtering. While the research focused primarily on noise, the composition also integrated experiments on mechanically filtering voices and feedback. This is manifest in the sound material diffused by the woofer. This succinct material is characterised by the decreasing richness of its spectral content, from white noise to wave-like Larsen tones. This process generates an underlying global non-linear process, which can be summarised as follows:

- **FILTERING: Noise-> Articulated Noise-> Voices-> Wave-like Larsen tones.**

Within the initial family of noises diffused into the Filter-Sax, several distinct components are distinguished and arranged according to the overarching compositional strategy of establishing analogies between the hybrid instruments. The first components consist of alternating short samples of white, pink, and brown noise. These are then followed by samples of the same noise types, but now incorporating digitally generated rhythmic envelopes with various *accelerandi* and *rallentandi* patterns.

The Filter-Sax exhibits a limited range of instrumental morphologies. The progression begins with its sole function as a filter for incoming noise. This is followed by the introduction of rhythmic envelopes generated by key action. The final stage involves the integration of sustained disturbances, such as trills and *bisbigliandi*.

The second experimental phase, utilising the already established *Contraccolpo* dispositive, was dedicated to developing instrumental techniques for noise production using the microphone. These experiments resulted in sound material that ultimately crystallised into distinct instrumental morphologies, which were then employed in the composition of musical figures. These figures embody transformations characterised by significant shifts in timbre, resulting from both the specific mode of sound production and the materials employed. These transformations mirror the framework of the preceding experimental phase, which organised the research on noise production and filtering based on the materials used. Consequently, I was able to identify distinct morphological characteristics within the continuum of noise generated by the components of the multi-dimensional installation. An ordering axis emerged from these experiments, subsequently serving as a guide and connecting link between the hybrid percussion instrument and the Filter-Sax. This axis focused on changes in texture within the noise continuum, progressing from a highly dense state to a sparser state. This axis was developed by conceptually transposing the grain separation parameter, a concept from granular synthesis, into the symbolic domain and materialising it as a "scale" of timbral textures.

- **NOISE: Dense-> Sparse -> Articulated/Güero-Like -> Resonant**

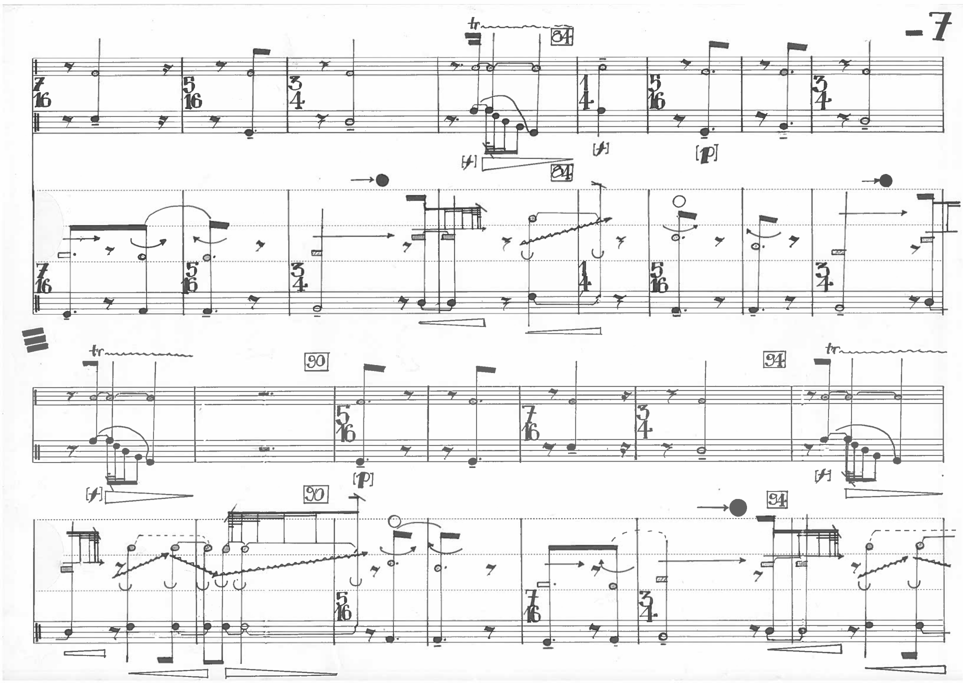


Figure 3.28, *Contraccolpo* (2020)
Page 7, unpublished score

The development of the first principal figure follows this morphological order, progressing from simple gestures to more elaborate ones and transitioning from materials that facilitate the creation of dense, textured noises to those that yield more dispersed textures. In addition to this progression, other criteria were considered, notably the spectral richness of the noise and the possibility of sweeping. The organisation of this first figure can be summarised as follows:

- **Figure 1:** <u>Batter-head</u>: reduced noise frequency band; dense granular texture. <u>Soft buckle tape</u>: reduced noise frequency band; less dense granular texture; sweeping. <u>Hard buckle tape:</u> richer noise frequency band; less dense granular texture; sweeping. <u>Hard brush with mic</u>: rich noise frequency band; sparse granular texture/soft güero-like; sweeping. <u>Hard brush in batter-head with increasing pressure:</u> changing but rich noise frequency band; sparse to dense granular texture; complex sweeping. Metal grid: articulated noise; metallic güero-like granular texture; sweeping.

Figure 3.29, *Contraccolpo* (2020)
Hybrid percussion instrument set-up

The instrumental figures in *Contraccolpo* were, for the most part, subjected to operations of symbolic granulation. These operations generate a gradual unfolding of the figures and their internal morphological transformations. The first of these figures was exclusively treated using sampling techniques[38]. This technique, in its most fundamental form, involves fragmenting an instrumental figure into small chunks that are then repeated. The onset and duration of these chunks vary according to the dimensions of a virtual sampling window that progressively scans the figure. The granular-based process applied to *Contraccolpo*'s first instrumental figure is quasi-linear, with the window moving from the beginning to the end of the figure while gradually increasing in size. Simultaneously, the process adheres to a strict logic, wherein the increasing size of the window correlates with a decreasing number of repetitions. This process creates an inevitable effect of meso- and macro-temporal "thinning" due to the increasing duration of the repeating fragments, which, in turn, influences the internal organisation of the figure's morphologies in anticipation of its subsequent unfolding.

[38] This compositional technique is discussed in more detail in the later chapter on Symbolic Granulation.

The two remaining figures in this work employ similar, albeit less linear, techniques of symbolic granulation. These figures also generate phenomena of repetition, alliteration, and assonance, though their impact on meso-temporality is less pronounced than that of the previous figure.

Summary

In this chapter, I have described and analysed three works in which the notion of the multidimensional aspect has been the key concept. What has been fundamental for me is the exploration of how materiality affects musical abstraction, how our experiments with the physical objects used to produce sound determine compositional operations, and how these means of making music relate to poetics.

I have discussed six works, each of which highlights a distinct perspective on this topic, showcasing particular spatial arrangements, unique methods of integrating dimensions, diverse devices or instruments constituting the dispositive, and specific interactions between materiality and abstraction. The primary similarities among the works discussed lie in the localisation of compositional matter and operations within a physical apparatus, as well as the integration of the dispositive into the music-making process.

There are, however, significant differences that emerge in each case.

In Morales' work, hybrid instruments are extensively multiplied, profoundly shaping both the sonic matter and the operations performed on it. Instrumental notation is absent, and sound exists within a narrowly defined range of time scales. The multiple dimensions of the apparatus are physically interconnected through the re-amplification of sound produced by the hybrid instruments through speakers. The exploration of materiality is central to Morales' work.

In Bauckholt's work, hybrid instruments are also multiplied, but their role is limited to that of non-interactive tools for sound diffusion. The localisation of sonic matter is predetermined, with each dimension fulfilling a specific task within the overall dispositive. Furthermore, their roles remain consistent throughout the piece.

In Zea's work we were introduced to a major difference in the dispositive, the incorporation of an audiovisual component which has a direct impact on instrumental action and consequently on instrumental writing and the approach to musical time.

In contrast, the three personal works discussed earlier in this chapter present a more dynamic engagement with the dispositive, involving interactions among dimensions. Two of these works feature instrumental writing, with acoustic and electronic sounds circulating across multiple time scales. In *Mutante/Amniótica*, hybrid modules function as tools for sound diffusion, while in *Contraccolpo*, they function as playable instruments with carefully notated actions that require the performative mastery of musicians. In the site-specific installation *Les sons ne sont pas des hommes*, interactions take place between the components of the dispositive and also with the environment.

To summarise, the design, construction, and implementation of sonic devices became compositional actions that enabled experimentation with new subjects of artistic inquiry and stimulated the musical imagination beyond established knowledge. These tools, initially used as technical objects for experimentation, evolved into epistemic things —emerging subjects of investigation at different stages of the experimental process. The integration of materiality into the compositional process introduces new fields of approach, fostering the ongoing mutation of the composable spaces and leading to their redefinition, potentially uniting matter, abstraction, and representation within a cohesive framework.

Chapter 4. Symbolic Granulation

An Introduction to Symbolic Granulation

This chapter examines musical works that illustrate symbolic granulation techniques within the composable space. Within this framework, this chapter will focus on the following points: the particular way in which each relevant work operates a category transfer from the signal to the symbolic domain and the compositional techniques that derive from it; the morphological properties of certain sonic entities that allow for particular compositional operations encompassed by this method as present in these works; and the singular relationship between global and local operations of score-based works deployed in a non-linear, cyclical, and recursive musical time.

This artistic methodology and its diverse compositional techniques are largely contained within a granular paradigm, a quantic and multi-scale approach to musical time.[39] In the context of contemporary score-based music, instrumental or symbolic granulation refers to a compositional technique that applies the principles of granular synthesis to musical notation and symbolic representation rather than to audio signals directly. It involves the fragmentation of notated musical material into discrete units or *grains*, and subsequently manipulating, reorganising, recombining, or transforming these symbolised fragments according to compositional strategies or algorithms. According to this method, compositional operations inspired by granular synthesis (such as density control, microscopic control of the playback point of an audio sample, overlapping, etc.) are applied to written musical elements, allowing for the creation of emergent and complex sound textures from simple source materials.

This chapter will investigate compositions that use or incorporate symbolic granulation techniques, evaluating both their relationship to score-writing practice

[39] This approach to sound was first mentioned in 1925 by Norbert Wiener, who had the idea of applying the notion of "energy grains" from quantum physics to music. Then, physicist Dennis Gabor theorised it in his article *Acoustical Quanta and the Theory of Hearing* (1947). Multiple later contributions, notably those of I. Xenakis and C. Roads, led to the development of the granular sound synthesis method. Granular synthesis is a method that operates on microsound time scales, whereby sounds are broken into tiny corpuscles that are then redistributed and reorganised to form other sounds. Granulation of sound is essentially an automated form of *amplitude modulation*, whereby portions of a larger sound file are multiplied by an envelope over and over again to form what are called *grains*.

and their unique strategies for structuring and defining particular composable spaces. Each work reveals a different perspective on this topic, exposes a unique manner of translating digital and analogue audio processes into instrumental writing techniques, showcases specific methods of granulation and sampling applied to the symbolic domain, and provides a particular approach to iterative and cyclical forms of musical time.

I will begin with my work for double bass, electronics, and a multi-dimensional dispositive *Mutante/Amniótica* (2018), this time focusing on the specific granular-based techniques for instrumental writing that were developed therein. I will outline the compositional strategies that shaped the instrumental writing, emphasising the iterative development through sampling [40] techniques and granular-based operations. I will also discuss the structural guidelines underlying the interaction between the different dimensions of the sound apparatus, facilitating shifts in listening perspectives across multiple temporal scales.

Secondly, I will examine how my instrumental writing techniques are inspired by granular synthesis in *Neon Frog* (2024), for five instruments and electronics. Detailing both the global processes and the nuanced local operations that shape the final form of this work, I will discuss how methods such as sampling and phasing[41] contribute to the transformation of instrumental figures into emerging textures.

Before that, I elaborate on a broader framework encompassing instrumental granulation methods and diverse compositional practices that translate digital and analogue audio processes into score writing. I highlight the central contribution of Iannis Xenakis to a granular paradigm and discuss recent works that have developed various techniques inscribed within this method. Comparing their approaches to symbolic granulation techniques with my own not only elucidates the rationale behind past methodological choices but also serves as a catalyst for generating novel research inquiries.

General Frame & Historical Repertoire

Symbolic granulation methods and techniques are generally situated within a broader context, characterised by a historical background that encompasses diverse musical creation practices. These practices arise from the translation of digital and analogue audio processes into score writing, which serve as models for composition. This translation implies a transfer from signal to symbol, transitioning from the

[40] In this context of score-based composition, *sampling* refers to the technique of microscopic fragmentation and recombination of small units of pre-existing notated musical material.

[41] In this context, *phasing* is the technique of superposing loops or iterative musical figures with different length duration.

domain of audio to that of musical notation. This is illustrated by the historical repertoire of contemporary and experimental music writing, which is rich in examples of artists using instrumental composition techniques and methods inspired by audio-digital and analogue processes.

The Spectralist movement exemplifies the translation of acoustic phenomena into musical notation through technological mediation. Gérard Grisey and Tristan Murail, its main founders, developed compositional methods based on spectral analysis, as evidenced in Grisey's *Partiels* (1975) and *Les Espaces Acoustiques* (1974-1985), as well as Murail's *Désintégrations* (1982-83) and *Gondwana* (1980). Their contemporaries expanded this paradigm: Hugues Dufourt employed spectral techniques to manipulate timbral masses in *Saturne* (1979); Jonathan Harvey used bell spectra data for creating recorded vocal parts singed by his son in his piece for tape *Mortuos Plango, Vivos Voco* (1980); Horatiu Radulescu explored fundamental spectra in *Wild Incantesimo* (1978).

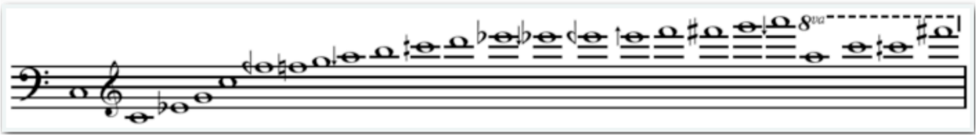



Figure 4.1, Spectrum of the tenor bell at Winchester Cathedral
Analysed by Jonathan Harvey using FFT. In C. Roads (Ed.), *The Music Machine* (1992, p. 92)

Kaija Saariaho exemplifies the systematic translation of technological processes into notational paradigms through works such as *Lichtbogen* (1986), in which electronic processing techniques inform instrumental textures. Similarly, Georg Friedrich Haas engages with technology-derived compositional methodologies through *In Vain* (2000), using microtonal systems based on spectral techniques.

Philippe Manoury illustrates the integration of digital methods and instrumental writing in works such as *Jupiter* (1987), which pioneered score-following techniques that directly informed notational decisions through electronic processes, and *Tensio* (2010), a composition that systematically employs real-time processing models.

Iannis Xenakis: Pioneer of the Granular Paradigm

The granular paradigm represents a quantum-oriented, non-linear, and multi-scalar conceptualisation of musical temporality, wherein discrete sonic corpuscles function as fundamental units that, through complex aggregation, generate emergent acoustic phenomena. Significantly, manipulations executed at meso-temporal scales precipitate transformative effects upon macro-temporal sound objects, establishing a causal relationship between microscopic interventions and macrostructural emergence. Granulation of sound is essentially an automated form of amplitude modulation, whereby portions of a larger sound file are multiplied by an envelope over and over again to form what are called *grains*.

Before the advent of granular synthesis software, Iannis Xenakis pioneered proto-granular techniques in his compositions by translating stochastic and mathematical processes into notation. *Analogique A+B* (1958-59) - *Analogique A* is for string ensemble, while *Analogique B* is for tape- represent one of the earliest implementations of granular-like thinking in composition. Xenakis created what he called "screens" of sound—clouds of sonic events distributed according to probability functions (Xenakis, 1960). He effectively calculated hundreds of microsonic events (grain-like sonic particles) with specific parameters for pitch, duration, and timing, then transcribed these calculations into traditional notation for strings. This work demonstrates a proto-granular approach where sound is conceptualised as particles forming clouds, directly anticipating modern granular synthesis.

In his orchestral work *Pithoprakta* (1955-56), Xenakis applied statistical mechanics and probability theory to orchestration. He calculated trajectories of particles (representing individual notes) using mathematical formulas derived from Brownian motion and gas molecule behaviour. Each instrument plays brief, discrete events that collectively form sound clouds—conceptually similar to the way granular synthesis combines many tiny sound particles to create textures. The score features graphs and mathematical calculations that were translated into standard notation, representing perhaps the first systematic application of granular-like concepts to orchestral writing.

Despite being an electronic work, *Concret PH* (1958) demonstrates the granular thinking that would influence Xenakis's scores. He created this piece by recording burning charcoal, then cutting the tape into tiny fragments (effectively creating "grains") and redistributing them according to mathematical principles. The compositional process he developed here informed his later instrumental scoring techniques.

In his *ST* series (1956-62), including ST/4, ST/10, and ST/48, Xenakis utilised computer algorithms developed at IBM to generate scores. This program calculated stochastic distributions of sound points (essentially grains) over various parameters, which were then transcribed into conventional notation. This is one of the earliest examples of computational thinking being applied to create granular-like distributions in notated music.

Xenakis effectively bridges the signal-to-symbol divide in these works by developing rigorous mathematical frameworks that translate granular-like processes into traditional notation, establishing compositional methodologies that prefigured contemporary granular synthesis techniques while remaining in the symbolic domain of music notation.

Digital Audio Workstations and Score Writing

The advent of digital audio workstations (DAWs) significantly impacted contemporary compositional practices. Techniques such as editing, chopping, mixing, sampling, looping, sampling, phasing, and filtering, originally developed for audio manipulation, have found their way into score writing. This translation of digital audio processes into notated music is particularly evident in the granular paradigm, where sound is treated as a collection of microscopic sonic events or "grains."

Inspired by Deleuzian philosophy, many artists employing these techniques explore the concepts of "difference and repetition" as a creative framework, emphasising subtle variations and reiterations within a sonic texture. By translating granular processes into score writing, composers can precisely control and manipulate these micro-sonic events, creating complex and evolving textures. For instance, the sampling technique, which involves the selection and isolation of specific segments of an audio signal, can be notated using precise rhythmic and dynamic markings in a score. Similarly, looping and phasing, which create cyclical patterns and variations, can be represented through repeated musical figures and gradual shifts in tempo or articulation.

The *DW* Cycle by Bernhard Lang: An Exploration of Difference and Repetition

The *DW* cycle, comprising 42 pieces to date, including the recent *DW 16.4 Songbook 1* (2021), encompasses a wide range of instrumental settings, from solo to orchestral works. The cycle demonstrates a particular focus on chamber music, with some pieces incorporating electronic elements such as loop generators, voices, or turntables. The title *DW* (Differenz/Wiederholung) references Gilles Deleuze's seminal work *Différence et répétition* (1968), which, alongside the work of video and film artist Martin Arnold, writer Christian Loidl, and various genres of non-academic music (jazz, techno, free improvisation), forms a framework of key influences on Lang's unique poetics.

His compositional approach involves the development of tools and procedures derived from contemporary audiovisual technology, including cut-and-paste techniques, looping, sound recording, and various digital manipulations. He also draws inspiration from the recoding of procedures and techniques from other disciplines, such as Loidl's semi-automatic writing and the differentiated loops found in Arnold's videos. Deleuze's influence[42] is evident in Lang's exploration of

[42] "Repetition alters nothing in the object that is repeated, yet it changes something within the mind that contemplates it." (Hume, 1739 as cited in Deleuze, 1968, p. 96)

non-linear time and his pursuit of the present moment,[43] achieved through the pervasive use of short, repeated fragments. This emphasis on repetition engages short-term memory and aligns with the ateleological, non-narrative discourse that characterises his artistic trajectory, prioritising the fragment over the complete narrative.

The *DW* cycle marks the inception of Lang's systematic investigation of the loop technique, which began with his 1996 pieces *Hommage à Martin Arnold #1* (based on an excerpt from Mozart's Symphony in G minor) and *#2* (an electronic piece constructed from the same recorded Mozart material). These works demonstrate Lang's early exploration of looping as a means of manipulating and transforming pre-existing musical material.

Looping, Sampling, Phasing, Shifting

Among a vast number of examples, one notable instance is the extensive use of *sampling* techniques by the Danish composer Simon Steen Andersen, with his 2004 chamber work, *Amid*, serving as an early example. The same composer also explored *phasing* techniques in depth, as evidenced in his work for chamber ensemble, *Chambered Music* (2007).

The *walking loop* technique, as employed by Alberto Bernal, involves the subtle shifting of intervals within a repeated loop, leading to a gradual evolution of both visual and sonic elements. This method, which shares similarities with other compositional techniques like *sampling*, is a recurring feature in Bernal's work. A notable example is his *Impossible Translations #4 «Suite»* (2013) for piano and video. In this piece, Bernal uses walking loops alongside other techniques, such as pixelation and the analysis of visual parameters, to create a rich texture of intersemiotic translations.

The work of the American composer Alex Mincek, for its part, is characterised by the use of repetitive loops and motifs that gradually transform through micro-

[43] Deleuze (1968, p. 97) states that: "Time is constituted solely within the original synthesis that pertains to the repetition of moments. This synthesis contracts successive independent moments into one another. It thereby constitutes lived present, the living present. It is within this present that time unfolds. Both the past and the future belong to it: the past inasmuch as previous moments are retained within this contraction; the future, because expectation is anticipation within this same contraction. The past and the future do not denote moments distinct from a supposed present moment, but rather the dimensions of the present itself as it contracts moments. The living present does not need to emerge from itself to traverse from the past to the future. Therefore, the living present proceeds from the past to the future that it constitutes within time, that is to say, from the particular to the general, from the particulars it envelops within the contraction, to the general it develops within the scope of its expectation (the difference produced in the mind is the very generality, as it forms a living rule for the future)."

variations[44]. This approach is evident in many of his works, including his string quartet *Pendulum II* (2008), in which rhythmic cells repeat and shift, creating a sense of constant movement and evolution. Another work that exemplifies Mincek's use of loops is *Harmonic Materials* (2011) for chamber ensemble. In this piece, melodic and harmonic loops overlap and morph, creating an emergent complex texture. In addition to these works, Mincek has also used looping techniques in his solo compositions, such as his *Three Studies* (2010) for piano. In these pieces, rhythmic and melodic loops are used to create a sense that evoques a hypnotic trance.

***Repetitions in extended time* (2008), by Bryn Harryson**

Bryn Harrison's work, in his own words, focuses on the "exploration of musical time through the use of recursive musical forms, which challenge our perceptions of time and space by viewing the same material from different angles and perspectives."[45] We could succinctly describe this particular piece as an iterative object in perpetual reconfiguration, whose nature interrogates the narrow threshold between difference and repetition. A central aspect of this piece is its work on phase, i.e., the superimposition of loops of different durations, which are always subdivisions of a longer period that serves as a time frame. Rhythmic material is conceived separately, using repetitive action frames in which the arrangement and density of events are changeable, creating a constant heterophony. These repeated sequences at different rates, with registral displacement in the individual voices of an emerging texture, blur the focus and suggest orbital fields rather than lines, despite their strictly contrapuntal conception. The morphological material is reduced to minimal gestalt units, some of which are fixed throughout the piece: the regular arpeggio of the piano spread over several registers that exposes the harmonic series of the given period, or the sustained chords with crossed envelopes of the keyboards. The remaining two or three planes of this textural object are exchanged between the strings, the electric guitar, and the bass clarinet. This morphological permutation reinforces the work's sense of circularity: the differences are minimal, concerning aspects such as loop density, register changes, or other parameters that create variations so subtle that they do not contribute to structural development. As with musical time, the harmony of *Repetitions in Extended Time* is organised cyclically. Each period exposes the chromatic total, progressing from the omni-interval series at the beginning to simple chromatic scales spread throughout the register. This gradual transformation occurs through well-known compositional operations: transposition, permutation, inversion, and retrogradation. The harmonic

[44] In https://www.musicandliterature.org/features/2016/5/05/on-the-outside-looking-out-alex-mincek (Accessed April 3, 2025).

[45] From the composer's website: http://brynharrison.com/index.html (Accessed April 3, 2025).

field of each cycle is exposed in the piano arpeggio with a regular pulse, providing the framework for the pitches used by the other instruments, assigned according to their rhythmic pattern to the corresponding pitch in the current time frame of the harmonic series developed by the piano. The almost imperceptible general articulation is provided by the tempi of each section, forming a global rallentando. The value of the metric unit of reference decreases progressively throughout the sections: A 96 beats per minute, B 84, C 72, D 60, E 48.

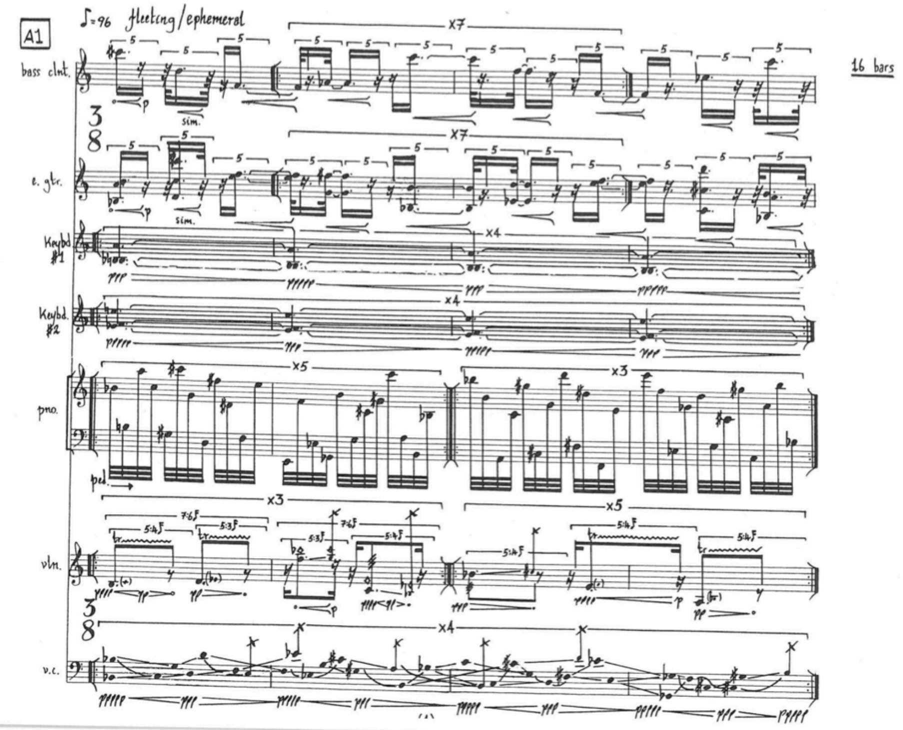


Figure 4.2, *Repetitions in Extended Time* (2008)
Bryn Harrison, p.1, unpublished score

***Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden (denn wir sind lange gewandert)* (2022/23) by Laure M. Hiendl**

The composition *Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden* (hereafter *SmW*) represents a significant departure from conventional New Music programming paradigms. Alongside *In Abeyance* (2021) and *Ray Ray of Light* (2022), this extended-duration work (60 minutes) constitutes the composer's deliberate rejection of standard ten-to-twenty-minute concert formats prevalent in continental European programming. Methodologically, *SmW* endeavours to transcend time-based concert dramaturgy in favour of a spatial-topographical approach informed by Berlant's (2011) "animated still-life" concept, thereby facilitating (Hiendl 2023, p. 85) "non-rhetorical, texture-based syntagmatic relations [and] non-narrative gestural implementations." This compositional strategy interrogates the problematic craft-concept dichotomy pervasive in Western compositional pedagogy, positioning Hiendl's work within a postmodern critical framework wherein hierarchical modernist structures dissolve into what the composer characterises as the "thick present." (Hiendl 2023)

In *SmW*, the composer deliberately employs an extreme form of material limitation, utilising merely four bars from Ralph Vaughan Williams' 3rd Symphony as the foundation for a sixty-minute composition. The selection of this particular excerpt—characterised by Dorian-type string mixtures, a simple horn melody doubled by clarinet, and a truncated flute gesture—was predicated upon its deliberate simplicity and cultural signification. The composer identifies this material as a decontextualised cultural signifier that, through digital distribution platforms such as Spotify playlists titled "relaxing orchestra music" (Hiendl, p. 86), has been reconfigured as a commodified sound object within late capitalism's consumption frameworks. This specimen of "score sampling" facilitates heightened perceptibility of structural transformations precisely due to the material's inherent simplicity, allowing the composer to explore the tension between minimal compositional resources and maximal temporal extension. The composer deliberately employed a sample characterised by subdued articulation patterns, creating an evenly distributed textural foundation devoid of dynamic extremities. This measured approach facilitates the composition's meta-textural objectives, wherein disparate segments from various positions within the source material can be juxtaposed while maintaining textural continuity, preventing any single expressive gesture from dominating the compositional landscape.

Score Sampling

The compositional technique, predicated on the perpetual recombination of similar yet distinctly varied sample segments, benefits from the homogeneous structural configuration of the source material. This provides consistently formed constitutive elements that allow for seamless integration while preserving gestural continuity. Furthermore, the original sample's 2+2 phraseological structure, characterised by repeated variation, enables cross-phrasal combinations that maintain gestural affect while generating endless variational permutations.

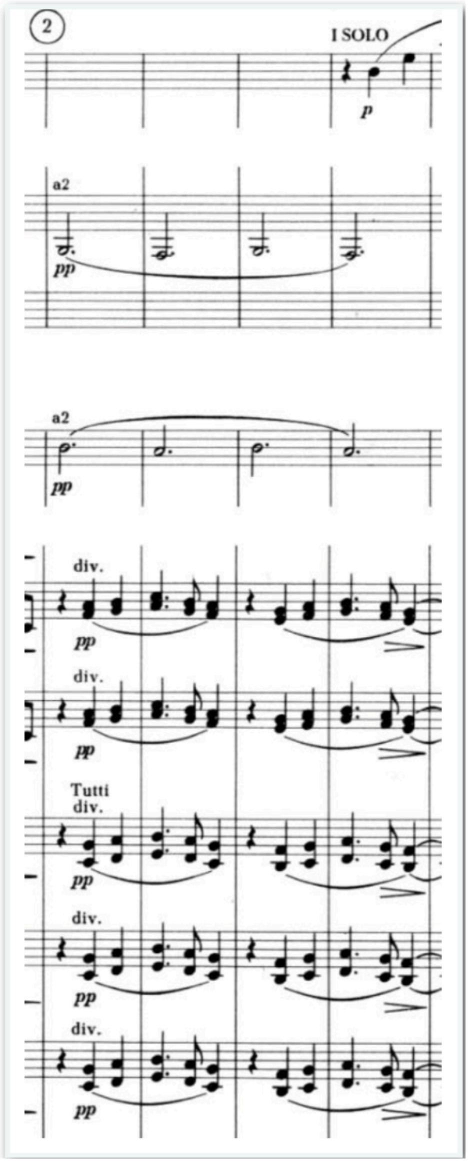



Figure 4.3, ***Symphony No 5, 3. Romanza***
Vaughan Williams (as cited in Hiendl 2023, p. 87)

The composer's aim to create a smooth yet ever-changing texture with minimal source material required harmonic flexibility, where any segment could be harmonically integrated with any other without breaking continuity. The Vaughan Williams excerpt's simple Dorian-modal harmonic framework satisfies this requirement through its non-teleological, circular harmonic structure that lacks a gravitational centre or directional impetus—a characteristic that *SmW* deliberately amplifies through the microscopic fragmentation and recombination of elements from throughout the sample, intensifying the perception of circularity and directional ambiguity.

Digitalising the Score

The composer's technical approach to implementing the sampling methodology for *SmW* involved a precise digitisation process. After identifying the Vaughan Williams source material, two critical steps followed: first, the exact transcription of the excerpt into notation software, and second, the quantisation of all durational values into multiples of sixteenth notes.

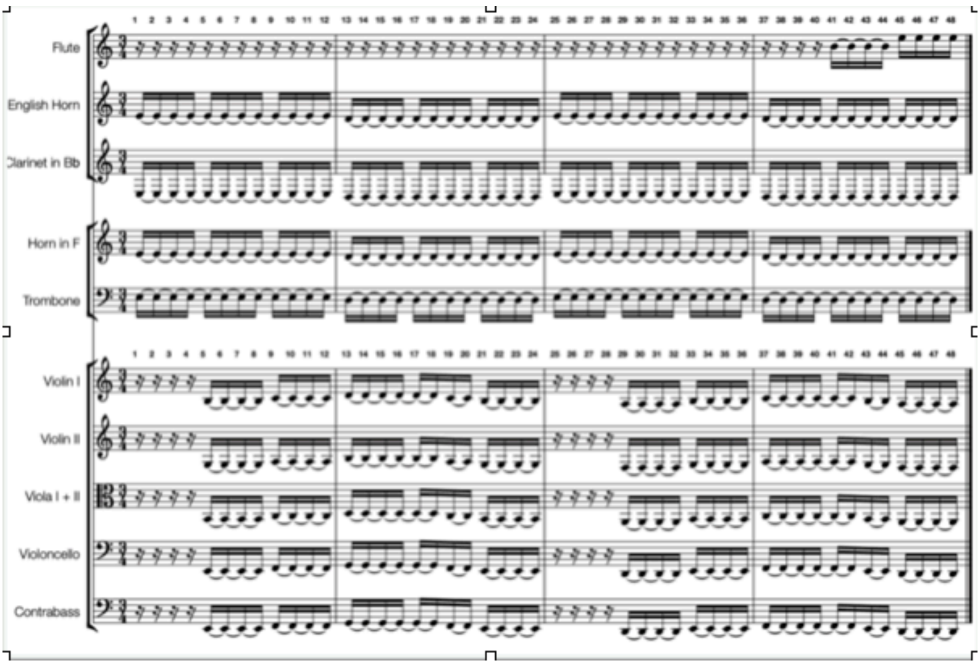



Figure 4.4, Excerpt of the score tied in 16th notes in "targeted" instrumentation (Hiendl 2023, p. 89)

This meticulous durational quantisation served a specific technical function related to the digital sampling mechanism employed in the compositional process. The discretisation of the musical material into a standardised numerical grid facilitated the programmatic sampling operations, enabling the custom-designed digital sampler to select specific starting points and durations from which to extract snippets of the source material. The composer notes that while the sampler did not directly interpret the score, it generated numerical data sets, which were then manually transcribed using the quantised score excerpt as a reference framework.

Quantising Music Material

The composer details a critical technical process of temporal normalisation required to align the audio recording with the quantised score. This procedure involves "warping" or "quantizing" the audio material—terminology borrowed from electronic music production—to synchronise it with the discrete temporal grid established in the notation software.

Hiendl highlights a fundamental tension between classical music's fluid temporality—particularly evident in the selected string passage where beat transients are less sharply defined—and the rigid temporal framework required for the score-sampling methodology. Unlike beat-oriented commercial music production software (e.g., Ableton Live) that automatically performs temporal analysis and alignment, classical recordings necessitate manual intervention.

The alignment process involves several precise steps: transcribing time signatures into the digital audio workstation (DAW) timeline grid, calibrating the project tempo to match the recording's performance tempo, and selectively compressing or stretching musical phrases within the audio recording. This meticulous temporal manipulation aims to achieve optimal correspondence between the rhythmic structure of the score and the temporal grid of the DAW, creating a standardised temporal framework essential for the score-sampling technique's implementation.

The composer acknowledges a deliberate limitation in the temporal quantisation process, recognising that complete rhythmic precision is neither fully achievable nor aesthetically desirable. This imperfect alignment between the audio recording and its idealised rhythmic grid generates what the composer terms as "musically interesting artifacts" (p. 89) —particularly when the sampling procedure intersects a musical phrase at points not coinciding with its natural boundaries.

These digital artefacts, rather than being treated as technical imperfections, become compositional resources deliberately exploited in the transcription process. The composer specifically translates the numerical output from the sampler by their auditory perception of these artefacts, resulting in distinctive rhythmic irregularities. The text identifies two specific manifestations: chains of triplet figures in section S of *SmW* and various ornamental configurations in the wind section.

These artefacts emerge from specific temporal misalignments—instances where the sampler cuts slightly before a phrase concludes or where the audio recording's quantisation extends marginally beyond the sampler's temporal grid. The composer characterises this phenomenon as a "bleeding over" (p. 90) of melodic fragments, which, when subjected to abrupt digital truncation, generates ornamental figures. This methodological approach reflects a dialectical engagement with technological precision and imprecision, wherein the artefacts of digital processing become integral compositional elements rather than incidental byproducts.

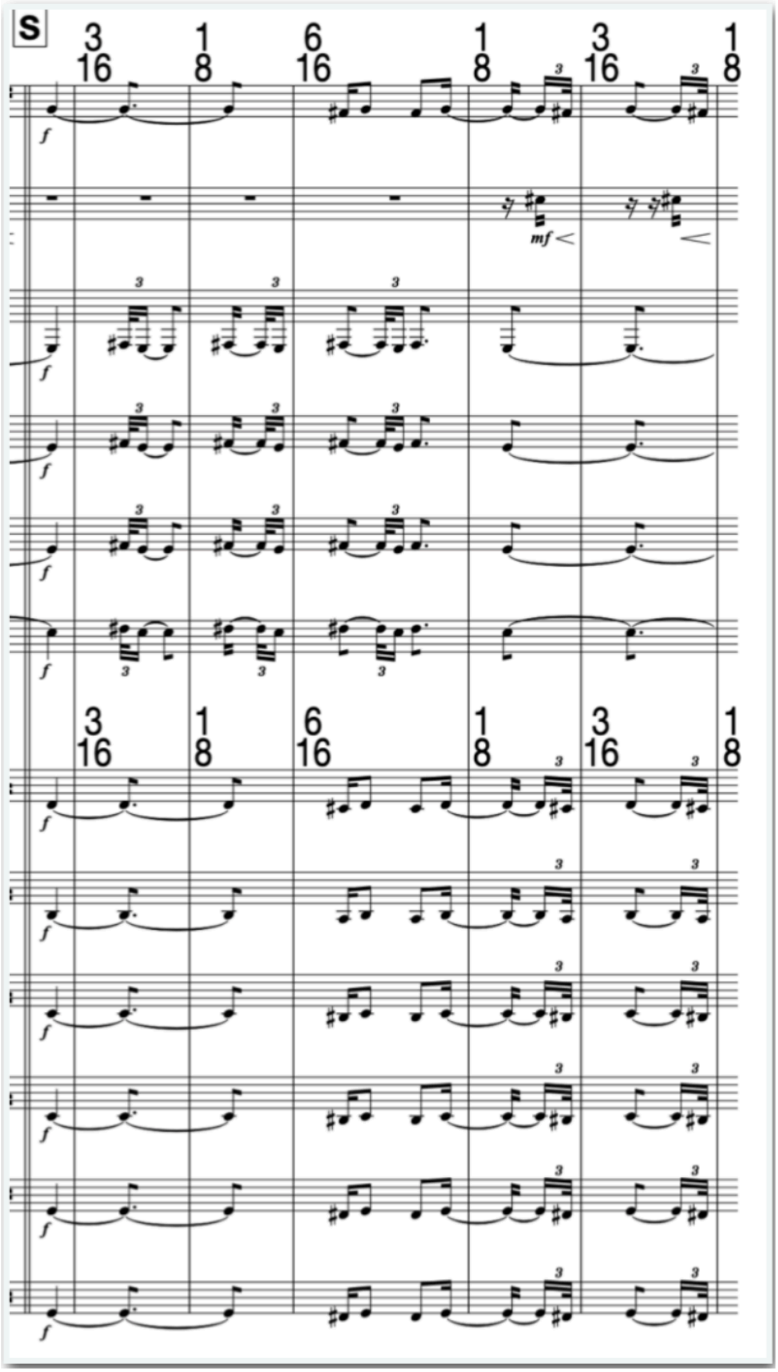



Figure 4.5, Section S of *SmW*
(Hiendl, p. 91)

Contextual Framework for the Application of Symbolic Granulation Techniques in my Work

In this section, I will briefly present previous works of mine that have developed sampling, phasing, and symbolic granulation techniques—a method that can incorporate these techniques whilst implementing other related approaches.

The first example of a systematic use of sampling in my work is the piece for amplified string trio and electric guitar *Limae labor* (2013/14), in which a single instrumental reference figure is deployed in a linear cumulative reading process. This process adheres to a basic principle, unchanged throughout the piece, which establishes a structural relationship between the size of the reading window (measured by the minimum established sampling unit) and the number of repetitions of its subsequent instantiations. That is, the smaller the sampling size, the greater the number of repetitions of the figure derived by the sampling operation in progress. This procedure produces a particular time-stretching effect, achieved by the gradual unfolding of the morphological characteristics of the figure at each iteration. The morphological material is 'unveiled', revealing its internal articulation, which enables a full perception of the repetition-based method. Composing this work allowed me to understand that there's no way to create effective repetition without having a source that articulates difference. There is no repetition without difference, and vice versa.

Other subsequent works also employed sampling techniques on a single reference figure of short duration. This is the case of the work for electric guitar *Interlude* (2014), which develops musical material similar to that of the electric guitar part in the aforementioned piece. This work was followed by two others that explored identical sampling techniques: *Granite Lip* (2014) for eight instruments and *NTPM* (2015) for accordion, two percussionists and electronics. The most recent work using linear sampling processes is *Contraccolpo* (2020), for two hybrid instruments, a work that I discussed in the chapter on multi-dimensional dispositives.

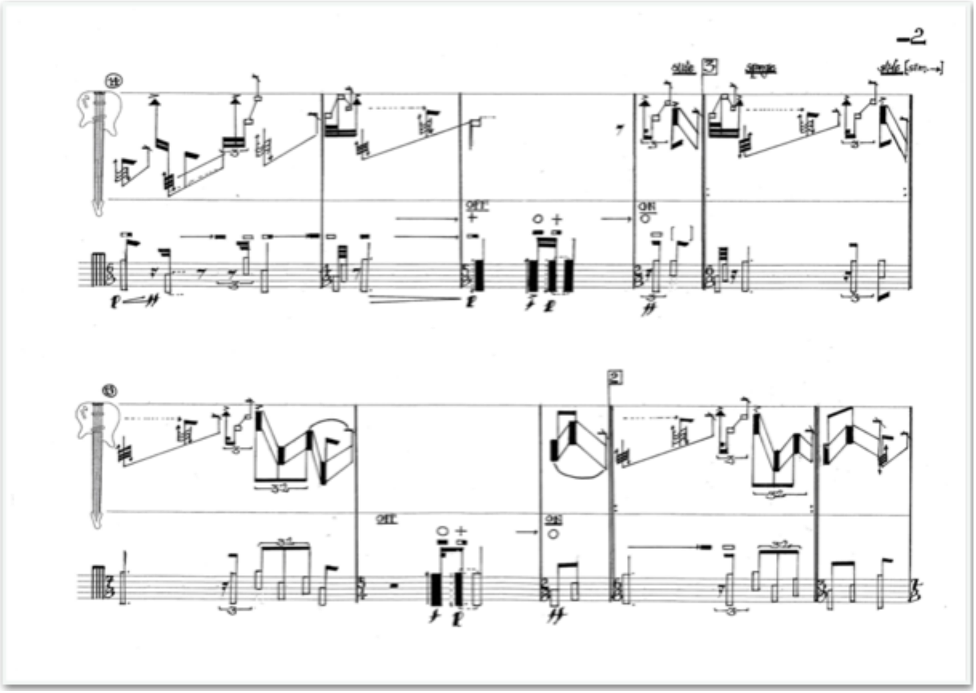


Figure 4.6, *Interlude*
Bars 14 to 23 from BabelScores (2014)

Other works incorporated additional methods alongside granular-based techniques for score-writing, such as the recovery of pre-existing musical material, the extensive use of samples of musical and non-musical material, the contextual extrapolation of sonic material, and diverse musical styles. In this category, I include the three pieces of the cycle *Avoidances*: *Ballad* (2012), for four instruments and electronics; *Bop* (2014), for sampler and seven instruments; and *Ragtime* (2015), for amplified trio and electronics. Another work that implements similar techniques in combination is *Fabula* (2015), for bass clarinet, double bass, and electronics. The most recent is the orchestral work *Trans-étude #3* (2022), entirely built with sampling techniques upon two bars of Igor Stravinsky's *Firebird.*

The first work in which I experimented with the phasing of repeated instrumental figures was *Ojo de buey* (2013), for a large ensemble. The first formal block of this work superimposes three instrumental groups whose reference figures unfold in cycles of slightly different durations, combining instrumental sampling and phasing techniques. This creates an emergent and paradoxical texture that is simultaneously repetitive and changing. In an incessant cycle of differentiated iterations, this complex object constantly reorganises and deploys its internal components.

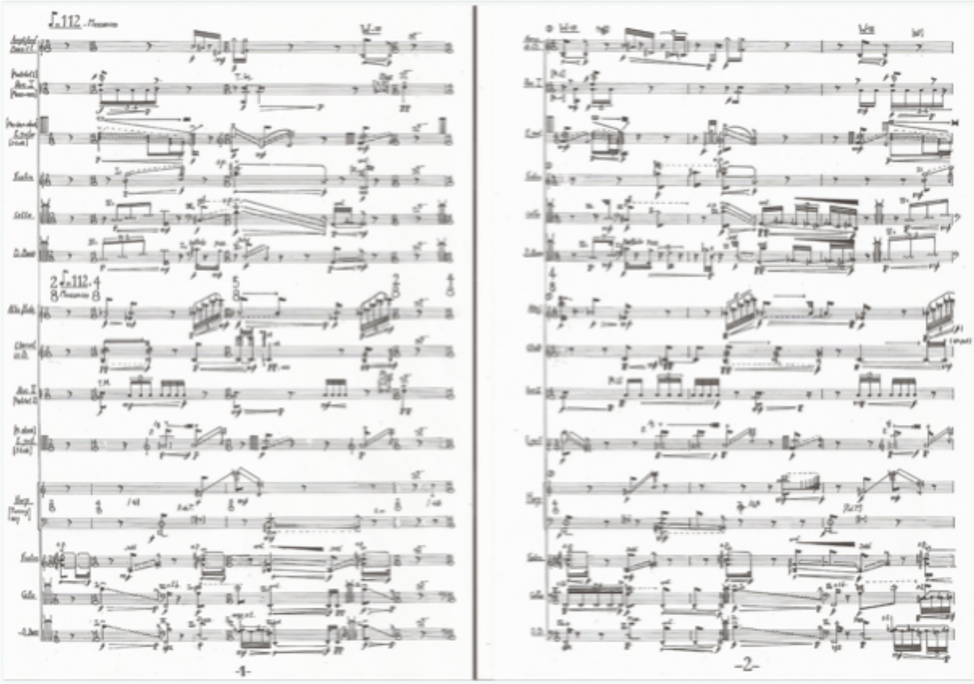



Figure 4.7, ***Ojo de buey***
Pages 1-2 from BabelScores (2013)

The 2016 work *Fabulae* (for seven instruments, electronics, and video) develops phasing and sampling techniques on figures that circulate through different time scales in both its instrumental and electronic parts. This work also employs samplers of musical and non-musical material and develops methods of contextual and stylistic extrapolation, and instrumental feedback.

Junkspace, a 2017 work for five amplified instruments, three hybrid instruments, and low-fi electronics, as well as the 2022 work *Cada trozo/cada ganglio* for five instruments, electronics, and video, explore phasing and sampling techniques alongside instrumental Larsen tones within positive feedback systems.

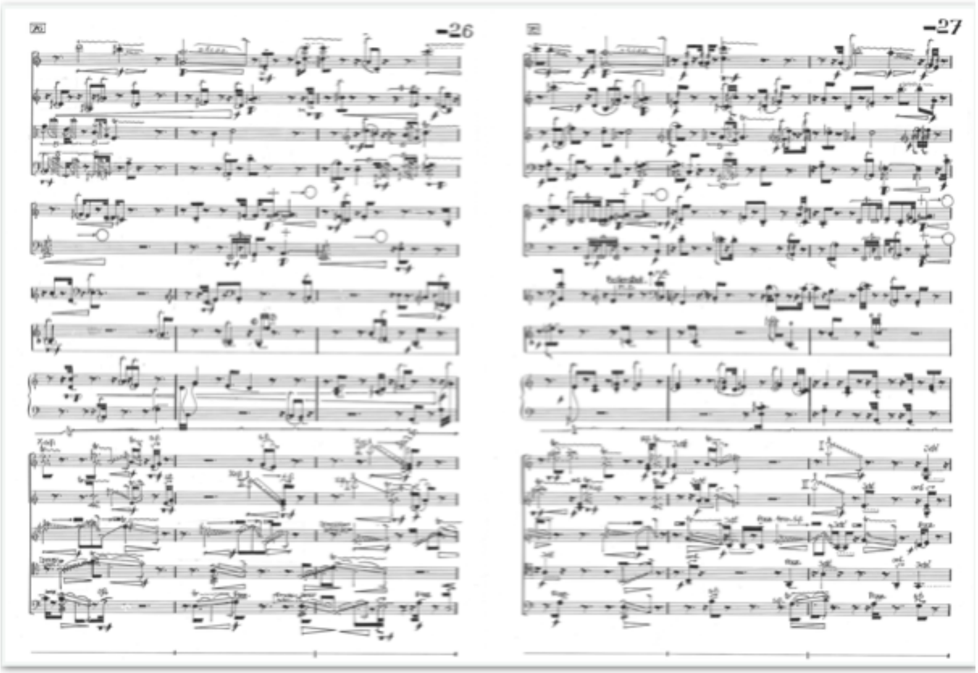



Figure 4.8, ***Dynamogramme: Allegretto***
Pages 26-27 from BabelScores (2019)

Other works explore various techniques of symbolic granulation include *Neon pig* (2017), for ensemble, hybrid instruments, and electronics; *Mutante/Amniotica* (2018), for double-bass, hybrid instrument and electronics; and *Dynamogramme: Allegretto* (2019), for large ensemble, self-regulated feedback, and electronics. The latter, also employs Markov chains to manipulate a small fragment of Beethoven's 5th Symphony and to implement symbolic granulation techniques.[46]

Mutante/Amniótica (2018)

In the previous chapter, I examined the genesis of the *Mutante/Amniótica* dispositive, outlining its integration into the composable space and its functional role within the work. That discussion centred on three primary aspects: the coupling

[46] In the image above, one can observe a dense instrumental granulation texture derived from three bars of the *Allegretto* of Beethoven's 5th Symphony, developed using Markov chains in the software AC Toolbox, created by Paul Berg at the Studio of Sonology in The Hague.

of instrument and transducer, the creation of a hybrid dispositive spanning both actual and virtual sound spaces, and the spatial strategies employed.

In this chapter, I return to the same work from a different angle, focusing instead on the symbolic granulation techniques at play—methods that operate across temporal scales to shape and articulate the musical material.

I will begin by examining the outcomes of the initial stages of development that led to the emergence of two contrasting sets of instrumental morphologies within the composable space, designed to interact with each dimension of the electronic sound diffusion apparatus in *Mutante/Amniótica*. These stages included several collaborative sessions with the French double-bassist Charlotte Testu, who premiered the work at the 2019 Venice Biennale.

I will focus exclusively on the initial set of instrumental morphologies within this piece. To this end, I will examine the formation process of the instrumental figure that served as the basis for all the instrumental writing in the first formal block. Subsequently, I will investigate the structural guidelines that provided the initial framework for the compositional process.

Finally, I will explore the granular-based operations applied to this figure and the shifts in the listening perspective, with particular attention to the graphemic material generated throughout the compositional process.

Genesis of Instrumental Morphologies

Between the end of 2017 and the beginning of 2018, we conducted a series of encounters with Charlotte Testu. The first encounter involved an exchange of ideas, questions, and suggestions, and, based on these exchanges, improvisations, that led to extensive audio and audiovisual recording sessions. By the time of our next meetings, I had already outlined the broad framework of the composable spaces for *Mutante/Amniótica* and identified the central issues to be addressed, the multidimensional dispositive including the hybrid instrument and the symbolic granulations techniques. Two main blocks within the composable space had been defined, along with their essential attributes. Each field would interact with the two primary dimensions of the apparatus: one corresponding to the eight surrounding loudspeakers and the other to the double bass coupled with transducers. At this stage, I envisioned a specific order of time scale magnitudes for each block, within which these morphologies would circulate. Rather than compiling a catalogue of extended techniques for the double bass, I aimed to highlight the fundamental attributes of the corresponding morphological fields that emerged from the interaction between my preliminary concepts and the instrumentalist's proposals. Through this iterative process, the first premises of the research began to unfold, allowing me to identify the central questions arising from these initial definitions. We then focused our investigation on creating:

- Morphologies whose instrumental production techniques allow them to traverse multiple temporal scales within the symbolic domain.
- Instrumental figures that facilitate micro-articulation within the symbolic domain.
- Instrumental techniques that enable diverse operations within a single figure and can be combined with others.
- A first approach to the instrumental morphological field would consider the capacity of a given instrumental morphology to support a minimal number of operations on itself while retaining a minimum of the attributes that define its perceptible identity.

The working sessions facilitated the development of a compositional strategy for addressing instrumental writing and its relationship to each dimension of *Mutante/Amniótica*'s apparatus. This strategy involved globally delineating each field based on the ability of the morphologies within them to traverse the time scales associated with each dimension. I began to organise the outcomes of our research by defining the instrumental morphologies for each dimension, to optimise the material as much as possible. I also identified the fundamental attributes that would characterise the morphologies specific to each field:

- The field interacting with the dimension of the loudspeaker would aim to produce morphologies capable of circulating across multiple temporal scales, extending to the smallest ones the instrument could reach—versatile enough to engage with micro-articulatory levels within the symbolic domain, and able to support multiple operations.
- The field that interacts with the dimension of the instrument/transducer pair would exhibit morphologies that can only evolve through temporal scales that extend towards the macroscopic. This field also includes morphologies that are difficult or impossible to articulate, as they are typically produced by instrumental techniques that require preparation time, which conditions their concatenation with other types of extended techniques. Additionally, the morphological field of this block includes others that can only operate at specific dynamics or within restricted dynamic contexts, and that allow for very few operations.

Instrumental Figure of Reference

For this block, I aimed to construct a reference figure composed of a limited number of morphologies. These morphologies needed to exhibit a distinct gestalt, instrumental versatility, and, as mentioned earlier, the capacity to support diverse operations while circulating across multiple time scales without losing their perceptible characteristics. Recognising that all the instrumental writing for this block would emanate from operations applied to this figure, I envisaged another crucial requirement: the potential for its deployment over time. This entailed ensuring that its internal components could change function throughout the work. Each component of the figure should alternately serve as the primary morphology to be developed or as a secondary element, facilitating the articulation of the musical flow and structuring internal periods at specific moments. In the end, I retained three morphologies that would constitute this reference figure. The initial and the final morphologies, A and A', are almost symmetrical:

- **A) Downward morphology**. This gestalt encompasses multiple parameters and undergoes timbral transformations throughout its deployment, transitioning from a granulated texture to a smooth colour. These transformations are achieved through gradual changes in the position of the bow, the pressure it exerts, the point of contact between the bow and the string, the actions of the left hand, and the dynamic envelope.
- **A') Upward morphology**. The final morphology of the figure is a non-linear inversion of Morphology A.

The second morphology is more complex, follows the upward and downward movement of a sound wave in a free manner and exhibits more contrasting components. It consists of two distinct elements that are repeated with near symmetry, including variations, around a central third element.

- **B) Wave-like morphology.** The first element combines various forms of *pizzicato* and *jeté* bowing. The second element transcribes an ongoing word, phrase, or sentence from a speech diffused by the electronic part.[47] At the centre of this quasi-symmetrical morphology is an *arpeggio* of natural harmonics.

The following image reproduces the sketch of our reference figure. The red numbers visible at the bottom correspond to the smallest time units used for sampling operations. These numbers facilitated the identification of onsets and offsets, as well as the size of the current sampling window—two fundamental parameters for the subsequent operations that will be discussed in the following sections.

[47] Their notation in the reference figure is deliberately incomplete and intended to be of approximate duration since different syntagms will alternate in the work, and will be composed through localised operations.

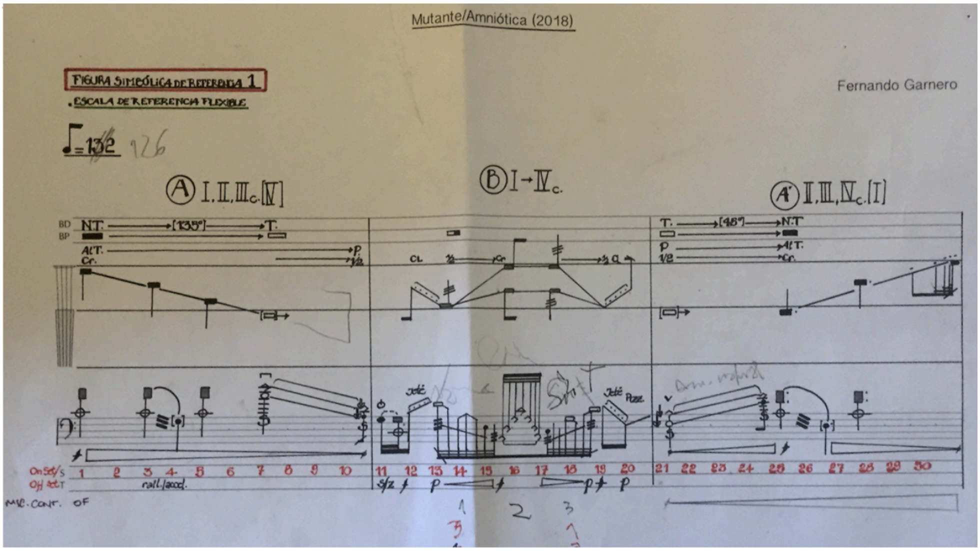


Figure 4.9, Instrumental Figure of Reference A
Composer's sketch

Structural Guidelines and Algorithms

My primary objective was to establish methods of interaction between the dimensions of the dispositive: the amplified instrument, the hybrid instrument, and the speaker system. The initial strategy was to associate each dimension with specific sonic materials circulating through their intersections. This approach delineated the field of exploration and subsequently informed an initial formal framework. This preliminary strategy resulted in the formation of two contrasting sets of instrumental morphologies. From these initial concepts and the early stages of experimentation, three structural guidelines were formulated:

- **Length interpolation of the two main formal blocks.** The first block, which intersects the amplified instrument and the speaker system, will undergo a reduction in length. Conversely, the second block, initially intersecting the amplified instrument and the hybrid instrument before engaging the entire dispositive, will experience an increase in length. The duration of both blocks will follow a non-linear exponential curve.

- ***Sampling* techniques for the first block.** The granular-based approach I developed focuses on sampling techniques, which involve scanning an instrumental figure with a changing-length frame and breaking the figure down into smaller portions.

- **Increasing the length of the sampling window.** The size of the sampling window for the instrumental figure of reference will expand globally along a linear trajectory from one segment to the next, while locally following a non-linear progression within each individual segment.

After several experiments within this initial framework, including modelling and layout, I was able to project the magnitudes of the total duration and internal articulation of the first block. These magnitudes allowed me to determine the average duration of the operation cycles used to scan the figure, providing a general sense of the average rate of change in the sampling window size throughout the process. This allowed me to establish a framework for the ongoing operations and the localised actions that would define the final state of the morphologies. The following sketch assisted me to visualise the overall parallel processes: the shrinking of the first block and the enlargement of the sampling window of the reference figure.

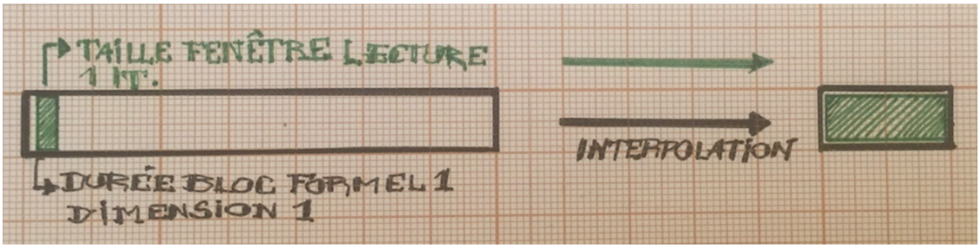


Figure 4.10,
French sentences, top left (in green): *Sampling Window Size* and *First Iteration,* bottom left (in black): *Formal Block 1 length*

Another fundamental parameter in this process was the ratio between sound and silence, which can be related to the grain separation parameter commonly used in granular synthesis. Based on the sampling operations and the guidelines of the process, I projected an estimated distribution rate for each formal block, followed by subdivisions within each segment, and ultimately within each instantiation cycle. The illustration reproduced on the newt page allowed me to conceptualise the form of complex objects arising from the interaction of all sound strata—instrumental and acoustic—in terms of the rarefaction or densification of sound activity. While the global relationship between these elements evolves imperceptibly, it plays a crucial role in the local articulation of instrumental morphologies and their interaction with electronics. This ratio is influenced by the framework established by the overall process: the smaller the size of the sampling window, the more rarefied the resulting complex form. Consequently, there is less sonic activity at the beginning of the process and significantly more as it progresses towards the end.

The decisions I made locally, influenced both by previous events and by projections of what was to come, concerned the specific articulation of the morphologies derived from the operations of scanning the reference figure. These decisions addressed whether the morphologies within a cycle or a section of a formal block would appear in a rarefied or compressed state or in a transition between states.

The following illustration shows the total duration of the decreasing segments, the evolution of the sampling window size as indicated by the increasing magnitude of the offsets, the average duration of an instantiation cycle, the number of cycles per segment—equivalent to the magnitude of the offsets—and their duration, along with the resulting envelope of the progression of cycle durations.

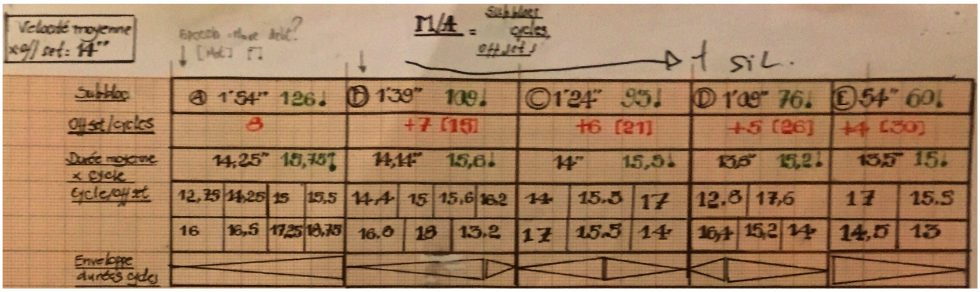


Figure 4.11, Composer's sketch

These lengths could be, and in some cases have been, modified locally by direct action. However, the framework described above does not provide relevant information about the morphologies, their relationships and interactions, or their connections with formal blocks in other dimensions, among other aspects. I deliberately chose not to elaborate on certain aspects of the formalisation—such as those outlined above—precisely because they were intended to remain ambiguous and allow for a margin of interpretation.

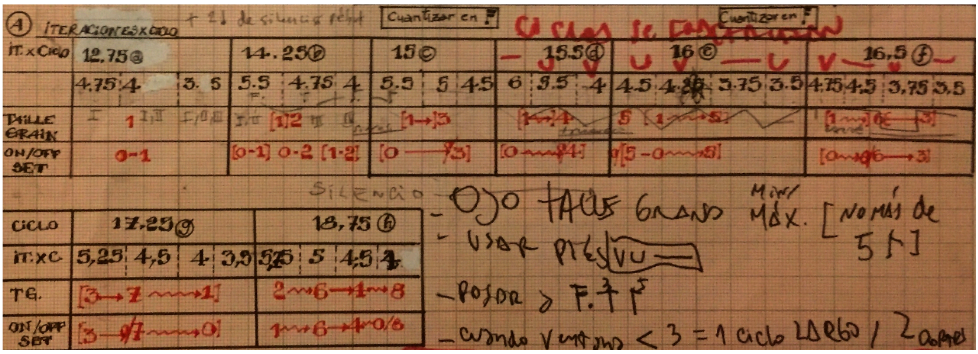


Figure 4.12, Composer's sketch

The previous illustration depicts the periods of the first formal block, the increasing quantity and decreasing lengths of each iteration, the range of the sampling window size, and the dynamic progression of the onsets and offsets within this range.

Granular-based Operations

In this manner, I established a structural framework that guided local operations. These operations, related to the instrumental writing of the first formal block were granular-based, relying primarily on sampling techniques. All instrumental morphologies were derived from these operations and applied to the reference figure "A," which was globally structured by the aforementioned algorithms. The primary parameter governing these granular-based operations was the sampling window size, defined on a global scale by the linear increment of the window offset in each instantiation cycle. Another parameter, previously mentioned, was the silence/sound ratio in each cycle, which can be likened to the grain separation parameter commonly used in granular synthesis.

While working with local compositional actions, I transposed other parameters from micro- to meso-sound time scales. This process initially introduced rhythm (analogous to the *grain size* parameter in granular synthesis) and register (comparable to *grain pitch* or *transposition*).

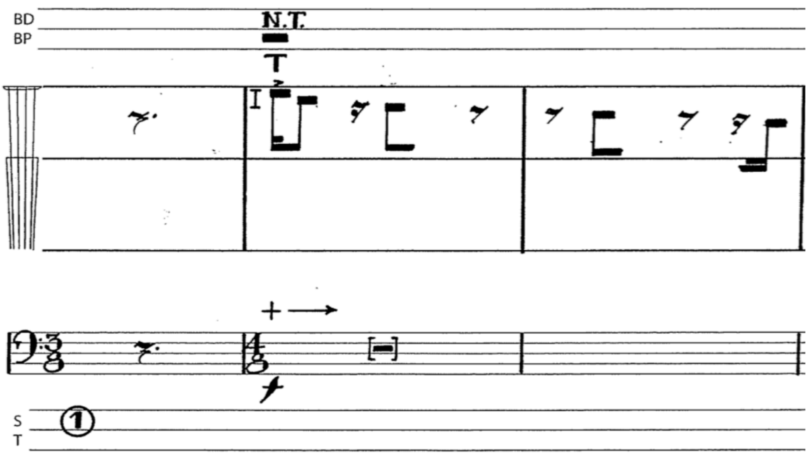


Figure 4.13, *Mutante/Amniótica*
Bars 1 to 3 from BabelScores (2018)

I then incorporated additional parameters to dynamically approach the sonic matter from a local perspective. These included the 'morphological' envelope (rarefied, compressed, or transitioning between these two states) and the 'variability' of the sampling window (its size and position within the globally established onset and offset limits). Finally, I developed a local 'morphological' profile model derived from the first morphology, which would be projected onto the initial segments of the first block.

After these experimental stages of modelling and formalisation, I was able to draft a sketch of the first and longest segment of this initial block, which clarified the structure of the subsequent segments.

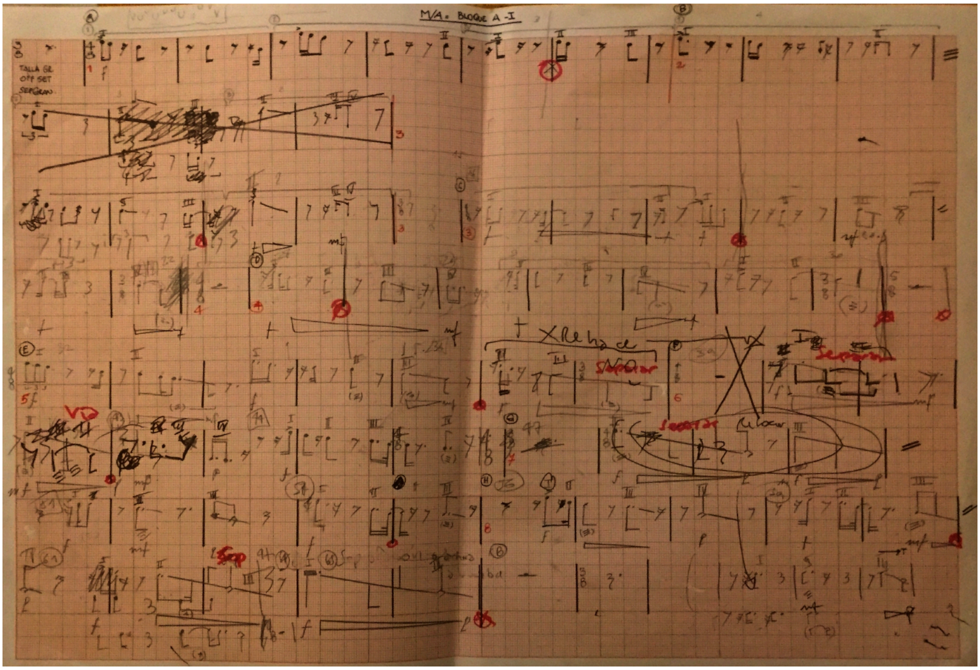


Figure 4.14, Composer's sketch

Navigating through Time Scales

The process of increasing the sampling window size also dictated the gradual unfolding of the reference figure, leading to a global transformation of the instrumental morphologies from a rarefied to a condensed state. The formal *apex* of this process occurs towards the end, when the reference figure is reproduced almost in its entirety, occupying the total length of its corresponding segment.

This global process was replicated locally within each cycle of instantiation. The strategy aimed to induce constant shifts in the listening perspective throughout the work, encouraging perception to navigate across various time scales. It was implemented through the local variability in the size of the sampling window combined with state changes, repeatedly transitioning from rarefied to compressed within each cycle. Throughout this process, I aimed to evoke the impression of approaching a musical figure whose size or definition changes—much like altering the pixels quantity of a digital image, causing the perceived contour to shift from blurred to sharp, from distant to near. This change in perspective and contour perception is already inherent in the reference figure, reflected in the selection and sequence of its internal morphologies. However, it becomes fully embodied in the morphologies that emerge from these operations.

The following examples, drawn from the score, illustrate various stages of the process employed in the first block.

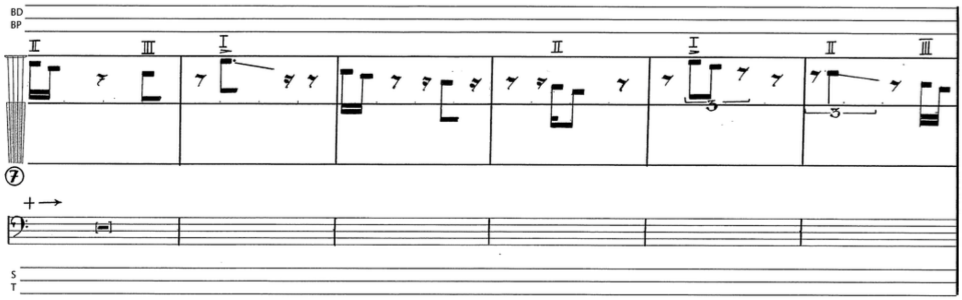


Figure 4.15, ***Mutante/Amniótica***
Bars 7 to 12 from BabelScores (2018)

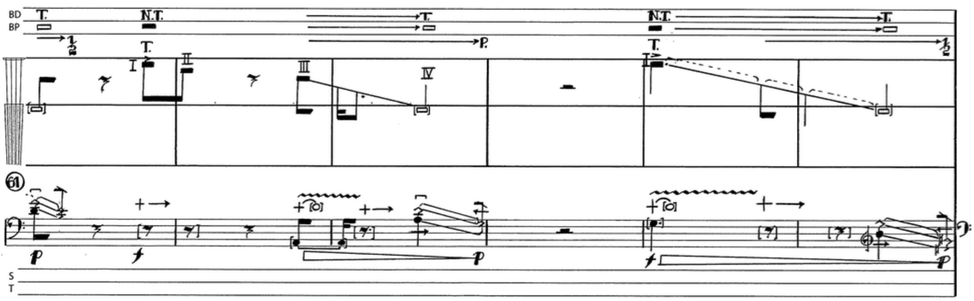


Figure 4.16, ***Mutante/Amniótica***
Bars 61 to 66 from BabelScores (2018)

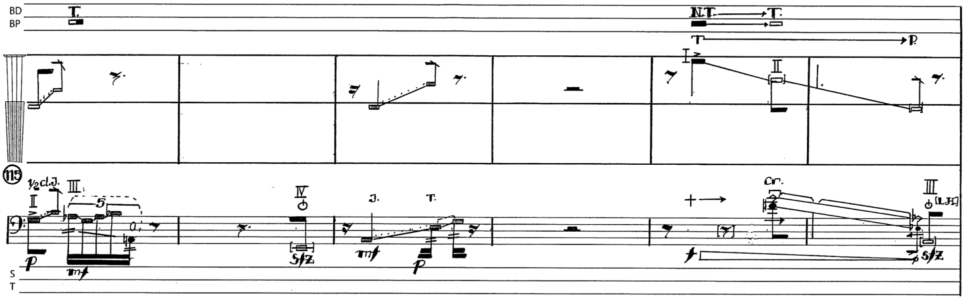


Figure 4.17, ***Mutante/Amniótica***
Bars 115 to 120 from BabelScores (2018)

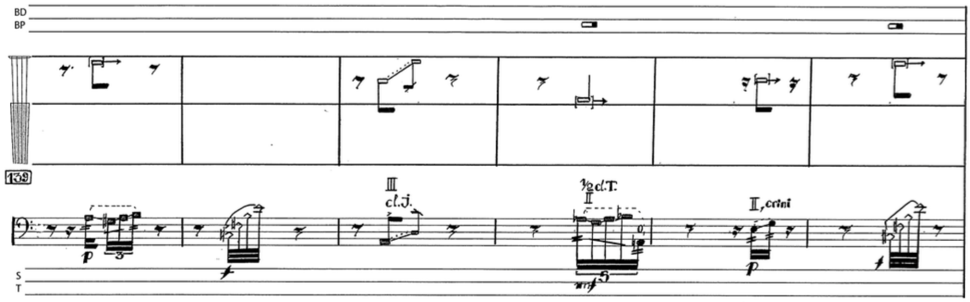


Figure 4.18, ***Mutante/Amniótica***
Bars 138 to 143 from BabelScores (2018)

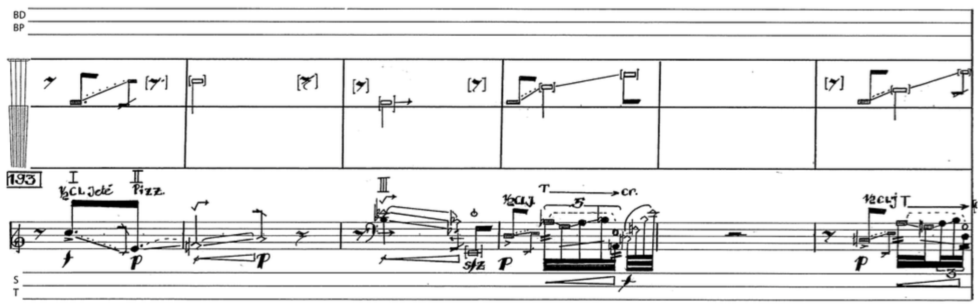


Figure 4.19, ***Mutante/Amniótica***
Bars 193 to 198 from BabelScores (2018)

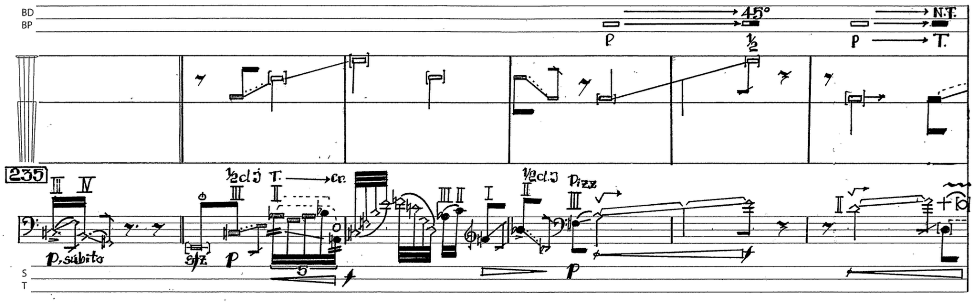


Figure 4.20, *Mutante/Amniótica*
Bars 235 to 240 from BabelScores (2018)

Neon Frog (2024)

In this instance, I shall examine the techniques of symbolic granulation and the specific manner in which they were applied in my work, *Neon Frog* (2023/24).

First, I will outline the immediate context of my recent projects developing instrumental granulation methods, with particular emphasis on sampling and phasing experiments.

Secondly, I will present the genesis of the instrumental morphologies that make up the first and longest formal block - the central focus of this case study. This block elaborates on the techniques that are central to the research examined here.

I will then explain the instrumental figures of reference that constitute the foundation of instrumental writing within this entire first formal block. In the following section, I will examine the global processes that guided the operations of symbolic granulation about this emerging complex texture.

To conclude this discussion, I will examine the local operations that were carried out, providing concrete examples of these direct compositional actions.

Genesis of Instrumental Morphologies

I will focus exclusively on the first and longest formal block in my approach to this work. This block contains the most paradigmatic operations of symbolic granulation, transferring numerous attributes of granular synthesis and parameters that operate within the signal domain into the symbolic field of instrumental writing.

Neon Frog represents the convergence of diverse artistic methods arising from two distinct approaches to sound. As previously explained, one approach regards sound as an acoustic phenomenon, which, in the context of the complex texture animating the first formal block, is primarily expressed through methods and techniques grounded in a granular paradigm.[48] The other approach perceives sound as a socio-cultural phenomenon. In *Neon Frog*, this is realised through compositional techniques framed within the method of sonic translation, which I will discuss in a subsequent chapter. Both methodologies are articulated at various levels within the composable space from which the work emerged, forming a hybrid field of operations that creates networks of objects connected by distinct operational sets. Both methodologies express the arising operations in different ways: at times, they simply alternate or overlap; at other times, they are synthesised or interrelated across different planes of the composable space.

The gestation of the instrumental figures of reference resulted from this hybrid field of operations, serving as a paradigmatic example of the synthesis of both approaches. In this process, the two sonic paradigms acted simultaneously, expressing themselves through two complementary and concurrent structural parameters. The first is defined by the poles that I refer to as *representation* and *abstraction*. This determining parameter for the creation of the reference figures will be addressed in the subsequent chapter that examines *Neon Frog* from the perspective of the sonic translation method. The structural parameter we are discussing here—stemming from the approach to sound as an acoustic phenomenon—considers timbre as the determining factor for the morphological attributes of the figures. This structural parameter is framed by two qualitative poles: on the one hand, different forms of noisy instrumental sounds, and on the other hand, various types of resonant sounds characterised by a high degree of harmonicity.

The following tables provide a general summary of the timbral evolution of the morphologies that constitute the reference figures, which transition from noise to resonance characterised by high degrees of harmonicity. This transition, represented in figures of short duration, will highlight the emerging changes in the global state of the complex texture that gradually unfolds in the first formal block of the work.

[48] In the final sections of *Neon frog*, this paradigm is articulated in parallel through additive electronic and instrumental synthesis techniques. I tangentially address this question in the chapter on sonic translation.

Table 4.1 & Table 4.2, Timbral Evolution

FIGURE A (timber)	Morphology 1	Morphology 2	Morphology 3
Violin	NOISY (Grainy & Scratched)	NOISY (Percussive)	RESONANT (Harmonics)
Viola	NOISY (Grainy & Scratched)	NOISY (Percussive)	RESONANT (Harmonics)

FIGURE B (timber)	Morphology 1	Morphology 2	Morphology 3	Morphology 4
Bass Clarinet	NOISY (Grainy)	NOISY (Percussive)	RESONANT (Clear & with beats)	RESONANT (Airy & transparent)
Percussion	NOISY (Grainy)	NOISY (Grainy)	NOISY (Rugged)	RESONANT (Airy)
Cello	NOISY (Scratched)	NOISY (Percussive & Grainy)	NOISY (Percussive & Grainy)	RESON/NOISY (Harmonics & Scratched)

Instrumental Figures of References

The instrumental gestures that constitute these reference figures were gradually defined not only by their timbral and morphological qualities. Throughout the extensive series of experiments conducted since previous pieces, I consistently seek versatility that allows for fragmentation into even smaller gestures (meso-temporal[49] *corpuscles* or *grains*) that can be concatenated in various ways and recombined with one another. These variable fragments can potentially circulate across different meso-temporal scales, enabling me to explore sudden changes of scale produced locally. Both figures share intersecting morphological attributes that facilitate their fragmentation, recombination, and continuous dephasing, thereby ensuring resulting textures with homogeneous global characteristics. This crossover of shared morphological qualities also enables local operations on the fragmented figures, which produce global state change effects on the emerging textures in progress.[50]

[49] Meso-temporal refers to a magnitude of time scales on which musical actions can be executed and notated by and for human performers. It is placed between micro and macro-temporal scales.

[50] This is akin to the impact on the overall timbre resulting from operations on micro-temporal scales in granular synthesis, which I draw upon.

Both figures were also constructed based on the principles of contrast and complementarity, considering easily perceptible morphological attributes such as timbre, direction and shared pitch. Other axes of ordering included the analogy or micro-variation of morphologies between the two figures, allowing them to withstand multiple iterations arising from operations of symbolic granulation without compromising their singularity or the state of the emerging texture in progress.

The reference figure of the violin and viola instrumental group is composed of three instrumental morphologies, whose timbral qualities mutate globally between noise and resonance.

- The first morphology is composed of two instrumental gestures with opposite attributes: the gesture of the violin is an ascending movement with decreasing bow pressure, transitioning from a 'screeching' to a 'whistling' sound in a *decrescendo*; conversely, the gesture of the viola is a descending movement in *crescendo*, with bow pressure increasing to its maximum. Both gestures converge in a *scratch sound* on double strings with arco *non tratto*, executed in an ascending movement and featuring a heterophonic rhythm, similar to a *hoquetus*.
- The second morphology consists of percussive sounds: the violin produces *pizzicato* gestures executed with the fingernail and muted by the left hand, followed by a *jeté* bow stroke; meanwhile, the viola repeatedly strikes the wood of the bow against the side of the fingerboard, then anticipates the violin's ascending *glissando* with a *battuto* bow stroke, followed by a *pizzicato* executed by the left hand.
- The third morphology is the longest and most complex, producing a general undulating movement primarily created with natural or artificial harmonics, characterised by opposing movements that converge in a parallel descending gesture. This morphology integrates *tremolos* with a perpendicular bow, *glissandi*, *trills*, and sounds produced with extreme bow pressure.

The audible pitches of this reference figure 'A' remain fixed during its unfolding; any minimal changes they may undergo are attributable to local operations. The perfect fifth interval is omnipresent and conditions a stable harmonic field. In the figure on the next page, we can observe that the eighth note serves as the minimum sampling unit for these figures. The onsets are indicated in red at the bottom. These indices are of utmost importance for understanding the algorithms that govern global processes and the locally performed operations.

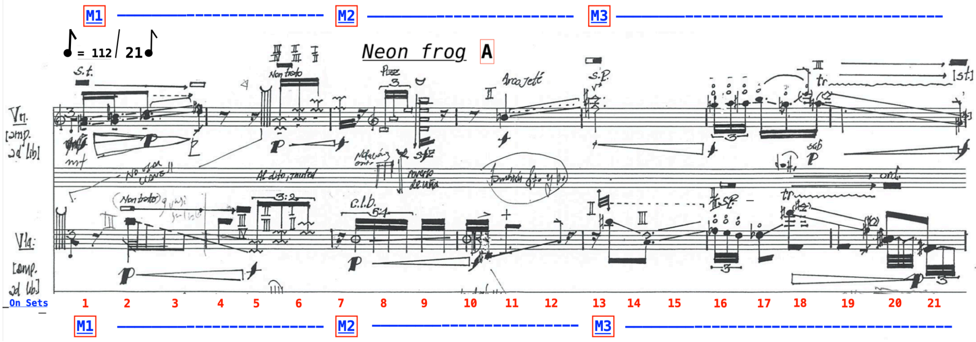


Figure 4.21, Reference Figure ‘A’
Composer’s sketch

The second instrumental group consists of the bass clarinet, percussion (a hybrid resulting from the coupling of a capsule microphone, various objects, and a snare drum), and the cello. The instrumental reference figure ‘B’ of this group encompasses four morphologies. The onsets of some of these morphologies could vary slightly for each instrument.

- The first morphology combines noisy sounds of varying qualities: *air tones* with or without *frullato* in the bass clarinet; granular noises produced by the microphone rubbing against the batter-head of the snare drum; and scratched sounds generated with maximum pressure from the *non tratto* bow stroke in the cello, resulting from a sonic translation operation that will be addressed in the chapter 5. Each morphology possesses a distinct and complementary profile: the cello performs a descending gesture; the microphone slides from the edge to the centre of the batter-head of the snare drum; and the bass clarinet produces a gesture akin to an irregular triangular wave.
- The second morphology combines percussive and rubbed gestures: repeated mini-slaps on the bass clarinet; a rubbing of the microphone against the soft the buckle tape that increases its speed (and thus its volume); and a combination of both generally declined timbres, including an initial strike with the *jeté* bow that responds to the clarinet’s first slap-tongue strike, as well as a tremolo with the *non tratto* bow that relates to the percussion’s gesture.
- The third morphology is the only hybrid, combining noisy and resonant sounds. It begins with a composite attack, resulting from the combination of a *Bartok pizzicato* in *sforzato* from the cello and a rapid rubbing of the buckle tape, which concludes the previous gesture of the percussion, thus concatenating both morphologies. This attack masks that of the bass clarinet multiphonic (the resonant and harmonic sound), whose dynamic envelope follows a *crescendo/decrescendo* arc, sometimes truncated. This instrumental gesture of the clarinet concludes with a repetition of the current multiphonic or with one

whose harmonics are in conjoint degrees. The percussion contributes to this composite morphology with a sound analogous to that of a güiro, whose origin is determined by an operation of sonic translation, that will be addressed also in the chapter 5, produced by the microphone against the fine teeth of a comb. The cello introduces another contrasting sound, resulting from a *tremolo* produced by the *non tratto* bow strike, whose profile opposes that of the percussion.

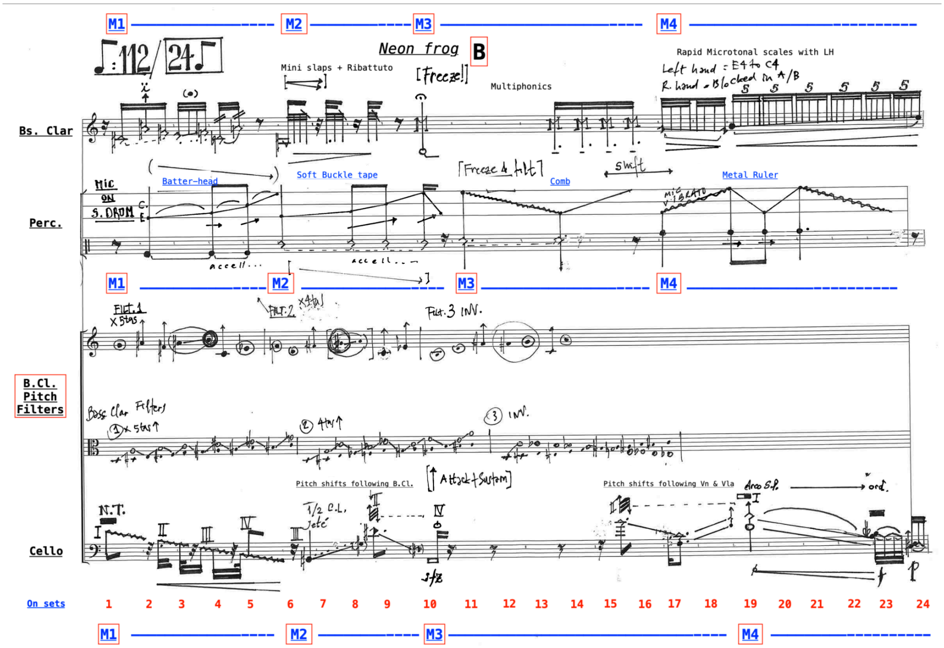


Figure 4.22, Reference Figure "B"
Composer's sketch

- The last morphology of figure 'B' combines three different profiles: the cello produces a descending movement; the bass clarinet performs a short descending movement followed by an ascending one; while the microphone, in combination with the metal ruler, produces a movement similar to a triangular wave. All three instruments exhibit varying degrees of contrasted internal timbre changes: the percussion alternates between vibrato techniques and smooth gestures; the clarinet transitions from air-tones to ordinary sounds, with both instruments executing extremely fast micro-tonal scales obtained by locking the right hand in one position and making a rapid chromatic scale with the remaining positions of the left hand; the cello presents the most drastic timbral change, moving from an ethereal glissando of overtones to sounds produced with maximum bow pressure (‘scratched’) on two simultaneous strings.

Global Processes

The formal structure of the piece is constructed through a temporal interpolation of three blocks. Each block is characterised by the development of specific methods, the articulation of particular networks of objects, the realisation of singular operative sets on designated sonic material, and the temporal scales through which the material circulates. This initial level of articulation of the macro-form was defined based on the experiments with the methods and subjects of investigation in progress. Its definitive setting will be one of the last compositional actions to be undertaken before the score is written and the electronic part is assembled. These formal blocks establish a precise timeframe in which a variable number of local compositional operations are developed, allowing for a certain degree of freedom. The precise mode of distribution of the global durations of the sections of each block was defined when the networks of objects, the operative field, and the methods of each reached a certain level of precision embodied in an intelligible global process.

The first formal block on which we focus our attention develops methods of sonic translation and techniques of symbolic granulation as explained before. This block is composed of three groups, from whose interaction emerges a complex texture in constant reconfiguration marked by a global process in which the reference figures and objects gradually unfold at different speeds, framed by internal phases of different durations. This complex process, based on multiple parallel iterations, aims to create a time-stretching effect on a reduced set of morphologies that oscillate between the sonic representation of a few extra-musical phenomena and the musical abstraction inferred from them.

The first macro-formal parameter concerns the evolution of the durations of the sections of each formal block. As demonstrated in the graph below, the first formal block follows a linear decreasing process, the second an exponential arc process—guided by a Fibonacci series—and the third an irregular increasing process.

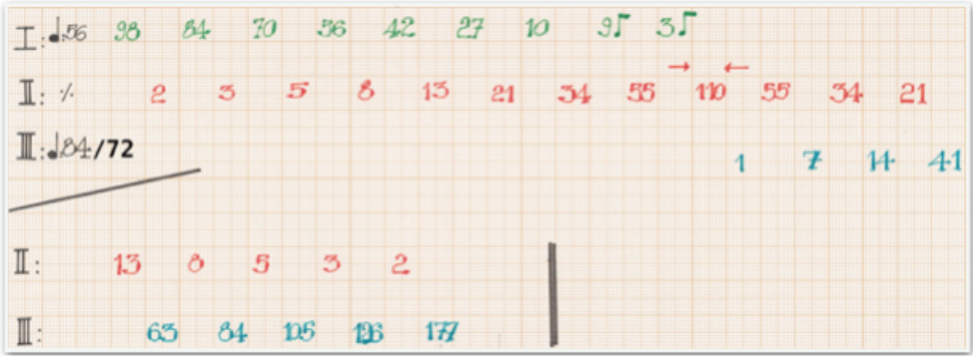


Figure 4.23, duration of *Neon Frog*'s formal blocks
Composer's sketch

The second globally determined process is the constant dephasing between the three groups that constitute the emergent texture. Each group is temporally articulated by its phase with its cycle of constant duration, as demonstrated in the descriptive table reproduced below. Each cycle is determined by a new instantiation in the iterative process. This can be influenced by several factors: by the electronic part, where a network of sound objects articulates each iteration, signalling a slight change of state in the sound objects of the main plane. By the two instrumental groups as examined here, marked by the alteration of one or more of the determining parameters of the global process of progressive reading of the reference figures. The unaltered phase of the internal temporal cycles of each group is restarted at each new section of the formal block; that is, the last cycles are always truncated, and the dephasing process recommences at each section.

The global processes of gradual development are not locally perceptible. These four parallel processes of instrumental granulation, shown in the table below, are determined by five main parameters:

- **Length of the sections.** The first process is the global contraction of the durations of each section, which frames a more significant one: the gradual opening of the scanning window module, signalling a gradual passage from an initial emergent texture toward instrumental figures and networks of electronic objects. This shows a slow change in the 'definition' of the same sonic matter, transitioning from a state of 'disaggregation' to a state of 'cohesion'. This process also entails a global change in the density of the sonic matter, transitioning from "sparse" to "dense".
- **Size of the reading window module.** This parameter is the most important in the symbolic granulation technique I employed in this work. The algorithm that governs its evolution defines the global rhythm of the sampling of the reference figure. In *Neon Frog*, it begins with an almost linear process where the size of the

reading window is maintained at regular values (except for the passage from section A to B) until the formal apex of section F, where its maximum opening exposes the reference figure in its entirety, albeit in a fragmented manner and within a local process of progressive accumulation. From the subsequent section onward, the size of the reading window initiates a decreasing inverse process until reaching the final minimum values.

- **Position of the reading window module.** The position of the reading window also starts with a linear process. Starting from the last onset up to the sixth quaver of the circular reference figures, the reading window scans progressively until its last morphologies are exposed in section E. After its total exposure in the next section, in the subsequent process of downsizing, its position is progressively shifted towards the centre of the reference figures.
- **Variation of the sampling unit (“Grain size variation”).** This parameter is the one that defines the figure’s current sampling mode, within the reading window size and position limits defined in each section. Its values increase almost linearly up to section F, to start an opposite linear process of reduction up to the last section of this formal block. Their manipulation directly influences the gradual state changes of the emerging texture in the first sections. The changing values within the internal phases produce immediately perceptible reconfigurations and progressive changes since the operations on this parameter affect on meso-temporal scales. Although this parameter is globally determined and conditioned by the one previously addressed, the final operations concerning it are inscribed in the multi-local character of the composable space of this work. The final decisions about it were taken in the final stages of the composition, at the time of the final draft of the score.
- **Variation of the sampling unit separation (“Grain separation variation”).** This parameter was defined through an empirical statistical approach, aiming to influence the state changes of the emerging textures unfolded in the initial sections. By examining the evolution of its values in the table below, one can readily appreciate the process of progressive densification of the sonic matter in this formal block of the work. The first section presents the greatest distance between its minimum and maximum values; in the last section, there is no longer any separation between the grains that sample the reference figure.

Table 4.3, Processes of instrumental granulation

Blocks I (in quarter notes)	Cycle lengths of Figures (in eight notes)	Window's module size and position in on & offsets (in eight notes)	Grain size var.: min. & max, and median duration (in sixteenth notes)	Grain separation var: rests min & max (in sixteenth notes)
98 (A)	A: 21 (Vn/Vla) B: 24 (Bs. Cl/Perc./Cello) C: 28 (Electronics)	A: 7 (21->6) B: 6 (24->5)	A: 1.5/10 (5) B: 1/10 (4)	A: 1/24 B: 2/26
84 (B)	A: 21 B: 24 C: 28	A: 14 (21->13) B: 13 (1->13)	A: 1/18 (6) B: 1/18 (5)	A: 1/20 B: 2/22
70 (C)	A: 21 B: 24 C: 28	A: 13.5 (5.5->19) B: 14 (6->20)	A: 2/20 (8) B: 2/22 (10)	A: 2/10 B: 2/9
56 (D)	A: 21 B: 24 C: 28	A: 13 (8->21) B: 14 (10->24)	A: 2/22 (12) B: 4/18 (14)	A: 4/10 B: 2/8
42 (E)	A: 21 B: 24 C: 28	A: 12 (9->21) B: 14 (10->24)	A: 2/26 (10) B: 6/30 (14)	A: 3/14 B: 2/4
27 (F) Reference Figures & 'Buffer'	A: 21 B: 24 C: 28	A: 21 (1->21) B: 24 (1->24)	A: 3/13 (9) B: 2.5/18 (11)	A: 3/15 B: 5/14
10 (G)	A: 15 B: 20 C: 10	A: 9 (1->9) B: 16 (6->22)	A: 4/10 (5) B: 3/18 (6)	A: 4/10 B: 5/8
4.5 (H)	A: 9 B: 9 C: 9	A: 3.5 (11->14.5) B: 2.5 (6->8.5)	A: 9 B: 5	A: 0 B: 4
1.5	A: 3 B: 3 C: 3	A: 3 (11->13) B: 3 (10->12)	A: 6 B: 6	A: 0 B: 0

Local Operations

As compositional practice carries tension between acquired and emerging knowledge beyond experimental stages, is difficult to trace precise boundaries. The multi-scalar approach of the composable provides flexibility in acting on the temporal dimension but demands in parallel a certain elasticity to move between global and local levels of articulation of the sound matter through the multiple stages of the compositional process. Therefore, both the framework established by the algorithms governing the global processes and the conception of the sonic material are conceived to leave ample room for multiple local compositional operations. Many of these operations concern the direct manipulation of symbolic granulation techniques' central parameters deployed during the compositional process of *Neon frog*. Some of these local operations concern punctual modifications of the instrumental or electronic morphologies. Others involve acting on several planes simultaneously. In this section, I will present some of the most significant operations and provide concrete examples of these localised actions.

- **Local sampling operations.** Almost all *sampling* actions are local operations within the frame set by the size of the sampling window module and by its current position in a given step of the global process. The central parameters of size variation and grain position variation constitute globally bounded multi-local action fields. These actions, carried out within meso-temporal scales, have a profound impact on the emerging complex textures. These operations also determine the "rhythm" of scanning, the final form of the « unfolding » process, and the way in which the phenomenon of temporal dilatation that occurs as the original sonic material is gradually unveiled materialises.

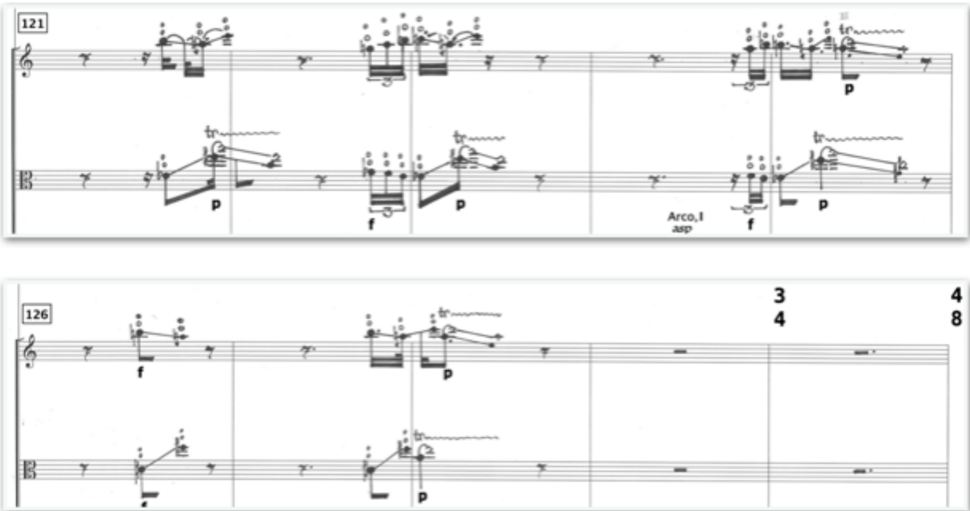



Figure 4.24, *Neon Frog*
Nested local process upon "Grain separation" parameter, following a wave-like model with changing amplitudes at the end of the section C (pp. 25-26) of the unpublished score (2024)

- **Local operations on matter's density.** The change in the state of density of matter, statistically framed by the algorithms guiding the global processes, takes its final form through local operations of distribution of instrumental actions. This is accomplished by punctually manipulating the parameter of separation of the "grains." Depending on the context, these actions can be performed with a wide margin of freedom. However, in several passages of *Neon Frog*, mainly in the initial sections of the first formal block, the variation in the grain separation parameter is determined by nested local processes of dispersion or densification of sonic matter. These processes follow simple models of transformation or oscillation between dispersed or dense states. They can be linear or exponential, produce a single or several transformations, or oscillate following patterns of different waveforms.

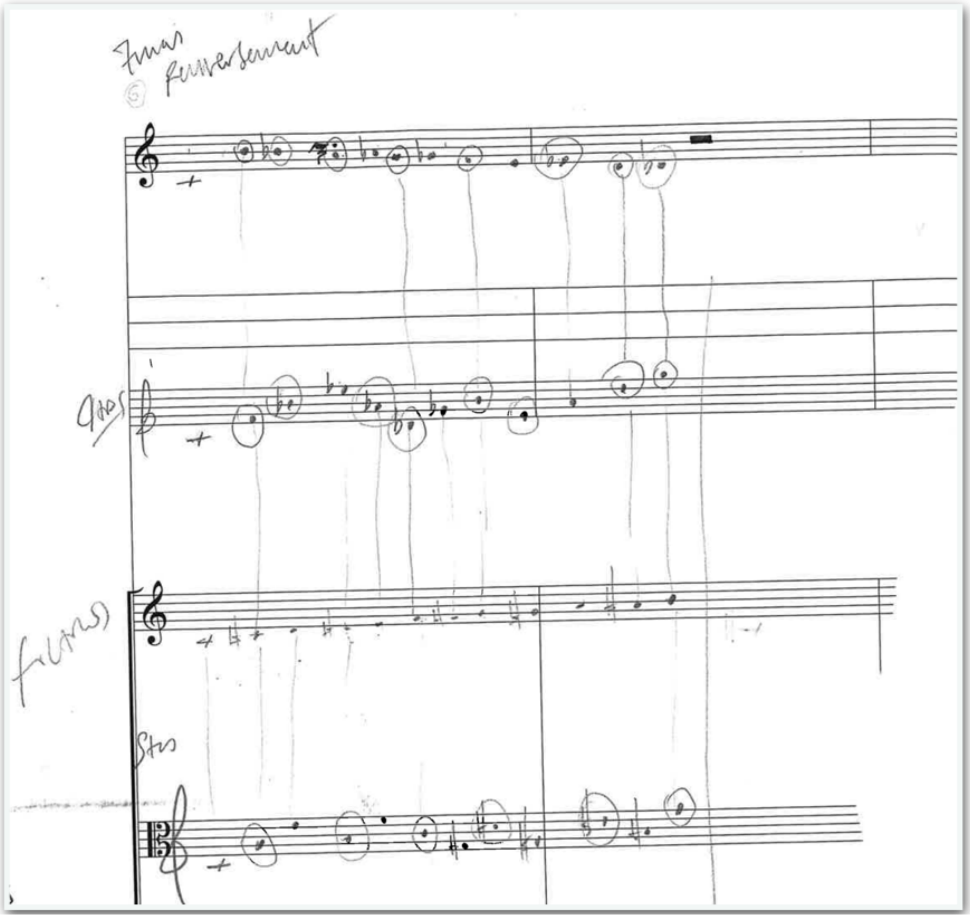


Figure 4.25, pitch filtering system
for the Bass Clarinet's first morphology

- **Local pitch manipulations.** The instrumental reference figures contain some fixed pitches that act as poles within a locally reconfigurable harmonic field. The operations on this parameter are varied, varying in complexity, and can respond to various needs that arise in the final stages of the compositional process. An example of this concerns the changes of some of the pitches that comprise the first morphology of the bass clarinet figure in *Neon frog*. In this particular case, I employed a system of filters that maintain central pitches and change some secondary, preserving harmonic relationships based on recurring intervals. These permutation techniques were previously used by other composers, such as K. Stockhausen, G. Ligeti, and M. Jarrell. In the image below, one can observe filter systems by ascending fifths and perfect fourths or by descending semitones (which is equivalent to making an inversion).

- **Local filtering.** Another recurrent local operation in this work is filtering, which simply consists of eliminating some morphology, or part of it, from the reference figures. These operations locally accentuate the processes of constant reconfiguration of the emerging textures by producing slight changes that do not affect their global state.

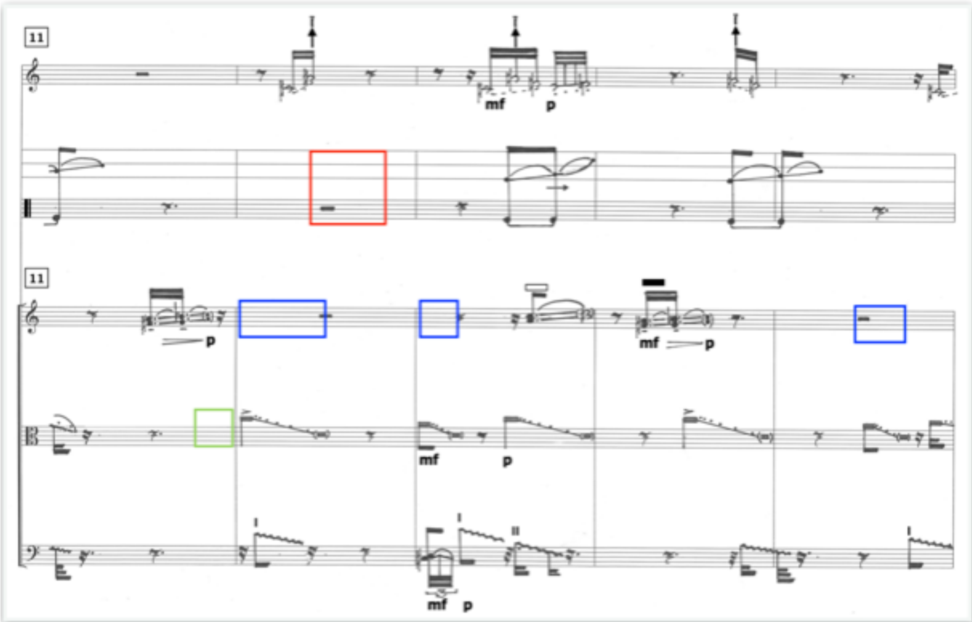



Figure 4.26, *Neon Frog*
examples of local filtering (p. 9) from the unpublished score (2024)

- **Micro-variation of morphologies.** The micro-variations implemented in *Neon frog* were singular operations with a shared aim: that of producing a local reconfiguration that does not affect the emerging global state of the granular textures in the first sections of the formal block examined here. One example concerns the second morphology of the bass clarinet, which initially repeats the same pitch but is then locally transformed into an ascending or descending motif per conjoint degree, as demonstrated in the following example.

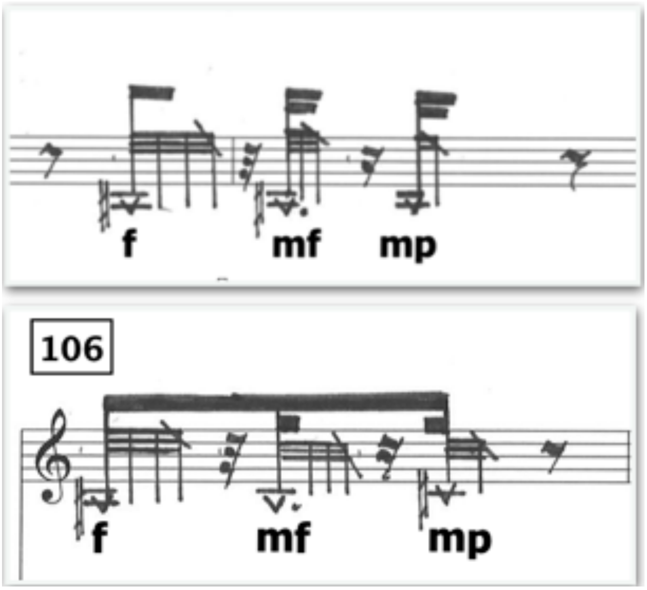


Figure 4.27, example of morphological micro-variation on the Bass Clarinet part
Bars 68-69 & bar 106.

- **Local shifting & internal phasing.** These operations respond to the same objective mentioned above: that of producing slight changes that do not affect the global iterative processes on the original sound material. They involve sudden and punctual jumps in the position of the current reading window in the sampling techniques, with an impact on the local articulation that does not alter the matter's global state. The punctual operations of dephasing within the reference figure composed by the same instrumental group serve the same objective.

Summary

In this chapter, I have focused on the symbolic granulation techniques employed in two of my works. The experiments conducted using these techniques during the composition of these works provided me with a significant lesson. Experimenting with these techniques during the composition of these works provided me with an important lesson, which serves as a starting point for future experiments in the development of the method discussed here. The relation between morphological properties of a given source material and the specific granular-based operations is mainly oriented by the main poetic idea and aesthetic goal of each specific work. The articulation of these two dimensions, which are always present in this method, must be continuously situated, which makes it impossible to determine a constant causal relationship. On one hand, morphological properties of the source material could determine the overall approach to this method: the global strategies, the main techniques, and the local operations. Conversely, global strategies for granular-based techniques could determine the shape of a created or an existing source material depending on its morphological properties. The experiments that characterised my relationship with this method reveal a more complex dynamic determined by several factors. Acquired and emerging knowledge, intuition, and new ideas that open up paths for exploration, coupled with constant feedback between sonic output resulting from experiments and abstract thinking derived from observation, mold an interactive and evolving relationship between the given shape or determined choice of the source material and the particular forms of its manipulation.

In addition to the two works of my own, in this chapter I have also discussed two works by other composers. Each demonstrate a unique approach to addressing the subject of symbolic granulation, utilising specific source material, and developing different techniques such as phasing or sampling.

The most remarkable similarities are the non-narrative and non-rhetorical articulation of musical flow of the examined works, an atomic conception of sonic matter and a non-linear, cyclical and iterative approach to musical time. They also present significant differences:

Harryson's *Repetitions in Extended Time* employs phasing and looping techniques framed by cycles of slowly permuting harmonic fields over reduced sound material. His focus is on the use of recursive musical forms to explore iterative and cyclic musical time through recombinations and micro-variations of minimal sonic gestures.

Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden by Laure M. Hiendl explores extended-duration musical forms derived from extremely reduced pre-existing source material, employing score-sampling, microscopic fragmentation, recombination, and other granular-based techniques. Hiendl's focus is on developing texture-based articulation in musical works and incorporating digital artefacts as compositional resources.

In a contrasting manner, my work *Mutante/Amniótica* is largely based on constructed musical figures that are then locally manipulated using granular-based operations guided by global processes, allowing for detailed micro-articulation across multiple time scales. My primary focus is on creating ever-changing, emerging textures through iterative operations on reduced material with changing morphology.

On its part, the source material of *Neon Frog* is a hybrid product oscillating between the representation of extra-musical sound and musical abstraction. This work incorporates density manipulation, sampling unit variation, filtering, shifting, morphological micro-variation, and other instrumental granulation techniques, as well as sampling and phasing. The poetic goal of this piece is to create hybrid textures navigating between a sonic real and a sonic imaginary, while circulating across several time scales.

The essence of these methodologies lies in their ability to deconstruct and reimagine sonic materials. By drawing inspiration from digital audio processes and translating them into notational frameworks, these techniques create a fertile ground for exploring the atomic dimensions of sound, manipulating time, and experimenting with time-scale transformations. They enable instrumental performance to generate complex textures from short fragments, opening a vast field for articulating diverse sonic objects within the composable space.

Finally, the paradoxical phenomenon of gradual change through constant iteration is an expression of a common quest that invites the listener to inhabit the present through the musical experience: to induce states of trance in the audience, or to stimulate a listening based on short-term memory induced by the concatenation of short fragments, and the desire to foster an experience of circular, almost ritual temporality.

Chapter 5. Sonic Translation

Introducing Sonic Translation Methodologies

This chapter examines musical works that showcase the artistic method of sonic translation within the composable space. Within this framework, it is essential to address the following elements: the object or phenomenon being translated (the source material); the specific methods of transformation from one domain to another; the means employed in the transfer process (such as technical objects used to perform operations or physical instruments used for materialisation); and the scale(s) of representation employed in works created through these sonic translation methodologies.

As an artistic methodology in contemporary and experimental music, sonic translation can be defined as the process of transforming non-musical data or experiences into sonic form. It encompasses a broad range of approaches but generally involves the mapping of information from one domain (visual, textual, physical, environmental, etc.) onto musical parameters (pitch, rhythm, timbre, dynamics, form, etc.). This mapping can be direct and literal or highly abstract and interpretive. Sonic translation often bridges disciplines, drawing inspiration and techniques from fields outside of music, such as visual arts, computer science, mathematics, literature, or natural sciences. The methodology often emphasises the underlying concept or idea driving the translation process, intending to explore the relationship between the source material and its sonic representation. Sonic translation frequently involves the use of data as a compositional tool. This data can be derived from various sources, and its manipulation plays a crucial role in shaping the resulting music. A central aspect of sonic translation is the development and exploration of mapping strategies. How does one translate visual colour into musical pitch? How does the movement of a dancer translate into rhythmic patterns? The choices made in these mapping processes are decisive in shaping the character of the work.

This discussion will examine works that employ sonic translation methods. It will explore their connection to artistic creation and their different approaches to shaping and delineating specific composable spaces. Each case study offers a unique viewpoint, presenting particular phenomena for translation, diverse methods of transferring data to the sonic realm, different means for performing the translation operations and media for their materialisation, and specific approaches to navigating the scales of representation of the translated data.

I will begin by presenting my work, *Trans-étude #4: Intérieur/Extérieur* (2022), for tuba, field recordings, and electronics. This work explores the sonic translation of indoor and outdoor environments, developed in close collaboration with the tuba player, who was invited to make field recordings of his immediate urban surroundings.

Next, I will examine several specific sonic translation techniques used in my recent work *Neon Frog* (2024), for five amplified instruments and electronics. This work, which utilises sound samples from vastly contrasting domains—including numerous South American frogs and toads, as well as satellites—explores the sonic continuum between nature and culture (Massumi, 2002, p. 11), along with specific forms of its representation.

Beyond my own compositions, I will also analyse three works by other composers, situating them within a brief overview of current practices in the field. A comparative analysis of their sonic translation methodologies alongside my own will inform past compositional choices, help formulate new research questions, and potentially suggest future directions for artistic inquiry.

Trains (2014) by Joanna Bailie

A significant part of Joanna Bailie's work revolves around the interplay between the real (often in the form of field recordings that are then electronically manipulated or assembled into montages) and its transcription for musical instruments. The inevitable distance that arises between these two elements becomes a productive space for musical creation. In this work, recordings of trains provide the basic material for both the tape part and the cello part. The latter unfolds according to the principle of *imaginary transcription*, capitalising on the inherent imperfection of its mimetic endeavour. In this initial stage, Bailie begins to blur the distinction between real and imaginary by slowing down the first six recordings. Through transposition, these recordings form an ascending minor scale that culminates in the final recording, played at its original speed. This scale creates a sense of gradual progression towards the real, which becomes perceptible as the playback speed approaches its original rate.

While sharing thematic connections with her work *Artificial Environment* series for instruments and tape, this composition differs from its predecessors in several key aspects. In particular, it uses high-sampling rate recordings to capture the train sounds, and shifts from an approach of "instrumental *doubling* of the field recording in favour of an idea of *implied melody.*" (Bailie, 2017, p. 145).

Bailie recorded train sounds at two locations in Brussels: Bruxelles-Chapelle (December 2013) and Gare de Schaerbeek (January 2014). These sites, chosen for their distinct sonic environments, provided a diverse range of train-related sounds, from passing and stationary trains to station announcements and even construction noises. As noted by Bailie (2017, p. 145), the selection of recordings was guided by the need to capture a rich variety of dynamics and timbres beyond the immediate sounds of train movement. Using high-fidelity equipment (96 kHz/24-bit sampling rate), Bailie sought to preserve a wide spectrum of frequencies, including ultrasonic components.

Working with the Recorded Material

A defining feature of *Trains* is its structured use of transposition. Bailie arranges the recorded train sounds into an ascending minor scale, achieved by slowing down six of the recordings before reaching the final one at its original speed. As she describes (2017, p. 146), this progression conceptually moves the listener from an altered, heightened reality toward an unprocessed representation of the real. To achieve these transpositions, Bailie employs the Audiosculpt software, disabling the time-correction mode so that pitch is affected alongside speed. The specific transpositions follow a calculated pattern: -11, -9, -8, -6, -4, and -2 semitones, culminating in unaltered playback of the seventh train. As Bailie explains, this not only introduces a melodic contour but also brings ultrasonic frequencies into the range of human hearing, effectively expanding the perceptual boundaries of the original recordings.

Beyond transposition, Bailie enhances and extends the spectral qualities of the train sounds using synthesised sine-tone drones and glissandi. These elements, carefully mapped through sonogram analysis in Audiosculpt, serve to reinforce and amplify the tonal structures inherent in the field recordings. In addition, the composer uses ring modulation to create subtle harmonisations, as she did in earlier works such as *Harmonizing (Artificial Environments No.7)* and *Artificial Environments Nos.9a-d* (Bailie, 2017, p. 147).

Another notable technique in *Trains* is what Bailie calls “hand-made granulation.” This involves manually cutting tiny fragments from the field recordings in decelerating patterns, a gesture inspired by the natural stuttering sounds of the rail tracks in *Train 1*. Additionally, in *Train 7*, she applies limited audio freezing to transform glissandi into discrete, stepped scales, reinforcing the structural ascent of transpositions that underpins the work.

The Cello Part

A significant departure from Bailie’s previous works is her approach to synchronisation. Rather than using a click track, *Trains* employs a video stopwatch to control the timing between the cello and the tape. This introduces a controlled flexibility that allows for subtle variations in performance while maintaining key structural points. Bailie’s score alternates between metered and unmetered sections, with time codes marking entrances and exits rather than dictating precise moment-to-moment synchronisation.

Different sections of *Trains* demonstrate different relationships between cello and tape. In *Train 2*, for example, Bailie constructs a cello melody derived from the extreme pitches of two police siren *glissandi*. While the melody is notated with bars and a tempo, its alignment with the tape varies between performances. Conversely, *in Train 1*, the cello responds to granular disruptions in the tape part with specific playing techniques—heavy bowing for noise, tremolo and *jeté* for rhythmic stuttering—that mimic the electronic textures.

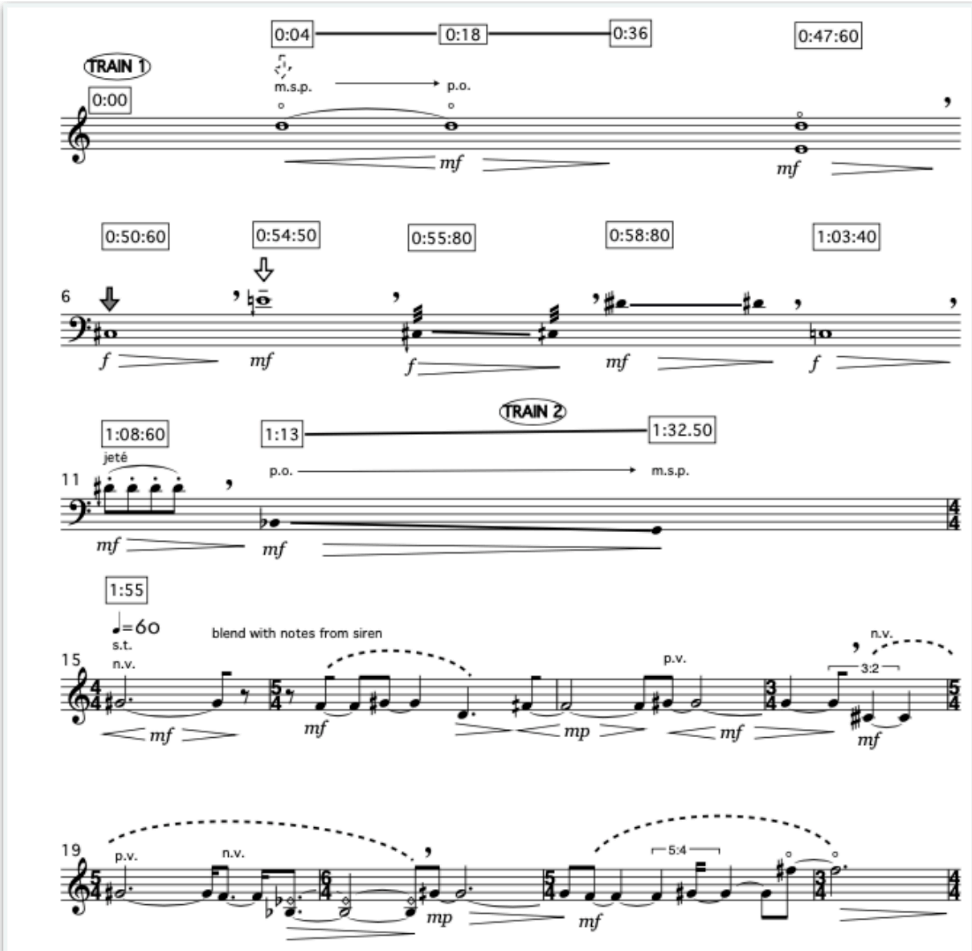



Figure 5.1, *Trains*
Bars 1-22 (2014)

A striking moment in this work occurs in *Train 5*, where Bailie introduces an excerpt from the Gigue of J.S. Bach's *Cello Suite No. 5 in C minor*. This passage is altered with additional sustained tones and glissandi that loosely correspond to the tape part. Bailie (2017) suggests that this inclusion furthers the central idea of the piece—namely, that *Trains* seeks to construct a heightened sonic reality where we access elements typically beyond normal hearing. Although Bach's music predates the railway era, its rhythmic qualities evoke a connection to the archetypal sounds of locomotion, creating a historical and perceptual bridge between past and present.

Intersemiotic Translation in Alberto Bernal's Work

Alberto Bernal's *Impossible Translations* series provides an important case study of intersemiotic translation between the visual and sonic realms. According to Bernal (in Vázquez Rodriguez 2015, p. 32), the *impossible music* can be understood as the materialisation of the sublime through kitsch, which creates a dialectical tension between the elevated and the banal. *Impossible Translations* is intrinsically linked to Bernal's *Impossible Music* series, where works are conceived as "music to be seen" (Bernal in Vázquez Rodriguez, 2015, p. 32), emphasising the visual dimension. Influenced by the work of Gerhard Rühm (especially the collage *Les adieux*, from the *Lieberbilder* series), both series share a conceptual basis in exploring the relationship between image and sound, although *Impossible Translations* specifically transcribes images into sound.

As Vázquez (2015) points out, Bernal identifies three different modalities of sonification within his process of translating visual images into sound:

1. **Translations of still images:** This approach shares similarities with the *Portraits* series, focusing on the translation of a static visual image into a musical form. A paradigmatic example of this technique can be found in the third movement of *Impossible Translations #1*, where the profile of the Gaza wall is transformed into a sonic score.
2. **Translations of moving images:** In this modality, the transcription emphasises dynamic visual parameters—including colour, activity, luminosity, and numerical data derived from the moving image—which are assigned to musical parameters such as pitch, dynamics, rhythm, or melodic morphology in a non-preset manner.
3. **Treatment of video:** This modality involves the application of musical processes to the visual image itself, with the aim of achieving an inherently musical outcome. It includes the manipulation of resolution and sharpness, abstraction through zooming techniques, and temporal modifications, such as altering playback speed and implementing *walking loop* techniques. [51]

[51] This concept, coined by the composer, describes a technique involving slight interval shifts within a loop after several repetitions, resulting in a gradual progression of both the visual and sonic material. A recurring element in Bernal's work, it shares similarities with compositional techniques such as *sampling*.

In his recent book, Bernal addresses the entire cycle, stating that:

> In the series of works *impossible translations*, different videos taken from everyday life in conflict zones (Palestine, Arab Spring...) are transcribed into scores using various operations of analysis of the moving image (presence of colours, centre of masses, movements...), in an attempt to force a relationship that puts two a priori incompatible fields on the same plane, of the paradox of an impossible music made possible by the materialisation of an impossible translation. If such operations can be qualified as 'inappropriate', it is precisely this inappropriation, this alienation of their medium that constitutes their possibility. The possibility that the real can be perceived aesthetically through its sonification, as well as the possibility that the aesthetic can be expelled from its purity and placed in relation to its other. (Bernal, 2024, pp. 32-33)

In a January 2025 interview I conducted with him, when asked about the role of media superimposition and repetition in his translation method, the composer stated, "The efficacy of my translation method is ultimately determined by the congruence of treatments applied to both visual and sonic materials within the same work."

Transformation process

Bernal's process of image-to-sound translation uses a combination of technical tools and artistic choices. As he explains (2025), "The process begins with video processing and analysis of visual parameters (colour, position, mass, luminosity) using Max and Jitter patches." To ensure accurate measurement of these parameters, Bernal employs downsampling, which divides the screen into distinct zones. This data is subsequently converted to MIDI and imported into Sibelius's music notation software. In this software, Vazquez (2015, p. 34) notes, "each video attribute that you want to translate into the sound world is placed on a different MIDI channel," creating a *data score*, an intermediate step in the translation process that is distinct from the final musical score. The MIDI note number is used for single parameters, while a combination of note number and velocity represents multiple simultaneous parameters.

Beyond these direct translations of visual parameters, Bernal also translates specific image points, such as parameter maxima and minima, into musical events, including clusters. He also incorporates non-visually derived musical modifications, adding layers of interpretation and creative input to the translation.

The synchronisation between music and image is achieved by a digitally generated clapperboard. Bernal explains (2025) that "the clapperboard is generated using the same translation method," with bars aligned to key points in the video. Modifications are implemented to facilitate both synchrony and performance. The clapperboard staff is then exported as an audio file and synchronised with the video in Final Cut. During the performance, the musician monitors the clapperboard through headphones, ensuring temporal coherence between the music and the visuals.

Impossible Translations #4 Suite (2013)

In this 16-minute work for piano and video, Alberto Bernal explores the intricate relationship between visual and sonic domains through intersemiotic translation. The work uses a variety of techniques to bridge these modalities, including the analysis of visual parameters such as colour, luminosity, position, and movement, which are then translated into corresponding musical elements. Pixelation and *walking loops* are employed to create both visual and musical textures, often mirroring each other's transformations. Numerical data, as seen in a custom-designed stock market display, also serves as a source for musical material, with fluctuations in the data triggering changes in pitch, rhythm, or dynamics. The piece explores the interplay between pre-composed musical sections and video in a particular example of how sound can be generated from visual information and vice-versa. Digital tools and processes—including software such as Max and Jitter—enable the analysis and manipulation of both visual and sonic materials. Synchronisation between the two domains is carefully managed, often through the use of digitally generated clapperboards or other temporal markers. Repetition and micro-variation of musical motifs play a significant role in the structure of the work, mirroring the visual transformations taking place on the screen. The piece culminates in a self-referential moment, drawing attention to the performative context (the current venue) and blurring the boundaries between representation and reality.

The composer provided the Max sub-patch he designed for his image-to-sound translation process. It reveals the various parameters involved in the image-to-score translation via MIDI. The matrices illustrate how Bernal uses six distinct MIDI tracks with associated pitch and velocity parameters to encode information derived from the videos. This data is primarily extracted using algorithms from the OpenCV (cv.jit) library.

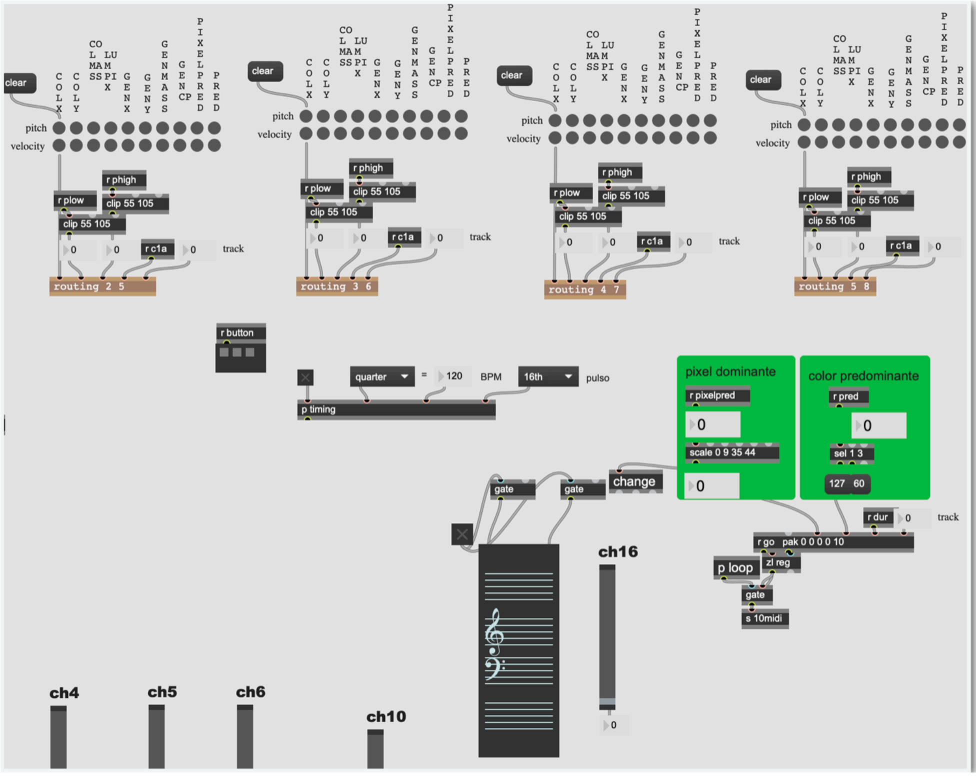


Figure 5.2, a partial reproduction of the Max sub-patch
Designed by Bernal to realise image-to-sound translation operations

The abbreviations of the visual parameters mapped onto the sound parameters are displayed at the top of the image. They correspond to the following meanings:

- **COLX, COLY:** The centre of masses (x and y) of a given colour.
- **COLMASS:** The total mass ('quantity') of a colour.
- **LUMPIX:** The brightness of a particular pixel. Significant downsampling of the original video (up to 3X3) allowed the composer to track the brightness of a large area (a 'pixel').
- **GENX, GENY:** The total centre of mass of the image.
- **GENMASS:** The total mass of the whole image.
- **GENCP:** The compactness of the image.
- **PIXELPRED:** The number of pixels with the highest brightness.

The information obtained was used to create an intermediate score (data score). The image below shows a fragment of the data score for the first movement, illustrating the six tracks with their pixel predominance values (pixelpred) and five distinct colours.

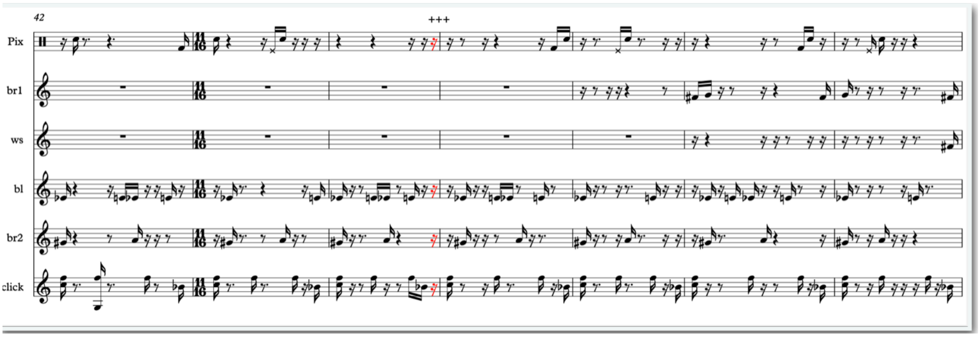



Figure 5.3, data score
Partial reproduction of the data score for the I movement

In our 2025 interview, Bernal explained that the process, which begins with the image-derived data in the intermediate score and culminates in the final performance score, was “completely handmade, without any criteria other than assigning some of these values to some actions, always maintaining the correspondence between image and sound.”

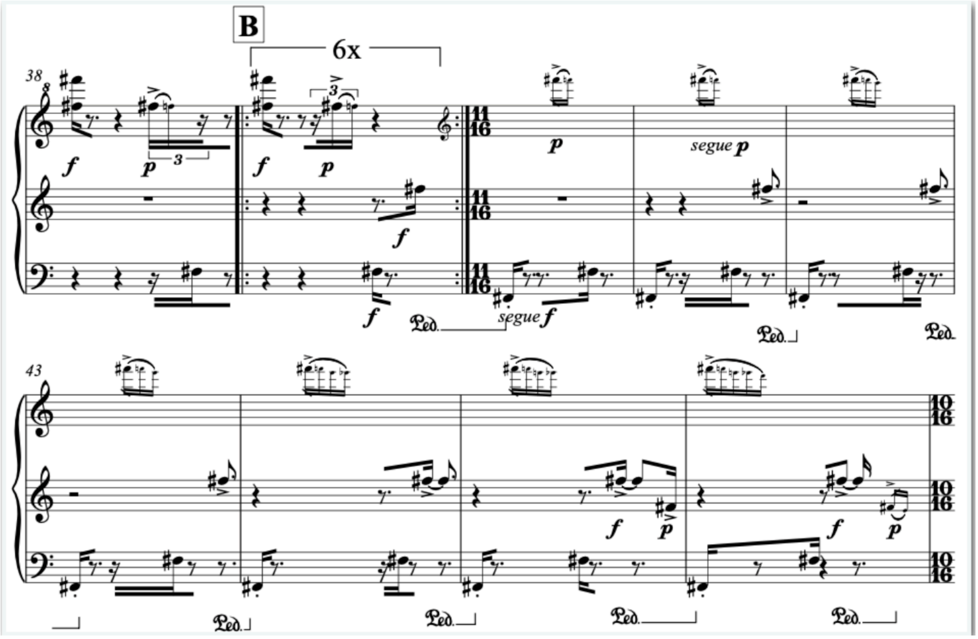



Figure 5.4, Movement I: *Ouverture*
Bars 38-46, corresponds to the previously reproduced data score fragment

This first movement mirrors *Impossible Translations #1* in its use of abstraction, pixelation, a *walking loop*, and colour-based musical analysis. It gradually reveals human figures ascending steps, culminating in the inscription "G-8 SUMMIT 2012," and recognisable world leaders, with the *walking loop* lending a caricatured feel.

Figure 5.5, frame of video
Corresponding to bar 38

Carola Bauckholt's Photographic Imitations

Imitating the sounds of nature, especially birdsong has been a recurring theme in Bauckholt's compositions over the past fifteen years. A preoccupation guided by the need for novel sonorities, which the composer "usually finds outside the music" through a process of attentive listening. Rather than reproduce "clichés of whatever music," the composer strives to capture the essence of these found sounds with a high degree of fidelity, akin to a "photographic" approach to the "acoustic experience" (Bauckholt, 2012). This involves a process of acoustic transcription—a "transfer" in Bauckholt's (2012) own words—that translates the observed sounds into a language playable by traditional instruments. This translation, however, is not merely imitative. It necessitates an expansion of instrumental technique and timbral possibilities, a process that relies heavily on the collaborative input of the musicians. The specific timbral characteristics of ensembles serve as inspiration and catalysts for the exploration of particular sound worlds. The composer's task is therefore twofold: to distil the fundamental qualities of the original sound and to construct a sonic environment that contextualises and surrounds it.

In the string quartet *Lichtung* (2011), composed for the Norwegian ensemble Cikada, Bauckholt reconstructs the sounds that might be found in a clearing (from which the work takes its title), the treeless space that can be found in the middle of a forest: the wind, various types of insects and birds, or the movement of branches and foliage. The composer provides with the score a series of birdcalls, which she has transcribed beforehand and which are to be imitated “as closely as possible,” following “pitches, rhythms, timbre, dynamics and the expressive quality of the sounds” (Bauckholt, 2011).

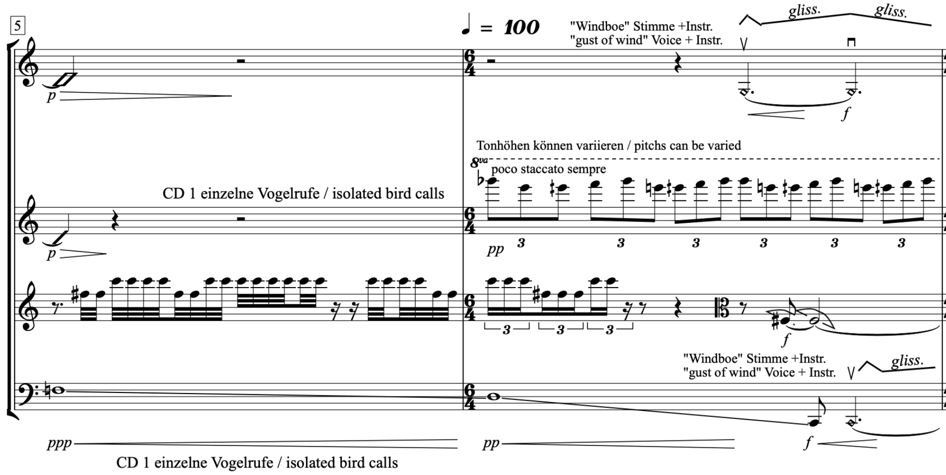


Figure 5.6, *Lichtung*
Bars 5 and 6, score provided by the composer. © Thürmchen Verlag

In a later work for five wind instruments (composed between 2011 and 2012), titled *Zugvögel* (Migratory Birds), she skillfully orchestrates recordings of diverse bird songs without electronic manipulation. The performers (oboe/English horn, alto saxophone, Bb clarinet, bass clarinet, bassoon/kontraforte, and two bird calls) are tasked with imitating the pre-recorded sounds of thirteen birdsongs (swan, whooper swan, pelican, common scoter, chicken, black grouse, chukar, Canada goose, duck, cormorant, falcon, common loon and harlequin duck) that Bauckholt notated in the score. While an exceptionally faithful transcription of these recordings is provided, it serves, in her words, merely as a guide. The challenge for each musician lies in navigating the interplay between the demanding rhythmic precision of Bauckholt's score and the more flexible phrasing and intonation of the original bird songs, thereby creating a unique interpretation.

Doppelbelichtung (2016)

In *Doppelbelichtung* (2016) — for amplified violin and 12-track tape — the composer explores a hybridisation between the sounds to be imitated and their imitations. For the first time, the sonic phenomena to be translated (birdsong) and their translation (Bauckholt's 'photographic imitation') coexist within the piece. Notably, in *Doppelbelichtung*, the composer also electronically manipulates the original sounds being imitated — another first in her practice.

Bauckholt transforms each dimension to further blur its contours. She asks the instrumentalist to listen carefully to recordings of birdsong, in order to find the most appropriate playing technique to reproduce it as faithfully as possible. At the same time, she manipulates the speed of the recordings, slowing them down to produce slower, lower-pitched songs but within a limit that still allows them to be recognised for what they are. The slowed-down birdsong (with an indication of name, speed of playback, transposition and location in the broadcasting space), and the imitation sounds of the violin are noted very precisely in the score, even if they serve once more as a reference. As Bauckholt (2016) explains in the programme note, the violin "is the only instrument that can produce this extreme height - but through a completely different process."[52] That is precisely why it is so appealing to bring both worlds together, like a '"narrowing in counterpoint."

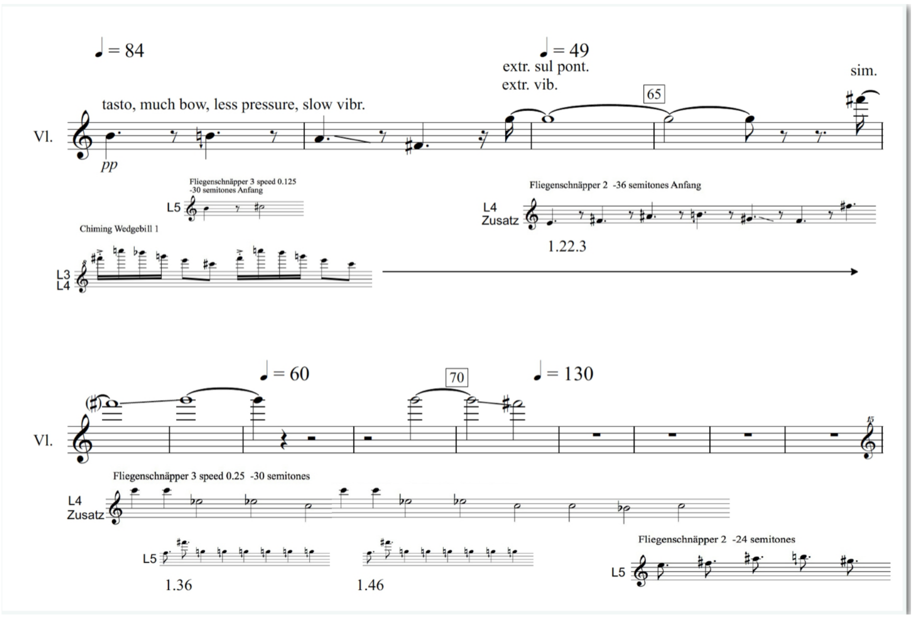


Figure 5.7, *Doppelbelichtung*
Bars 62 to 74. © Henry Litolff's Verlag GmbH & CO. KG

[52] Note: Process that differs from the birds' complex methods of sound production.

The title of this work, *Doppelbelichtung*, translates as *Doble Exposure*, a "technique from analogue photography in which one image is exposed on top of the previous one. In this way, several levels of reality are captured in one picture" (Bauckholt, 2016). This piece presents a sonic interplay between violin and bird song, where each sound appears to be a composite, a 'double exposure' of the two. The violin imitates the bird's vocalisations, which are subsequently manipulated to evoke the timbre of the violin itself. The hybridisation between the original sound object, its electronic manipulation and its translation is reinforced by the multidimensional dispositive of the work. As Caty Van Eck (2017b) observes, "every bird recording acquires the spectral characteristics of a violin" albeit through the diffusion of these sounds via "tactile transducers attached to violin corpuses hanging in the air."

Trans-étude #4: Intérieur/Extérieur (2022)

This section explores the implications and nuances of sonic translation as an artistic method, focusing on its application within my work *Trans-étude #4: Intérieur/Extérieur* (2022), composed for amplified tuba, field recordings, and tape. The version discussed here emerged from an extended collaboration with British tuba player and researcher Jack Adler-McKean.

To begin, I will briefly introduce the central concepts underlying the ongoing artistic project, the *Trans-études* cycle, and outline the origins of the work discussed in this chapter.

Secondly, I will present and explain the various work stages that comprise this piece's creation process and others involving the artistic method discussed here. Finally, I will address the outcomes and developments achieved during these stages as they unfolded throughout the composition of *Trans-étude #4: Intérieur/Extérieur.*

About Trans-études Cycle

I began composing *Trans-études* in 2019 as an ongoing cycle of musical works. The primary aim of this cycle is to explore the translation, transcription, or transduction of various objects, processes, or phenomena into musical compositions. Rather than focusing on the consistency or fidelity of reproducing a given entity into the musical domain, this cycle aims to explore the thresholds between the abstraction of musical discourse and the sonic traces of something identifiable as external to art. This passage, where perception shifts between the logic of music and the recognition of something beyond it, motivated the creation of this cycle. Another central point of interest in this cycle resides in exploring the fertile navigation domain between scales of representation in the instrumental or electronic sonic transcription of a given object or phenomenon.

The final format of each study remains open, varying from traditional forms of notation—such as written scores—to alternative modes of mediation, including graphic, textual, or sonic instructions for creation and/or performance. Echoing conceptual art, this cycle emphasises the process and the subject or artistic method under investigation rather than the final outcome.

The cycle encompasses a variety of artistic methods and techniques—including re-coding and transcoding, sonic mimesis, the recuperation and recomposition of cultural artefacts, sonic mapping, and the translation of extra-musical phenomena into musical form. Some of the works already realised, in progress, or forthcoming address these specific topics:

- *Trans-étude #1* (2019): A random spoken text as a sonic matter to be superimposed on a random score used as a map, disconnected from the sonic matter originally represented by it.
- *Trans-étude #2* (2020): An excerpt of a text from Jacques Lacan serving as a sonic framework for creating and performing music.
- *Trans-étude #3* (2021): Digital audio techniques applied to music quotations and sound archives.
- *Trans-étude #5* (2023/24): Transcription and musical re-encoding of wildlife sound files.
- *Trans-étude #6* (2023/24) Transcription interpolations of wildlife sound files with musical sound files.
- *Trans-étude #7* (2025) Inventory of silences with parasitic noise in archives of classical music recordings. Inventory of silences with parasitic noise in archives of field recordings. Interpolations between the two.
- *Trans-étude #8* (2026): Biographical sonic ecosystems.
- *Trans-étude* #9 (2026): Re-encoded scores: hacking piano works using sound files from field recordings. This involves overlaying excerpts from field recordings onto the symbolic material of a piano work's score, performed with a digital keyboard.
- *Trans-étude #10* (2027): Public transport GPS Data used for real-time sound synthesis.

Manipulated Soundscape: Real and Imaginary

Trans-étude #4: Intérieur/Extérieur explores the irruption of reality into music—or, as composer Peter Ablinger described his concept of *phonorealism*[53], "the observation of 'reality' through 'music'". In this work, I use sounds from reality as both the source and catalyst for musical abstraction. Field recordings and instrumental mimesis serve as the foundation for developing compositional strategies. The interaction between these elements, combined with the application of digital signal processing (DSP) techniques, facilitates the creation of sonic objects, networks of objects, and compositional operations. This approach gives rise to what I name a "manipulated soundscape"[54]—a dynamic interplay which oscillates between the representation of real-world sounds and the realm of musical abstraction.

Trans-étude #4 is constructed from a series of field recordings captured in a room from various vantage points and urban environments, with its initial versions featuring recordings from the city of Berlin. The instrument and electronics focus on diverse sounds and noises that constitute the original soundscape throughout this work, oscillating between the original field recordings, their instrumental imitation, and musical abstraction. It incorporates variations in the time scales used for their reproduction, as well as other compositional operations largely derived from the morphology of the specific sounds under focus.

My primary concern during the compositional process was to examine the representation of an object or phenomenon recorded from a sound situation at different time scales and to conduct artistic experiments at the threshold between transcription and manipulation. What might be referred to as the 'real 'in this work is contextualised within specific sonic environments of urban landscapes—whether situated inside or outside enclosed spaces—the particularities of which will be detailed later in this chapter.

Trans-étude #4: Intérieur/Extérieur emerged from my collaboration with British tuba player and researcher Jack Adler-McKean in 2021, at the height of the COVID-19 pandemic, during my residency at the French Academy in Rome. Over the course of a year and through various iterations, the work gradually evolved, culminating in its most recent version in 2023. This version, like the ones that preceded it, should not be regarded as definitive. It includes written instructions for its staging and is conceived as a situated composition, closely tied to the performer's surrounding space, with the performer actively involved in the work's creation. The instructions serve to guide the necessary field recordings, their electronic manipulation, and the performance of the instrumental part. The work does not require a written score,

[53] Peter Ablinger's web-site, https://ablinger.mur.at/phonorealism.html (Accessed April 3, 2025).

[54] "The field recording becomes something akin to a *Nature Morte*, its objects distorted under the focus of a directed light." Garnero, programme note for Inter Feral Arts Festival.

although nothing prevents one from being created. In its initial 2022 versions, I produced an electronic montage of the instrumental part—based on recordings previously made by Adler-McKean—which served as the foundation for preparing the concert version. This version can be understood as an audio score, functioning as a sonic reference. Up until its latest version to date, the duration of the piece has varied, ranging between 8 and 12 minutes. The electronic part underwent three different versions, all based on the same field recordings. The three versions of the work were developed for performance by Adler-McKean in the four concerts I cite here in chronological order:

- The first montage was played in Malmö (Sweden), during the *Inter Feral Arts* festival in October 2022.
- The second montage was played in the city of Avignon (France) during the *Viva Villa!* festival in November 2022.
- The third montage was played in Germany during the *Darmstädter Ferienkurse* festival in August 2023.
- The same montage was performed in Berlin (Germany), during the cycle *Unerhörte Musik* in February 2024.

Stages of an Artistic Method

A method may encompass various stages, develop strategies, and implement procedures or techniques. These elements facilitate the creation of a compositional framework comprising networks of objects and operations. Although the method may follow a primary sequential order, the different stages often interact or overlap throughout the compositional process. In *Trans-étude #4: Intérieur/Extérieur,* as well as in other works employing the artistic method of sonic translation, I have identified four distinct stages:

- **Documental stage.** This initial stage involves identifying overarching subjects of interest for a given project and subsequently retrieving, collecting, or producing sound archives or related sonic data. These may include sonic documents available online as open data, materials sourced from physical or virtual archives with restricted access, or sounds generated through direct recording or created using various media.
- **Analytical stage.** The subsequent stage focuses on indexing and classification. It involves developing operational categories for cataloguing, based on the origin of the sound source, its socio-cultural implications, the meaning it conveys, and the specific morphology of the sound itself. These and other parameters guide the initial approach to this stage, which may also involve cross-referencing categories, leading to the creation of new ones. This process may reveal new

perspectives on the archival material, prompting a return to the initial stage for further exploration.

- **Mimetical stage.** This stage may include a preliminary quantitative and qualitative analysis of the sound documents and involves evaluating the qualities of the medium used for mimicry, whether instrumental or electronic (e.g., the tool used to re-synthesise a sound). It is essential for the deduction, inference, or derivation of compositional operations. Mimetic operations often reveal an unexpected potential for the musical abstraction of extra-musical sounds. This stage encapsulates what is perhaps the most significant act of this artistic method: mimesis as translational operation. It is intrinsically connected to the final stage of the process.
- **Operational stage.** In this culminating stage, primarily abstract musical operations that relate, articulate, or transform sound objects are carried out. This stage may also lead to modifications or reinterpretations of the work completed in earlier stages.

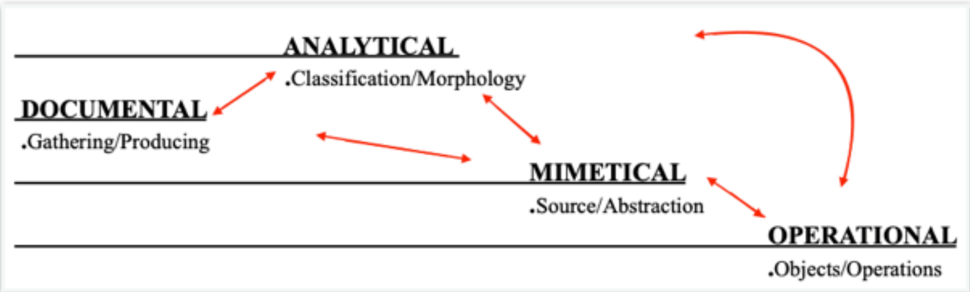


Figure 5.8, graphic of the stages of the making process of works involving sonic translation methods

Surround Recording: Observing and Documenting

The creation of any version of this piece necessitates a series of preparatory stages in which the collaborators engage in a structured, iterative process. *Trans-étude #4: Intérieur/Extérieur* can be realised and performed by a single individual or multiple participants; the number of collaborators is not determined, and their roles may overlap. A fundamental requirement for every version is that it must be situated, with the performers actively participating in a series of field recordings from their surrounding environments. This initial stage is a crucial component of the creative process, as it significantly influences the specific realisation of the piece. The instructions for this stage outline sonic situations that will shape the unique characteristics of the version being developed. These situations are defined by specific surroundings and additional requirements designed to achieve particular acoustic conditions, as well as to capture potential human and non-human presences, movements, estimated loudness, and general activity. They also prescribe specific conditions for the equipment and its positioning during the recording sessions.

The first page of the instructions establishes an initial classification for urban field recordings of the collaborator's surrounding environment, which may pertain to either an indoor or outdoor context. From this initial general classification, eight specific recording situations are required. Each situation is described using the aforementioned definitions, including the positioning of the equipment and the input volume of the recording device, which will shape subsequent versions within a similar acoustic context. These eight situations are organised into three groups on the first page of the instructions, which outline the necessary procedures for conducting the specified field recordings, as shown in the following reproduction.

Trans-étude #4:

Intérieur/extérieur

Malmö version (15-10_2022)

Instructions for field recordings

- About the microphone(s)*[1]

- **FR1**: Quiet Interior/empty room, almost silence with quiet regular noises - mainly statics from household electric appliances - & other parasitic sounds, sustained quiet sounds, eventually sounds from other nature as well, always maintaining a very low overall volume that is amplified in a variety of ways. Do not avoid random or unexpected sounds/noises. Could be set up in advance.
- 1a: 3 RP (at least 5 minutes each). Next to a reference, close, far but audible reference. Take one noisy electric device as a reference for microphone placement, **entry-level should be quite high.**
- 1b: 3 RP. The same place, with open window/s: Use the window as a reference for microphone placement. The **entry-level should be quite high.**

- **FR2:** Loud Interior/full room, a) small room; b) big room (bar, etc)

- **FR3**: Exterior: choose an urban environment (street, square, etc.) inhabited by different sounds (human and non-human).
- 2a (5'): Day. 3 RP. Take as a reference a group of sounds/noises (or a single one) from a stable source: some electrical or mechanical device, the entrance of a busy place, etc. the three recording points mentioned above (next to a reference, close, far but audible reference) must be interpreted on a wider scale than in the previous ones, within the operating range of the selected microphone(s). **Avoid saturating the sound in the closest takes, but make it loud enough to pick up the ambient sound well within the range and azimuth of the chosen microphone.**
- 2b (5'): Night. 3 RP. in the same place, repeat the operation late at night, at a time when the sound footprint of human activity (including non-human noise) is at a minimum. Take as a reference any stable and sufficiently audible noise/sound from far away. Repeat the same positions as in the previous recordings, without taking any reference.

Figure 5.9, *Trans-étude #4*
First page of the Instructions (RP means Recording Points)

Archives as Musical Matter: Imagining and Organising

The central role of the sound archive in this artistic method positions the composer as both a compiler and a cataloguer. The processes of searching for or producing archives, as well as indexing them, serve as creative acts of equal significance to the abstract compositional operations characteristic of the Western musical tradition. The composer Alberto Bernal (2024, p. 105) refers to the "paradigm of the archive" as a "new air [that] has been stirring some contemporary artistic practices for years."

I emphasise in this artistic method the intention to sonically recreate or translate any given archive into sound using another medium, object, or acoustic instrument as an act of musical creation in itself. In the same text, Bernal warns us that "it is not about the archive of sound as such, understood as a purely documentary practice, but quite the opposite: the sonification, as an aesthetic practice, of that vast archive of music, sounds, authors, performers, and people in general who, (...) are part of our cultures and societies" (Bernal 2024, p. 105).

The sonic archives for *Trans-étude #4: Intérieur/Extérieur* are to be generated, with specific requirements outlined in an initial general classification that serves as the foundation for this stage of the creative process. However, the instructions intentionally incorporate a degree of ambiguity, enabling the emergence of sonic phenomena that require an additional indexing stage to organise the situated field recordings produced. This additional stage, which involves classifying and, where necessary, segmenting the recorded files, introduces a new set of parameters—some general and others specific to the sound archives produced. Some of the most significant general parameters may include, for example: **Source, Localisation, Movement, Sound morphology, Dynamics, Timbre, Register, Frequency, Duration or Rhythmic Behaviour.**

Some examples of categorised sonic phenomena present in the specific acoustic situations of the field recordings that constitute the 2023 version of *Trans-étude #4: Intérieur/Extérieur*—organised from general to more specific descriptions—include:

Field Recording #1: Indoor; closed space; washing machine (source); close/centre (localisation); still (movement); short percussive attacks (sound morphology); generally *piano* (dynamics); *metallic* (timber); medium-high (register); non-pitched (frequency); long (duration); repetitive/almost regular (rhythmic behaviour).

Field Recording #2: Indoor; open space; human voices (source); different positions (localisation); still/moving from centre to the right (movement); generally *mezzoforte* to *forte* (dynamics); medium (register); long (duration); irregular (rhythmic behaviour).

Field Recording #3: Outdoor; street; ambulance siren (source); left to right (movement); *piano* to *forte* to *piano* (dynamics); high (register); Doppler effect upon A5 and E5 (frequency); short (duration); repetitive/ regular (rhythmic behaviour).

Thresholds of Representation: Mimesis as Translation

The instructions for creating the field recordings required for each montage of this work represent the first compositional operation and, simultaneously, one of the few elements common to all versions. In contrast, the guidelines for the realisation of the instrumental and electronic parts are intentionally more general. These instructions provide a framework but must be adapted to the specific field recordings produced for each instance and to the instrument(s) involved in each version.

The instructions for performing the instrumental part specifically address instrumental mimetic operations. These operations necessitate an adaptation to the instrument employed to reproduce the targeted object. The distinction between the original source and the mimetic instrument constitutes an obvious condition for this artistic method of translating *into* or *towards* sound.

The general instructions do not specify how to perform instrumental mimesis but instead guide the selection of the sonic phenomenon to be reproduced. The primary guideline is to focus attention on one of the many objects comprising the soundscape captured in the field recording. To facilitate this, the selected object must possess at least the characteristic of being perceptible as an individual entity within a complex sonic context.[55]

A second set of more precise and context-specific instructions was required to realise the 2022 Malmo version. Following the completion of Adler-McKean's field recordings and their preliminary indexing, I selected a small number of sound phenomena for their distinctive characteristics, while also considering the specific qualities of the tuba. Once these sound objects were identified, we conducted a collaborative working session to explore methods of reproducing them with the tuba, thereby establishing a specific framework for the execution of the mimetic operations.

At the conclusion of this experimental stage, and with the aid of the recordings made during that period, I began drafting a series of instructions that would serve as the foundation for the creation of the instrumental part. These instructions not only outlined specific instrumental techniques for the mimesis of the selected sound objects but also provided guidance on how to perform progressively divergent

[55] Some of the mimetic operations in this version were performed on artificially enhanced objects. This scenario is anticipated in the instructions, which restrict electronic manipulations to basic filtering operations or to amplifying specific frequencies or frequency bands. This highlights the retroactive nature of the work stages, where earlier processes may be revisited to accommodate insights gained during later phases.

musical operations. My desire to explore the thresholds between the representation of reality and musical abstraction began to take form in these transformative operations applied to the chosen objects, which were inferred from their morphological qualities. These selected sound objects thus became thus both the model to be reproduced and the source of the abstract operations to be executed on their reproduction.

The following images present examples of selected objects, suggested instrumental techniques for their reproduction, and simple operations to modify the result of the instrumental reproduction.

Trans-étude#4 : Intérieur

Instructions to imitate Sound files

- **SF1 & 1b Near** *Washing Machine mechanics.* 2 percussive sounds to imitate. Suggestions for the lowest sound, **dynamics** around ***pp/mp***: different kinds of slaps or noisy attacks (consonants-occlusives) (tongue-mouth-hand), explore half (and less) valve positions, try to explore different resonances (dry/wet), try the mouthpiece alone. Suggestions for the highest sound, **dynamics** around ***pp/p***: valve noise, tongue clicks, mechanical noise. **Rhythm:** take the recording as a model, changing pulses. Play both separately, then together, think of **hoquetus** as a rhythmical model. **Variations:** first you will have two pitched inharmonic sounds, if possible, variate the pitch in ascending/descending intervals (microtonal if possible)–variate speed. Create inner rhythmical cycles by creating regular/random accents. File 1b (normalized & filtered) could be useful as a model. Do not consider dynamics. **Try different mutes. *Inner & outer amplification.***

Figure 5.10, Instructions for instrumental mimesis
Partial reproduction of the first page

- **SF7, SF7b, SF7c, SF8 & SF8b Close** *Main frequencies from continuous motor noise.* Suggestions: select louder frequencies from motor noise, mainly around a low G1 (48.1 hz) and his principal harmonics partials. Record quite long *tenuti* sound of the fundamental & a selection of the loudest partials you can hear from the recordings (6 y 7 are quit presents), **dynamics** around ***ppp/pp,*** without any *crescendi*. **Variations:** mainly in tone colour & envelopes. Try long & symmetric dynamic envelopes. Change the spectral content & pitch. Bending, slow vib, valve vib, singing (& *battimenti*), Multiphonics. **Try different mutes. *Outer amplification.***

Figure 5.11, Instructions for instrumental mimesis
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Operations: Articulating and Transforming

The instructions for the field recordings and instrumental mimesis, particularly those developed following the production of the sound archives for a specific context, can already be considered compositional operations. In the 2022 Malmö version discussed in this text, the instructions for creating the instrumental part focus on instrumental mimesis, selective instrumental mimesis (filtering components of the reproduced sound objects), looping and sampling techniques, as well as micro-variation techniques applied to loops. The preceding images provide examples of these compositional operations within the contextualised instructions.

Another preliminary compositional operation involved creating an initial reference sketch of the instrumental part using recordings made by the collaborator. This montage, which I produced, proved highly useful for further development by Adler-McKean, who employed this audio track as an initial model. During the performance of these versions, Adler-McKean utilised the muted audio track, accompanied by annotated notes, as a reference to guide the selection of instrumental morphologies to be played at specific moments.

Montage was one of the primary compositional operations in the creation of the electronic part. The sonic material employed included segments of the field recordings of varying lengths, simple digital treatments of these recordings (preserving their recognisability), fragments of tuba recordings performing mimetic operations on selected sound objects from the field recordings, simple digital treatments of these instrumental morphologies, and complex digital treatments of both types of recordings (where the original source sound becomes less recognisable).

The first group of DSP techniques applied to the original files, those that do not drastically alter the sound morphology of the original audio samples, included, among others: resynthesis by partials (generally through modifying the amplitude of formants or specific partials), filtering by frequency bands, frequency shifting, spatialisation of originally localised sounds, reverberation of short duration files superimposed on original field recordings, modification of spectral brightness, and the doubling or overlapping of formants with frequencies generated by oscillators.
These operations aimed to achieve an initial degree of transformation of the field recordings—understood as a "trace" of the Real—into "fictional" sounds, created and organised according to an abstract musical logic. The objective was to establish a sonic threshold oscillating between these two states while remaining close to the recording of non-musical sonic phenomena.

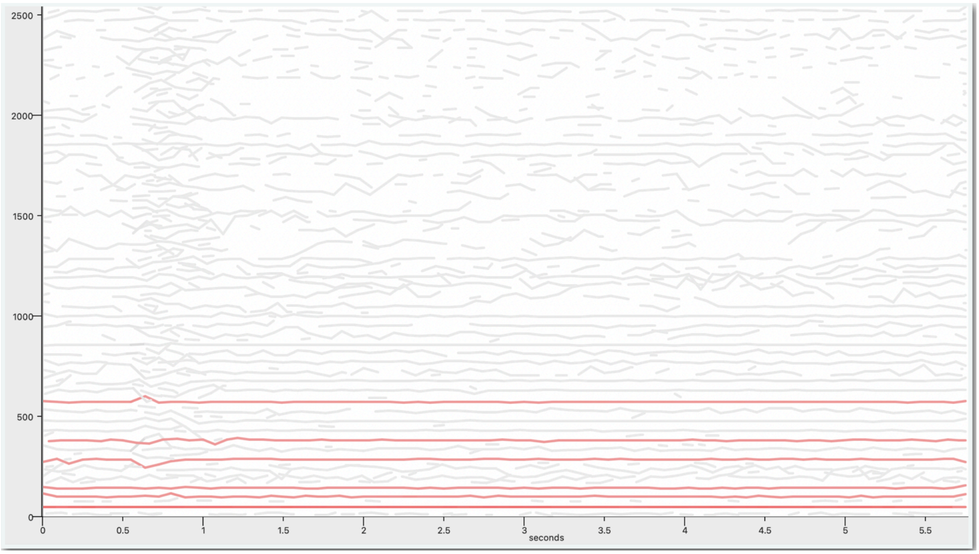

Figure 5.12, spectral analysis of the recording of a closed room, as referenced in the previous image[56]

The second group of DSP techniques applied to the original sound files—drastically altering their initial morphology—primarily included granular synthesis and the generation of complex textures through time-stretching operations. These textures comprise multiple stretched versions of the same sound file, running at different speeds, and looped regularly with significantly reduced amplitude. Together, they form a mosaic of sonic objects whose phase relationships and spatial trajectories are continually reconfigured. These transformations were realised using Max software.

[56] The red lines highlight a foreground pitch (around G1), which served as the pivot note (at the bottom). The other frequencies functioned either as secondary notes for the instrumental part or as artificially emphasised pitches in successive spectral re-synthesis of the audio file.

The aim of these techniques was to radically reshape the morphology of the original sound files, whether derived from field recordings or from tuba sounds imitating extra-musical sonic objects. In the oscillation between sonic representations of the Real and musical logic—the central axis of this work—these processed sounds represent the most extreme degree of abstraction.

Neon Frog (2024)

In this section, I will discuss the methods of sound translation in my work Neon Frog (2024), for five amplified instruments (violins, viola, cello, bass clarinet and percussion) and electronics.

First, I will present the work, the confluence of different approaches to sound and musical time and the resulting artistic methods, the underlying ideas, the general strategies that guided its conception, and the specific techniques of sonic translation employed within it.

I will then discuss the primary material used in the piece—samples and recordings from very a variety of sources—focusing on the most prominent non-musical sounds that articulate it, mainly South American frogs and toads, and satellite recordings, and the functions they serve throughout the work. I will address the specific techniques of sonic translation present here, primarily transcription, mimesis, and instrumental analogy, and the particular ways in which they are implemented.

In parallel, I will present the means employed in the translation process and the ways in which these objects and instruments were used to perform the transfer operations and their materialisation. I will also examine the question of the various scales of representation of the original sources when they are translated, and the role they play in the structure of *Neon Frog*.

Bridging Two Approaches to Sound and Musical Time

Neon Frog integrates diverse compositional methods and techniques that coexist, interact, and synthesise within an experimental framework. This framework is not always devoid of tension between its various forms of knowledge production and the specific relationship between acquired and emerging knowledge. These methodologies and techniques emerge from two concomitant approaches to sound and musical time, highlighting the specific relationship that arose between the two during the work's composition process.

One approach considers sound as an acoustic phenomenon, employing electronic sound synthesis and techniques derived from Digital Signal Processing (DSP) as a compositional model, predominantly situated within a granular paradigm. Conversely, the other approach perceives sound as a sociocultural phenomenon, engaging with issues related to representation and meaning. This latter approach incorporates artistic methods and techniques derived from sound translation, which are the focal point of the present chapter.

The starting point of this work closely resembles that of *Neon Pig*[57] (2017, for large ensemble, hybrid instruments, and electronics): the construction of a complex and paradoxical sound object that continually reorganises its internal components and unfolds through an incessant cycle of differentiated iterations. It is an emergent object that, while repeating itself, is constantly changing.

However, unlike *Neon Pig*, this work does not aim to construct an improbable object from families of sounds grouped by morphology—distinguishing strata according to spectral qualities, the presence of noise, or the citation and appropriation of non-musical sounds. Instead, it follows an almost opposite trajectory: sampled sounds that capture or represent aspects of reality form the basis of all the sounds produced here, serving as the foundation from which musical abstraction is constructed. The work begins with a series of false soundscapes—canvases composed of fragments of non-musical sounds—causing it to oscillate between the representation of reality and the music built upon it.

The constructed soundscapes and networks comprise non-musical sound objects and phenomena inscribed within the Nature/Culture[58] continuum[59], which was a principal focus of the experimental process undertaken for the composition of *Neon*

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[57] I have written in *Neon* Pig's programme note: "Some of my recent works are based on an augmented concept of 'hybridisation', a conceptual framework that helps me to create sonic objects constructed from very diverse or disparate components. These objects can synthesise a wide range of sounds, taking as descriptive thresholds their spectral content (harmonic/inharmonic, saturated/filtered/net) or 'aural '(their historical or semantic charge). They are also immanent sound objects, which unfold or reveal themselves in a context of complex repetition or self-similarity. Like sculptures that light gradually reveals in an incessant coming and going." (Garnero, F., 2017)

[58] According to an approach grounded in the theoretical contributions of constructivism within the social sciences, nature itself is a concept imbued with significant cultural content. As Augustin Berque (1990, p. 52) argues, "nature is necessarily translated into terms specific to a culture; it is integrated into the world that man is capable of conceiving, perceiving and developing. In this case, nature is not defined without or against man, but by man."

[59] In his work *Parables for the Virtual: Movement, Affect, and Perception* (2002), Brian Massumi reconceptualises the traditional binary of nature versus culture as a dynamic continuum rather than a dichotomy. He argues that natural phenomena and cultural practices are not isolated domains but are co-constituted through ongoing processes of affect, emergence, and transformation. In this framework, both nature and culture are seen as fluid, interpenetrating dimensions that continually inform and reshape one another. Massumi's approach challenges static categorisations by emphasising the potentiality and constant becoming inherent in all forms of existence, thereby offering a more nuanced understanding of how material and symbolic forces are deeply intertwined.

Frog. As one of the methodological frameworks I established was to engage with open data, all recordings capturing these objects were sourced from the Internet. My primary interest lay more in indexing and organizing than in creating original material, as these were the first and most significant compositional operations undertaken.

These operations initially aimed to categorise the original material based on its affiliation with one of the two poles of the Nature/Culture continuum. This categorisation ultimately served to form families and networks of objects linked by seemingly improbable connections between manifestations of nature and culture—such as the juxtaposition of sounds produced by frogs and satellites. These connections were defined in parallel with their conveyed meanings, reinforced by their morphological or spectral qualities, such as the similarities in frequencies or rhythms between the sounds of falling droplets and the noises of an elevator. Once these articulations based on improbable links were established, I began composing the false soundscapes and networks of objects that formed the foundation of this work. Upon these, I applied further operations, including instrumental sonic translation, symbolic granulation, electronic manipulation, or morphological transformation.

Translation Techniques

The various types of sonic translation techniques present in this piece are delineated by their operational modes, the degree of proximity to the source, and the intended fidelity in the reproduction of the source. The operational mode of each technique may vary in accordance with the morphological characteristics of the original sound to be translated, the type of technical object employed to execute the translation operation—if any—and the instrument through which the translation is realised. During the composition of *Neon Frog*, three types of translation techniques were used in the experimental process:

Transcription: This technique aims to achieve high-fidelity reproduction and the greatest possible proximity to the original source by the reproducing instrument. It requires precise information across the frequency domain (harmonic and inharmonic partials, formants), the temporal domain (attack transients, onsets and offsets of partials), and the spectral domain (amplitude of partials, dynamic envelope). To carry out these operations, I employed a Max patch for spectral analysis via partial tracking, which transcribes the data onto a symbolic medium that enables the visualisation of the frequencies, durations, and dynamics of the analysed sound. This tool also allows the resolution of the analysis and its reproduction to be calibrated by adjusting the values of its operational parameters. Furthermore, it enables the simulation of transcription using the chosen instrument(s) (through the

Orchids [60] system or any connected sample database) and facilitates the quantification of the analytical data for conversion into standard musical notation.

Mimesis: This is a technique that necessitates an experimental process with the instrument employed to reproduce the targeted sound. It does not aim to achieve a high degree of fidelity in the translation or a maximum degree of timbral proximity within the capabilities of the reproducing instrument; rather, it focuses on generating an idiomatic and appropriate instrumental writing derived from the external sound model that is to be represented.

Analogy: This modality seeks to generate a multitude of variables of instrumental techniques capable of reproducing partial morphological qualities of the targeted sound, such as specific timbral qualities, rhythmic behaviour, or predominant frequencies. It does not aim for faithful or approximate reproduction; rather, it aspires to an external model whose partial reproduction can serve as a primary source of derived sound morphologies or abstract instrumental figures.

These techniques of sonic translation, occasionally combined with various abstract operations, served as the primary tools for exploring different scales of representation of the targeted non-musical sound phenomena. The specific mode of translation employed at any given moment was as determinant as the sonic phenomenon(s) being translated. These operations were crucial in creating the intended oscillatory movement sought between the representation of a sonic reality and the musical abstraction, which constitutes the primary aesthetic focus of this work.

An Emergent Texture Born from the Croaking of a Toad

The initial formal section, which has a duration that is gradually reduced in a non-linear manner as it interpolates to the subsequent section, presents an emergent complex texture. Its various components, encompassing both instrumental and electronic elements, investigate diverse methods of oscillating between the sonic representation of reality and musical abstraction. Furthermore, they encompass multiple time scales and various dimensions of representation concerning non-musical sonic phenomena.

The components of the electronic part explore continuous oscillations between the two poles in distinct manners. The primary layer, which assumes a dominant role, oscillates at varying speeds following the shifting rhythm of low-frequency waves that govern several parameters, including the reading, spatialisation, and electronic transformation of a field recording from Impenetrable National Park in Argentina's Chaco province, an arid subtropical region of lowland forests and savannahs. In contrast, the secondary layer, which functions as an articulator of the musical flow,

[60] https://forum.ircam.fr/projects/detail/orchids/ (Accessed April 3, 2025).

comprises a network of objects designed according to the morphological model of an envelope with four stages: attack, decay, sustain, and release (ADSR). This layer is constructed from original samples, processed samples, and synthetic sounds that are inspired by the initial samples.

The instrumental section consists of morphologies derived from sampling operations applied to two reference figures, which unfold across phases of varying durations. These instrumental layers further explore different strategies of continuous oscillation between the representation of real phenomena (REP in the tables reproduced below) and musical abstraction (ABS). Both figures adhere to a similar strategy of superimposing morphologies that transform between representation and abstraction, thereby forming discrete scales that are challenging to distinguish. This difficulty arises because the more abstract instrumental morphologies are derived from or share characteristics with morphologies resulting from sonic translation operations. The latter translates a range of phenomena situated along the Nature–Culture continuum. The following graphs provide a straightforward means of visualising the dynamic relationships that evolve within this complex, iterative, and constantly evolving texture:

Table 5.1, Morphologies' Functions of Reference Figure A

FIGURE A	Morphology 1	Morphology 2	Morphology 3
Violin	REP (Toad 2)	REP/ABS (Conveyor belt)	ABS
Viola	REP (Toad 2)	REP/ABS (Conveyor belt)	ABS

Table 5.2, Morphologies' Functions of Reference Figure B

FIGURE B	Morphology 1	Morphology 2	Morphology 3	Morphology 4
Bass Clarinet	ABS	REP (water drop)	ABS	REP/ABS (Conveyor belt)
Percussion	REP/ABS (Toad)	ABS	REP (Conveyor belt)	REP/ABS (Satelite)
Cello	REP (Toad)	REP/ABS (water drop)	ABS	REP (Satelite)

In this manner, the real and the imaginary converge into an emergent complex texture, characterised by oscillations that blur the boundaries between representation and abstraction. This interplay creates a sense of strangeness that renders the familiar unfamiliar, and vice versa.

Some Examples of Instrumental Analogy Operations

All sonic translation operations within the instrumental section of this part were conducted using analogy techniques. During the experiments, I focused on specific parameters of the sound for which I aimed to create an instrumental analogy. I was already anticipating the concept of a hybrid texture oscillating between the real and the imaginary, which could potentially encompass at least some of the sounds to be translated, either in their original form or in a transformed state. Moreover, the translations and morphologies derived from these sounds would orbit around them.

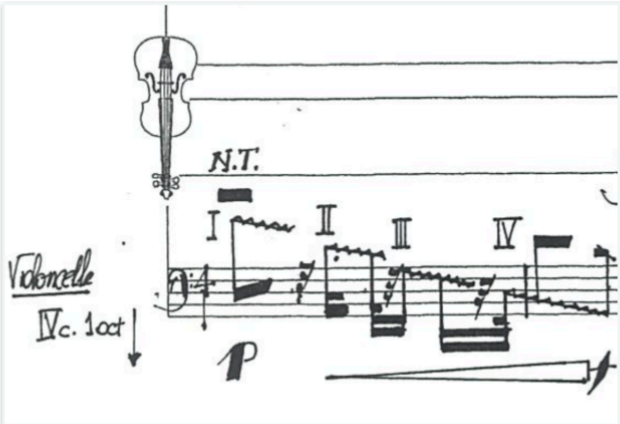

Figure 5.13, Reference Figure A[61]
The first morphology of the cello part

The origin of the reference figures stemmed from an initial analogy operation intended to represent the sound of a toad using the cello. I conducted a series of empirical experiments with the cello, seeking to establish analogies with the target sound and quickly focusing on its timbral characteristics. I explored alternative instrumental techniques to reproduce the distinctive hoarse and granular sonority of this South American toad, aiming to create an effect analogous to the dynamic formant filtering that characterises it. Following several experiments, I concentrated on sounds produced by extreme pressure applied with the heel of the bow sliding across the string, closely muted by the left hand. Rubbing the mane of the bow against the string with considerable pressure produced a timbre analogous to the hoarse, granular timbre I was looking for, while gliding over the string produced a result similar (though not identical) to the filtering effect produced by the toad's modification of its mouth sack. This operation produced the first morphology of Reference Figure A, as well as derived morphologies that progressively diverged from the original toad's croak.

[61] The complete Reference Figure A is reproduced in Chapter 4.

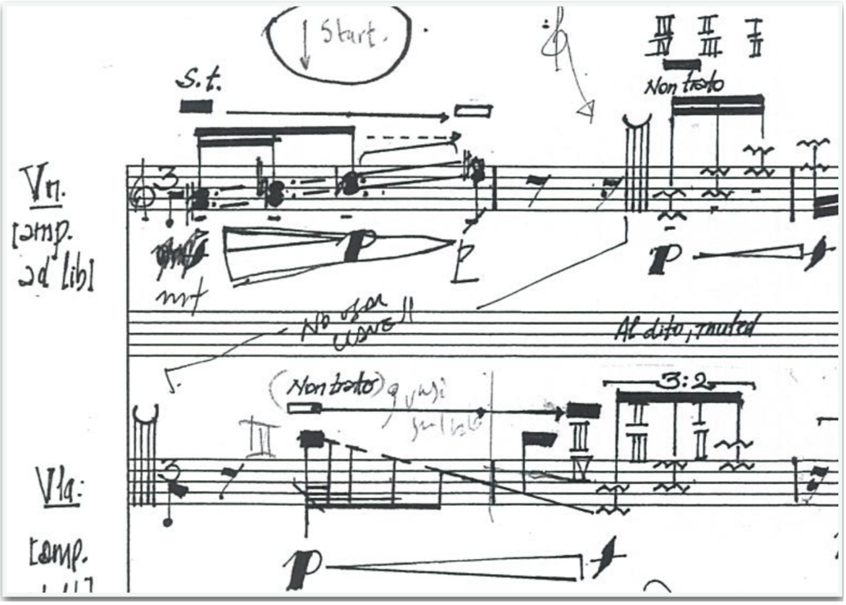

Figure 5.14, Reference Figure A[62]
The first morphologies of the violin and viola part

From the first operation of instrumental analogy, I carried out two more in a similar way, focusing on the results of the previous operation rather than the original sound. This approach enabled the creation of two morphologies of Figure A', one on the viola and the other on the violin, incorporating variations of the original technique involving extreme pressure applied with the heel of the bow sliding along the string. These morphologies are intertwined, each concluding with an articulated movement of double ascending strings, also executed with extreme bow pressure, which changes the string but not the position, thereby producing a *hoquetus* with an identical timbre. Both morphologies commence with complementary instrumental gestures, contrasting an ascending movement executed by the violin's left hand with a descending motion performed by the viola's bow. They also symmetrically contrast a progressive decrease in bow pressure (the violin) with a progressive increase in bow pressure (the viola). This instrumental analogy, which generates a sound akin to the characteristic granulation and modulation of the toad, served as a reference to create two intertwined morphologies that resemble that of the cello, yet bear little resemblance to the original sound.

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[62] The complete Reference Figure A' is reproduced in Chapter 4.

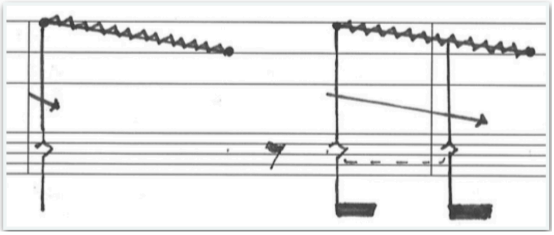

Figure 5.15, Reference Figure A
The third morphology of the percussion part

Another example in Figure A involves the percussion reproducing the sound of an object moved by an industrial conveyor belt through an instrumental analogy. This sound is present in the network of objects within the secondary layer of the electronic section. It creates a complex attack alongside other sounds, making it difficult to distinguish from the whole of which it is a part, serving as a sign of a represented reality. However, the characteristic sound of this recording, which resembles that of a large güero, is perceptible, and the instrumental analogy produced by the percussion generates an immediate association. The percussion set is quite similar to the one used in my work, *Contraccolpo*: a hybrid instrument resulting from the coupling of an omnidirectional microphone, a snare drum, and various objects. I conducted a series of experiments where I rubbed different surfaces with the microphone, applying varying degrees of pressure, from glass paper to a metal grid sourced from an old coffee machine. I did a series of experiments, rubbing the microphone against various surfaces with varying degrees of pressure, from glass paper to a metal grid from an old coffee machine. Ultimately, to reproduce the characteristic sound of the regular percussive sweep of the conveyor belt, I opted for a comb with teeth of differing sizes, reinforcing the resemblance to the modulation present in the original recording.

Based on this resulting morphology, I conducted a series of experiments with the bass clarinet to explore analogies that diverge considerably from the original and its corresponding analogy. From the latter, I retained only the descending movement and the rhythmic regularity. The instrumental gesture of the microphone on the comb, which transformed the almost scraping sound, akin to that of a conveyor belt's guiro, into a regular percussive sweep, evolved into a rapid descending microtonal slurred scale, devoid of the original aggressive articulation, replaced by an *air-tone* technique.

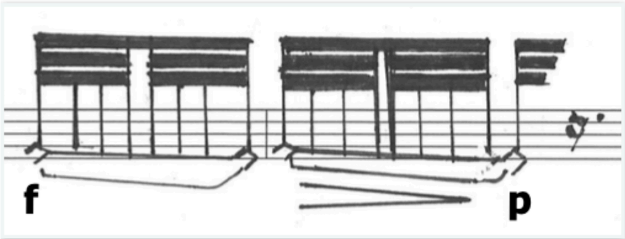

Figure 5.16, Reference Figure A
First part of the fourth morphology of the Bass Clarinet part

Transforming a Satellite Signal Sound

The musical flow of the final formal section is articulated successively by two distinct sound objects. The first object comprises several sounds, specifically a mixture of samplers, treated samplers, and synthetic sounds. This complex object is organised around the sampler of a satellite signal, which combines a sustained sound with another sound characterised by quasi-regular repetitions, both at a similar frequency (approximately a B5).

The sampler of the satellite signal was subjected to various transformation operations, the result of which gave rise to the complex sound objects that constitute the initial segments of the last formal section. These operations were executed using a Max patch, which facilitates the multiplication of the original sound into eight layers, each possessing phases of varying duration. Each iteration modifies the speed and frequency of the original sound, attenuates its volume, varies the size of the reading window and its position within the sampler buffer, and adjusts both the direction and speed of its stereo panning. The Max multi-channel objects performing these operations are governed by four low-frequency oscillators, whose incidence can be adjusted according to a statistical weighting system. Following several operations with diverse settings, I selected four complex objects derived from the satellite signal sampler, organised according to their increasing duration. Each emerging object represents a complex mosaic formed by multiple layers of loops with different phases circulating across various time scales, thereby multiplying the original morphology represented. Each object embodies a hybrid form that simultaneously transforms the satellite signal sampler across multiple scales, exhibiting a varying degree of proximity to the original sound.

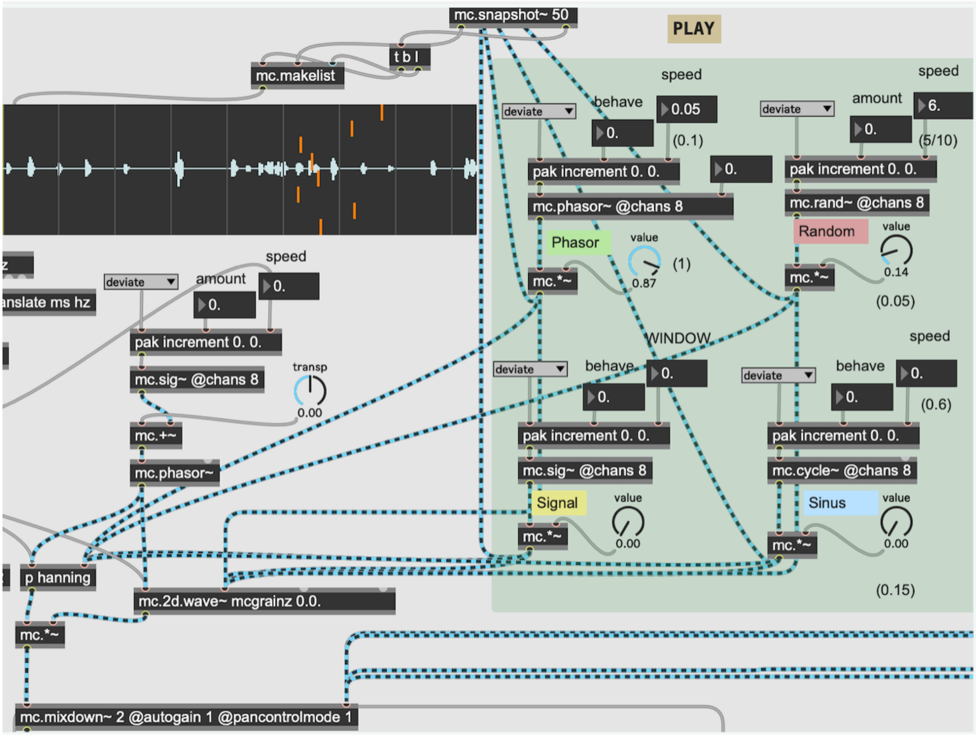

Figure 5.17, patch Max used to transform the original sample
Partial reproduction

Using the spectral analysis patch (partial track-to-roll), I extracted the necessary data to perform a high-fidelity transcription, with the aim of merging the timbre of the electronic sounds with the instruments. I configured the analysis parameters to capture the most audible frequencies by establishing a high-velocity threshold and identifying a single peak, along with their respective durations and dynamic envelopes. The secondary objective of employing additive instrumental synthesis was to generate a multi-band delay effect on the most audible frequencies and to distribute the instruments across different layers. To achieve this aim, I implemented a strategy of non-strict canonical writing between instruments and electronics, ensuring that I alternated the peaks of the dynamic envelopes for each targeted partial in each instance.

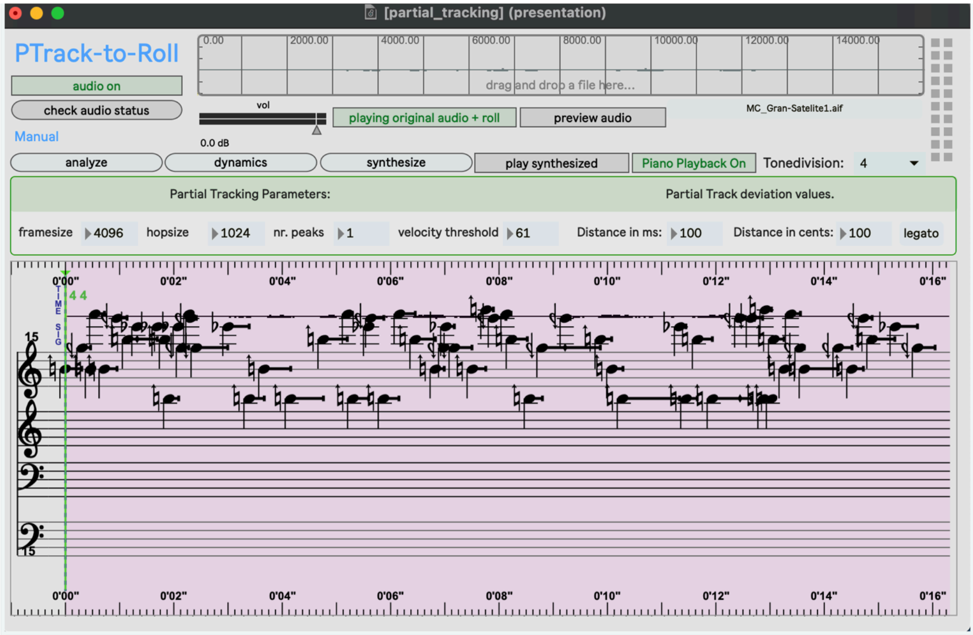

Figure 5.18, Partial Tracking Analysing
The fourth transformation of the original sample
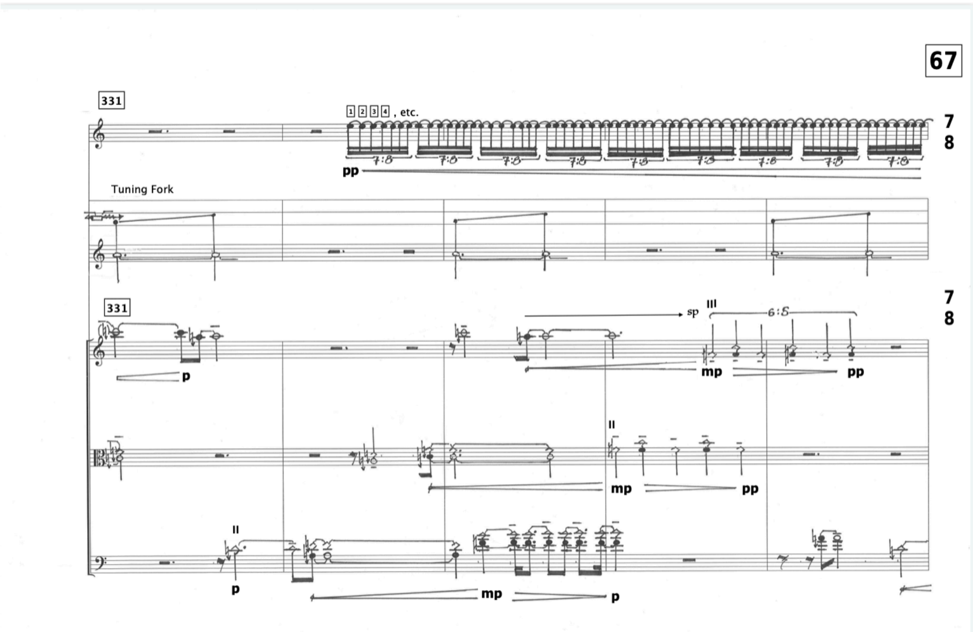
Figure 5.19, *Neon Frog*
Example of Instrumental Sonic Translation of the fourth object, p. 67 from the unpublished score (2024)

The string writing of the fourth and longest object resembles that of a prolation[63] canon. The bass clarinet's role is to reproduce the lower frequencies, echoing the dynamic envelopes of the longer-phase electronic layers with a delay. The percussion serves a dual function, incorporating two contrasting sound dimensions. The first, which is present in all four objects, consists of low-volume noises produced by the e-bow on the snares of the second drum, which is inverted (this represents a sonic translation of a sampler from a different satellite signal, which will be addressed in the subsequent section). The second dimension, present only in the last object, is a sinusoidal sound generated by a tuning fork set into vibration on the batterhead of the first snare drum, which reinforces and interferes with a foreground frequency a few cents lower than the A4 it produces.

Instrumental Analogies on a Satellite Signal Sound

In the final sections of the piece, a sample of another satellite signal progressively emerges. Always accompanied by its instrumental translation, it occupies a secondary plane by superimposing itself on the four complex objects mentioned in the previous section. It maintains the same role at the end of the piece by overlapping with another complex object (which will be addressed later), a role facilitated by the acoustic characteristics of this coupling between the sample and its instrumental analogy, as well as the low volume of both. The sample of this particular satellite signal resembles the sound of wind, white noise that is dynamically filtered by varying frequency bands. Its importance in the musical discourse grows towards the end, transitioning from a secondary to a principal plane. It is gradually revealed by the diminishing presence of other elements and the increasing signal volume.

The sound translation technique employed in this case was instrumental analogy, concentrating on identifying sounds characterised by a significant portion of noise, coupled with effects akin to dynamic filtering. Initially, I conducted tests using small motors—specifically, nano hex-bugs—clattering on the surface of the snare drum and inducing vibrations in the snares; however, I ultimately discarded this approach due to their excessive volume. In considering ways to resonate the unstressed snares and produce noise encompassing wide frequency bands traversing the spectrum, I gravitated towards the use of the e-bow. When one separates certain snares to position the e-bow above them, they vibrate and interlock, generating a constant buzz that is amplified by the resonance of the instrument. The volume, amplitude of the frequency bands, and the presence of audible frequencies or multiphonics depend on numerous variables, particularly the positioning of the e-bow on the snares. This position, which the performer can select by seeking specific qualities

[63] A prolation canon—also known as a mensuration or proportional canon—is a contrapuntal technique, rooted in medieval and Renaissance practice, in which a single melody is imitated by other voices at varying speeds, entering either simultaneously or in succession.

of the resultant sound, changes increasingly as the piece progresses toward its conclusion.

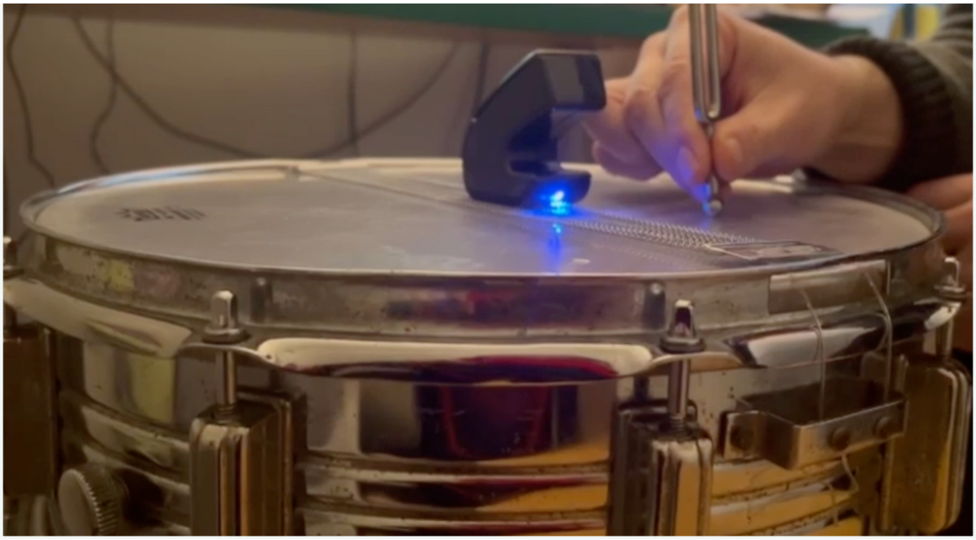

Figure 5.20, The use of the e-bow on snares
Serves to produce an instrumental analogy to a targeted sample of satellite signal

Transcribing Frogs

The leading sound object in the final section of the piece integrates recordings of frogs, occasionally accompanied by toads and falling water droplets, with their sonic translation produced using microtonal piano samplers. The croaking of the recorded frogs generates brief reiterative melodies over a limited set of microtonal frequencies within an interval of approximately a perfect fourth, exhibiting an overall descending profile, with two recurring poles centred around the notes C#6 and D6.

The sonic translation was executed using transcription techniques that were identical to those employed for the four complex objects resulting from the transformations of an original sampler of a satellite signal. Using the same Partial Tracking-To-Roll patch, I conducted a spectral analysis with a configuration similar to that previously used, characterised by high-velocity values and single-peak transcription. The transcribed data within the Max patch illustrate the differentiated frequency regions of the frog, the toad, and the falling water droplets. The transcription of these targeted sounds was accomplished using piano samples tuned in quarter tones. This translation technique aimed to achieve the highest degree of fidelity in their reproduction with the piano samplers. It was materialised within the closest possible scale of representation to the targeted sound, transcribing as faithfully as possible its frequency, rhythmic, and dynamic components to the timbre of the microtonal piano without any transformation of the original sample.

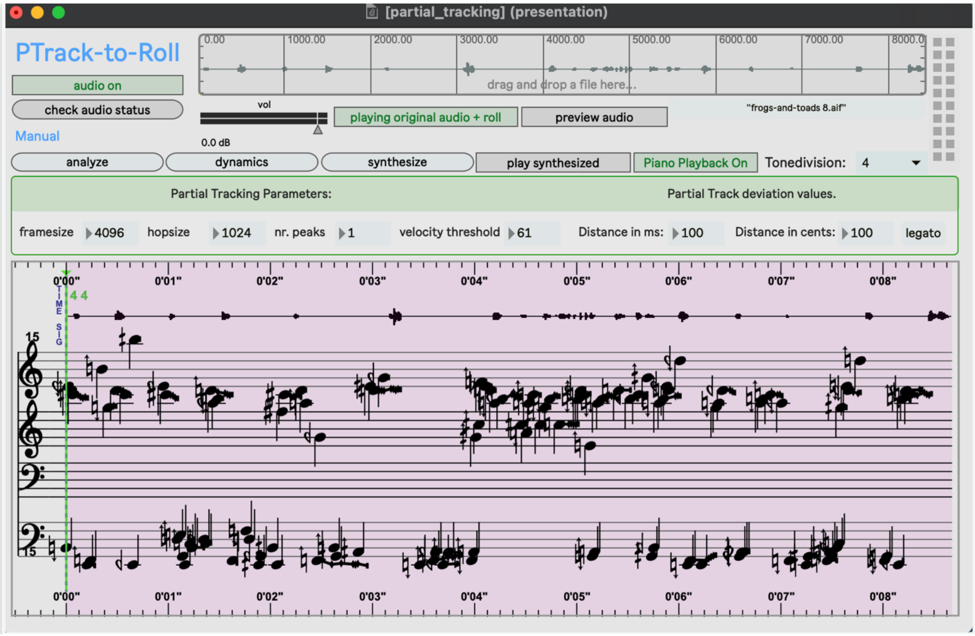

Figure 5.21, Spectral analysis and transcription
Of a recording of frogs, toads and falling water droplets

Towards the conclusion of the piece, this object gradually assumes a more prominent role in the musical discourse, shifting from a formal articulator to occupying a central position. The sonic manifestations of nature—real phenomena and the sounds of living animals—progressively lose their familiarity as they are juxtaposed with their instrumental translations, evolving into a melodic figure whose morphology undergoes slow transformation. At the outset of this process of "denaturalisation," the original sample and its transcription are spatially separated by contrasting panning and unequal volume, with the former significantly more pronounced. However, in each instance, this relationship is gradually inverted through a non-linear and progressive cross-fade, reinforced by a spatial cross-fade. As the piece unfolds, the piano increasingly envelops the volume of the original sample, until the inflections of croaks and drops become melodic in nature. In this way, familiar natural sounds are rendered strange, as they transition into musical abstraction.

Summary

This chapter discussed two of my works that employ specific sonic translation methodologies. Through this exploration, I recognised the importance of transcription and mimesis as main operations towards musical abstraction, as well as the preeminence of the specific form of sonification over the source material. I also observed that the translation of sound production into another medium constitutes an act of artistic creation in itself, resulting in an aesthetic shift. Directing attention to a non-musical sonic phenomenon transforms it into an aesthetic object, regardless of the specific method employed in its transfer from one domain to another. Music is traditionally abstract, but sonic translation methods introduce a mimetic element by reproducing real-world sounds. However, they also create a sense of estrangement, making the familiar unfamiliar.

Alongside my two works, this chapter also examined three other works that utilise sonic translation methods, each demonstrating a distinct approach to the subject, a specific phenomenon being translated, a different translation method, and various means for conducting the transfer operations and their materialisation.

The primary similarities among the five examined works lie in their pursuit of idiomatic instrumental writing based on the transcription or mimesis of non-musical data; their use of varying scales of representation within a single piece; and their exploration of the relationship between a sonic real and abstract musical operations (such as transposition, manipulation of playback speed, and various looping techniques, among others).

Despite these similarities, each case reveals substantial divergences.

Bailie's *Trains* uses recorded train sounds as its primary material, which is then used to derive the cello part through *implied melody* techniques. The train sounds are manipulated by slowing them down (and subsequently transposing them) to create a sense of approaching reality. Her primary focus is on the interplay between the real and the imaginary.

Bernal's *Impossible Translations #4 Suite* uses videos from the 2012 G8 Summit as its primary material. The videos are analysed for visual parameters, which are then used to create a data score for the piano. In Bernal's work, the homologation of different dimensions through superimposition, the parallel application of identical looping techniques, and the transfer of visual parameters to sound parameters generate a translational effect. His main focus is the realisation of this *impossible* connection between disparate dimensions.

Bauckholt's *Doppelbelichtung* uses birdsong recordings as its primary material. These recordings are manipulated to evoke the timbre of the violin, which is subsequently used to imitate the birdsong. Her primary focus is blurring the distinction between the imitated and imitating sounds.

In contrast, *Trans-étude #4: Intérieur/Extérieur* uses field recordings of urban indoor and outdoor environments as its primary material. Neither the electronic nor the instrumental parts are fixed; it is not so much a score as it is a set of instructions for the performance and for the electronic montage. The instrumental part is constructed according to a general method of instrumental mimesis of the electronic part, which in turn is created from the original recordings and manipulations. My primary focus was exploring different environments and situations while oscillating between sonic manifestations of reality and musical abstraction.

For its part, *Neon Frog's* primary material consists of sound samples and field recordings from vastly contrasting domains, ranging from animals (primarily frogs and toads) to various satellites. The work integrates different translation methods—such as transcription, mimesis, and analogy—exploring degrees of proximity to the original sonic source and implements these methods with instrumental granulation and instrumental additive synthesis techniques. The poetic focus of *Neon Frog* lies in creating hybrid textures or figures composed of the original sounds, their manipulations, and their transcriptions.

While defining the objects or phenomena to be translated, determining data transfer parameters, establishing scales of representation, and devising mapping strategies are common operations in this artistic methodology, sonic translation entails a unique transformation process. In this process, the source material is adapted to musical parameters following a specific path created by the artist. This transformation can be highly interpretative and involve important artistic decisions, which may abstract or distort the original material. In short, the underlying concept driving each translation process delineates a singular field for exploring the relationship between the represented and its representation—a specific terrain for navigating between a sonic real and a sonic imaginary. A composable space that articulates matter, abstraction, and representation.

Chapter 6. Feedback

An Introduction to Audio Feedback

The purpose of this chapter is to present and examine works that exemplify the use of Larsen tones for musical purposes within the composable. In doing so, I will focus on audio feedback as a compositional and performative tool, encompassing its historical applications, the various techniques used to generate and manipulate it, and its role in shaping specific composable spaces.

A central notion for this exploration is that of audio feedback[64] as a compositional resource involving various devices and techniques for producing and transforming sound. It considers both the technical configurations that make feedback possible and the artistic approaches to its integration into a musical work. Questions regarding the nature of music-making can be re-examined by grounding artistic considerations in materiality, thereby providing a viewpoint that challenges the historical tendency to allow musical concepts to dominate our interaction with sonic matter.

In this chapter, I will present pieces that incorporate feedback systems, exploring their role in the musical works referred to, and the distinctive artistic methodologies they employ in shaping and defining the composable. Each case study presents a unique perspective, illustrating specific configurations, distinctive techniques for generating feedback, various devices or instruments integrating the system, and the nuanced interactions between these elements.

First, I will discuss four works that use Larsen tones as musical material within a positive feedback[65] system. I will examine the following pieces in chronological order—*Fabulae* (2016) for video, ensemble, and electronics, and *Allegretto Dynamogramme* (2019) for ensemble and electronics. Subsequently, I will address two works that showcase the same hybrid instrument—the Feed-Timpani—to

[64] Sanfilippo and Valle (2012, 2013) developed typologies of feedback systems specifically within the context of experimental music practice.

[65] **Positive audio feedback** is a phenomenon where a sound loop is created between an audio input (like a microphone) and an output (such as a loudspeaker). When the output sound is picked up again by the input and re-amplified repeatedly, it results in a sustained tone known as a *Larsen effect*. This process can be intentionally used in musical composition as a way to generate and shape sound.

produce Larsen tones: *Cada trozo/cada ganglio* (2022), for video, five instruments, and electronics, and *Mutante* (2023), for four instruments and electronics. I will investigate the operational dynamics of their respective feedback systems, detailing their components and modes of interaction. Additionally, I will examine the contexts in which these works were conceived, their processes of implementation, and the specific functions they serve within each composition. This comprehensive approach aims to elucidate the intricate relationships between the musical techniques employed and their wider artistic implications.

Secondly, I will address instrumental feedback within a self-regulated system in my work *Campo amniótico* (2021), for two performers playing Larsen tones, synthetic voices and real-time electronics. This work is, so far, the only piece in my repertoire that uses positive Larsen tones self-regulated by a negative feedback[66] system and places them at the centre of the compositional process as the main sonic material. *Campo amniótico* addresses the challenging question of how to compose and perform with the unpredictable.

For this chapter, I will establish a broad framework that encompasses various methodologies relevant to the subject before delving into an analysis of my works. This will include specific strategies for creating audio feedback systems, as well as a range of compositional practices from other artists that use audio feedback as either the primary or exclusive musical material. This state-of-the-art review will allow me to compare other approaches to feedback with my own, inform my past choices with new perspectives, raise new questions regarding this artistic concern, fostering consequently renewed observations that could significantly impact my future artistic inquiry.

Historical Repertoire

Several authors suggest that one of the earliest examples of feedback used for musical purposes appears in The Beatles' 1964 song *I Feel Fine* (Sanfilippo and Valle, 2013). This song opens with a Larsen tone produced by John Lennon's guitar. Pop and rock music of the last century offers other significant examples, such as *Anyway, Anyhow, Anywhere* (1965) by the band *The Who*, whose guitarist Peter Townshend frequently incorporated feedback as a musical resource. Also from the same year are the songs *I Need You* (*The Kinks*) and *I Can't Get No (Satisfaction)* by *The Rolling Stones*, pioneers in the use of feedback, as was the later *European Son* (1967) by *The Velvet Underground*. However, the most paradigmatic case was that of Jimi Hendrix, who, between 1967 and 1970, incorporated feedback into musical material in songs such as *Foxy Lady, Purple Haze,* and *Star-Spangled*

[66] **Negative audio feedback** is a process in which a portion of an audio signal is inverted and fed back into the system’s input to reduce or control the output. In audio and musical contexts, it is used to stabilise sound levels, suppress unwanted resonance, or shape sonic behaviour—allowing for greater control over dynamic range and clarity within a sound system or compositional setup.

Banner. The use of feedback for musical purposes became a fairly common resource in pop music. However, it became a refined compositional tool for bands such as *Sonic Youth* and *My Bloody Valentine,* towards the end of the 80s and the beginning of the 90s of the past century.

Regarding contemporary and experimental music, some of the earliest and most significant examples of works incorporating feedback include John Cage's *Electronic Music for Piano* (1964), *The Wolfman* by Robert Ashley (1964), Gordon Mumma's *Hornpipe* (1967), *Microphone* (1973) and *Tone Burst* (1975) by David Tudor.

Steve Reich's *Pendulum Music* (1968) is a classic example of an analogue feedback system, in which microphones are suspended in front of loudspeakers and set into a pendulum-like motion. As they swing and pass through the loudspeakers 'cones—the space of sound projection—they generate Larsen tones. The tones fluctuate in frequency and amplitude with the motion of the microphones, and the performance concludes once they come to rest.

Alvin Lucier's *Bird and Person Dyning* (1975) explore spatial dynamics through feedback generated by ear microphones and loudspeakers, modulated as the performer moves throughout the performance area. Other notable work by Lucier that incorporates feedback include is *Music for Gamelan Instruments, Microphones, Amplifiers, and Loudspeakers* (1994).

Sanfilippo and Valle (2013) highlight the performance *No-Input Mixing Board* by Japanese improviser Toshimaru Nakamura as a "clear example" of a non-linear feedback-based system. Nakamura loops the outputs of a mixer back into its inputs, transforming the mixer into a feedback-based oscillator. This approach produces intricate and evolving sonic textures that arise solely from the internal feedback mechanisms of the mixer. The authors also draw attention to the work of Australian sound artist Malcolm Riddoch, who combines digital and analogue devices in his performances. By employing feedback loops with microphones, electric bass, guitar, and computers, Riddoch explores real-time dynamic spaces, focusing on environmental factors and indeterminacy.

The British saxophone player and improviser John Butcher has been utilising feedback since 1991, as exemplified in his work *Thirteen Friendly Numbers*, as noted by Coello Rodríguez (2021) in his writing on the saxophone as a feedback controller. Coello Rodríguez also references Fischer's work, who has been developing his feedback saxophone since 1999, as documented in recordings such as *Solos* and the more recent *Nights* (2020).

Pea Soup (1974) by Nicolas Collins

Designed for a self-stabilising feedback network incorporating performed sound and movement, this piece represents a pivotal exploration of feedback systems in experimental music and holds a significant position within the lineage of site-specific sound art.

Created during his time at Wesleyan University, *Pea Soup* exploits the dynamic potential of feedback to explore the resonant frequencies of architectural spaces. The acoustic characteristics of the performance space, combined with the interactions facilitated by the audio feedback system, act as active agents in shaping the sonic output. This dynamic interplay culminates in what Collins (2020, p. 1) describes as a "site-specific raga," highlighting the piece's dependence on the unique acoustic properties of each environment. As a result, the soundscape is not a pre-composed entity but an emergent phenomenon arising from the interaction between the electronic system, the sound produced by the moving performers, and the physical space.

Initially developed using a network of analogue circuitry, most notably three Countryman Phase Shifters, the system was designed to emulate the physical movement of microphones in space. Collins specifies that:

> I discovered that when I connected a microphone to a speaker through a phase shifter, varying the delay (degrees of phase shift) emulated moving the microphone towards and away from the speaker, in turn causing the feedback to break to different frequencies. Controlling this virtual movement with the loudness of the signal (via an envelope follower circuit conveniently built into the control-voltage input of the Countryman) mimicked a nervous sound engineer jerking a microphone away from the speaker as soon as it starts to feedback. (Collins, 2020, p. 3)

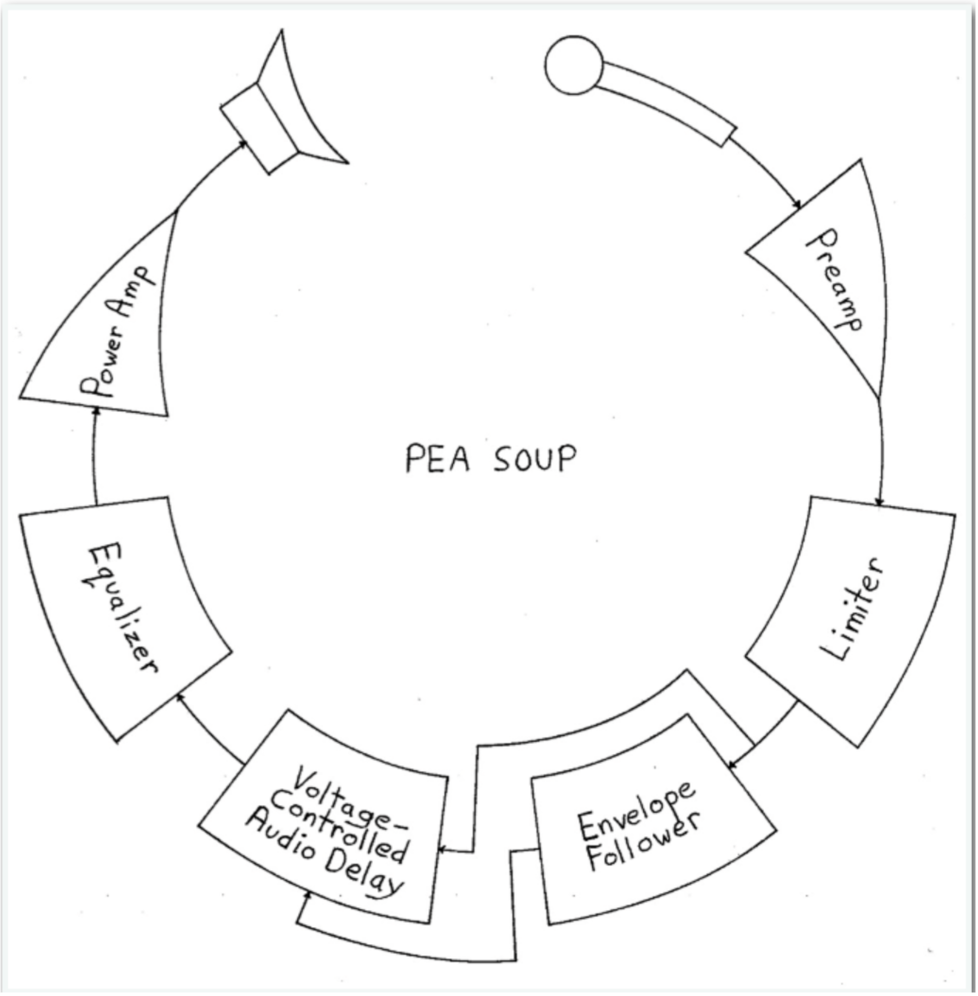

Figure 6.1, *Pea Soup*
Original patch diagram (1976). In Collins (2020, p. 3)

Pea Soup's self-regulating system features nested positive and negative feedback, with positive feedback from the Larsen phenomenon and negative feedback from phase shifting controlled by an amplitude follower. This self-stabilising system of *Pea Soup*, designed to modulate audio feedback, incorporated, according to Collins (2020), "four of what I regard (in all modesty) as significant innovations in what was already the well-trodden field of feedback music:

- **Phase delay** changes feedback frequency by emulating (the) physical movement of the microphone.

- A **limiter** transforms feedback's usual shriek into a mellow sine wave.
- **Omnidirectional** microphones (especially dynamic ones) produce more controllable feedback than cardioid microphones, with a more balanced frequency range.
- To the best of my knowledge, this is the first composition to use automatic **negative** feedback (the typical 'control feedback' studied in cybernetics) to control audible **positive** feedback." (p. 5)

Seeking to "preserve the core of the old analogue *Pea Soup* while adding a minimum of appropriate innovations" (p. 7), the work has been subject to numerous iterations, notably its adaptation to digital platforms using the software Max. The key functionalities implemented within the program are: an emulation of the Model 968 of the **Countryman Phase Shifter** (with an envelope follower that changes phase delay responding to loudness); a **limiter** with an adjustable threshold to prevent distortion; and an **equalization** module with "low and high-frequency shelving filters with boost and cut controls, as well as adjustable corner frequencies; to roll off shrieking high-frequency feedback, boost the bass response, etc." (Collins, p. 8).

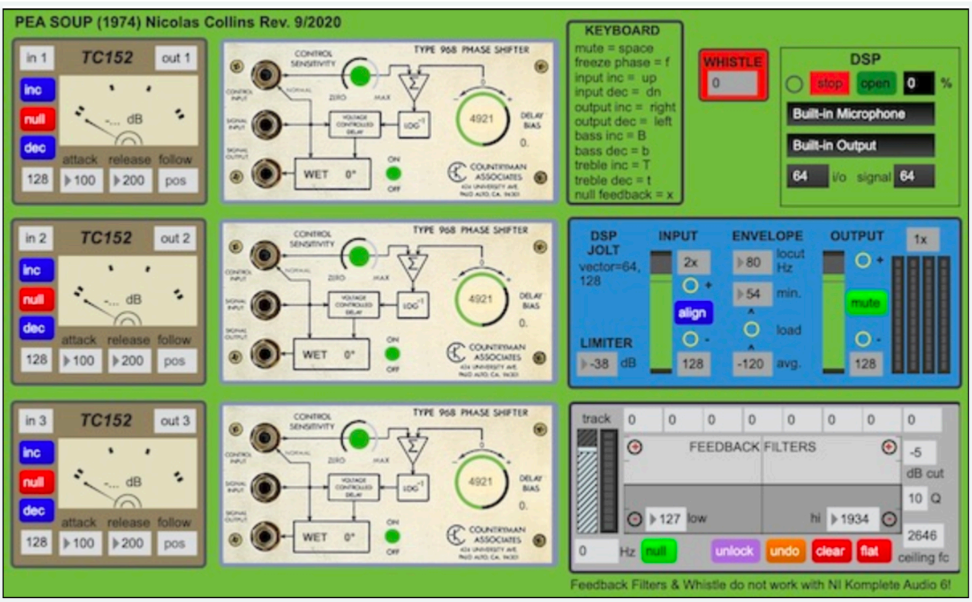

Figure 6.2, *Pea Soup*
Max patch. In Collins (2020, p. 8)

Collins (p.8) added new functions in the digitalised version of the system., prioritising two as “the critical ones.“ These modules are:

- **Feedback Nulling Filters**: This functionality facilitates the attenuation of prominent system resonances during sound checks, thereby expanding the range of available feedback pitches.

- **Whistler:** This module generates detunable sine waves, which induce beating and pitch discontinuities when their frequencies interact with the feedback.

Each *Pea Soup* performance reveals the room's unique tuning, influencing subsequent musical events. Faced with the challenge of editing numerous recordings into a fixed composition, Collins opted for a "shuffle play" approach, resulting in *Pea Soup To Go* (2014)[67], a web application that pseudo-randomly sequences and crossfades over 70 recordings, creating a 24+ hour “encyclopedia of architectural harmonies.”

Feed-Drum by Michelangelo Lupone

The Feed-Drum is a hybrid instrument developed by Michelangelo Lupone and Lorenzo Seno, consisting of an imperial bass drum coupled with an electronic skin-conditioning system. Feedback is generated on the bass drum membrane by a multimodal oscillator—comprising a transducer, microphone, and piezoceramic sensor detecting membrane deflection—and manipulated by the player via a pedal controlling the feedback loop's gain. This “adaptive instrument” (Lupone & Seno, 2006), a result of a collaborative effort between CRM - Centro Ricerche Musicali in Rome and Istituto Gramma in L’Aquila, was conceived for Lupone’s works *Feedback* (2002) and *Gran Cassa* (1999-2003).

[67] In https://www.nicolascollins.com/peasouptogo/ (Accessed April 3, 2025).

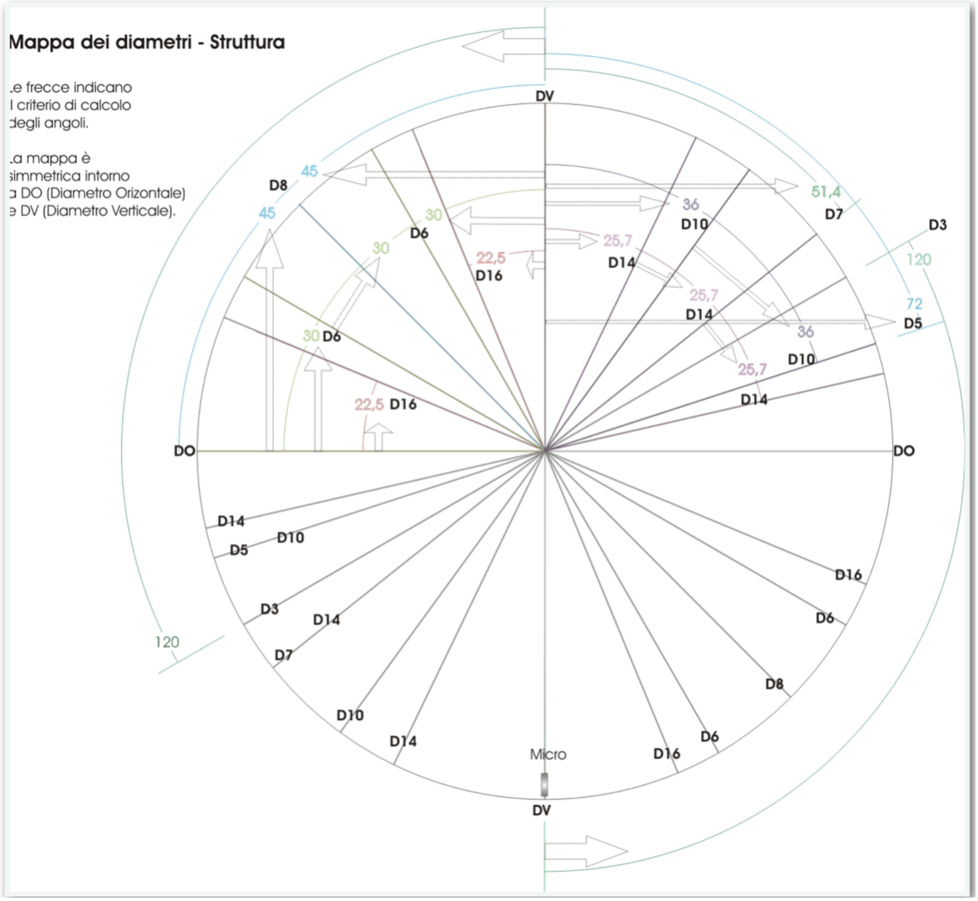

Figure 6.3, Feed-Drum
Map of the first 13 nodal diameters (Lupone & Seno, 2006)

A preliminary phase of instrumental listening and analysis, incorporating unconventional excitation techniques such as "rubbing and jetée with wire brushes," informed the composition of *Feedback* by identifying and classifying a "wide range of possible sounds with different degrees of contiguity." (Lupone and Seno, 2006, p. 150)

The experimental methodology was designed to meet the following objectives:

1. variation of the basic frequency through the application of nodal constraints to the skin,
2. identification of timbres on the basis of type, mode and point of excitation,
3. sound modulation through glissandos, vibratos, portamento and rhythmic micro-articulation,

4. continuous and/or step variations of the dynamics, on the basis of the type of damping applied to the skin. (Lupone and Seno, 2006, p. 151)

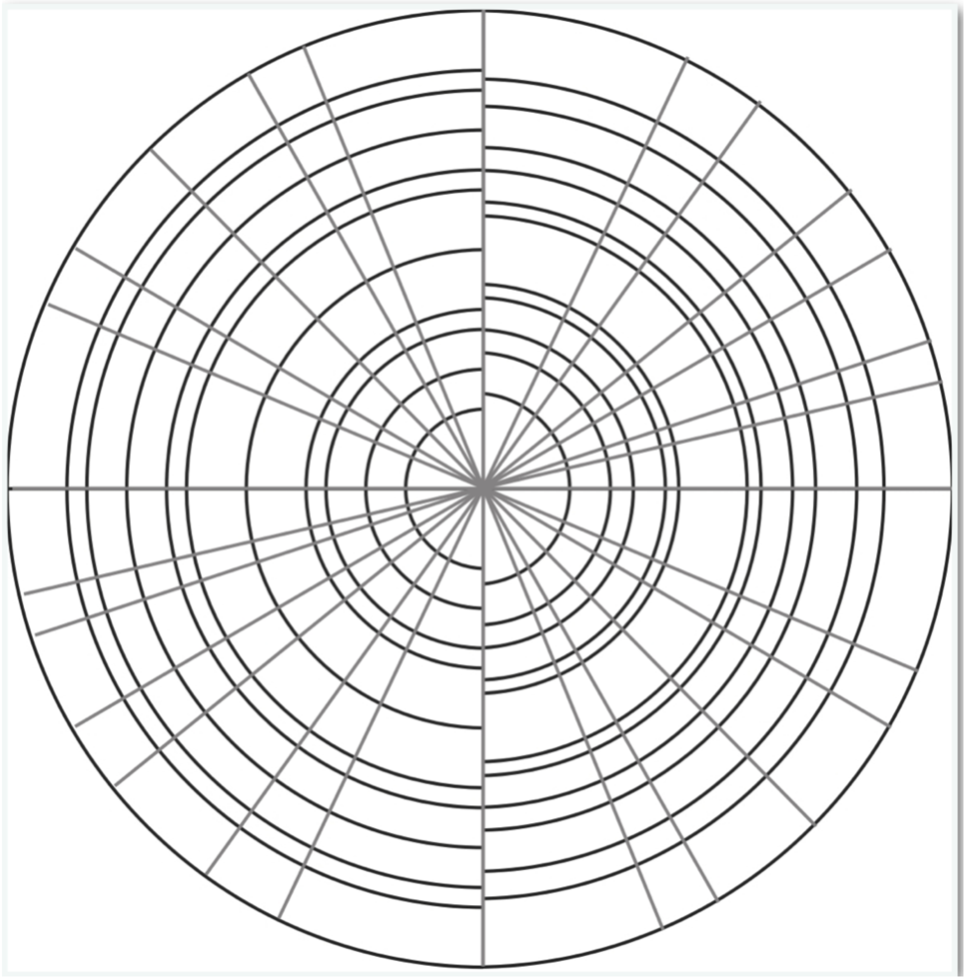

Figure 6.4, Feed-Drum
First map with 13 diameters and 8 nodal circles (Lupone and Seno, 2006)

Conventional bass drums lack the ability to offer such features. To address this limitation and enable the exploration of the timbral richness inherent in the attack phase, as well as the isolation of specific vibrational modes, the creators developed a system for the "electronic conditioning of the (drum) skin" (p. 151). Through the application of the feedback principle, the signal generated by the excitation of the skin is redirected back to it as acoustic pressure, resulting in an infinitely sustained sound. This system enables precise control over the damping of the movement of the skin, thereby regulating the sound's decay rate, and allows for the “isolation of high-frequency modes by the combined influence of the nodes present on the skin and of the amount of feedback input energy” (p. 151). The design on the surface of the drum skin serves as a simplified representation of oscillatory modes derived from Bessel functions. This mapping is limited to 13 diameters and 8 nodal circles, with the latter divided into even semicircles on the left and odd semicircles on the right.

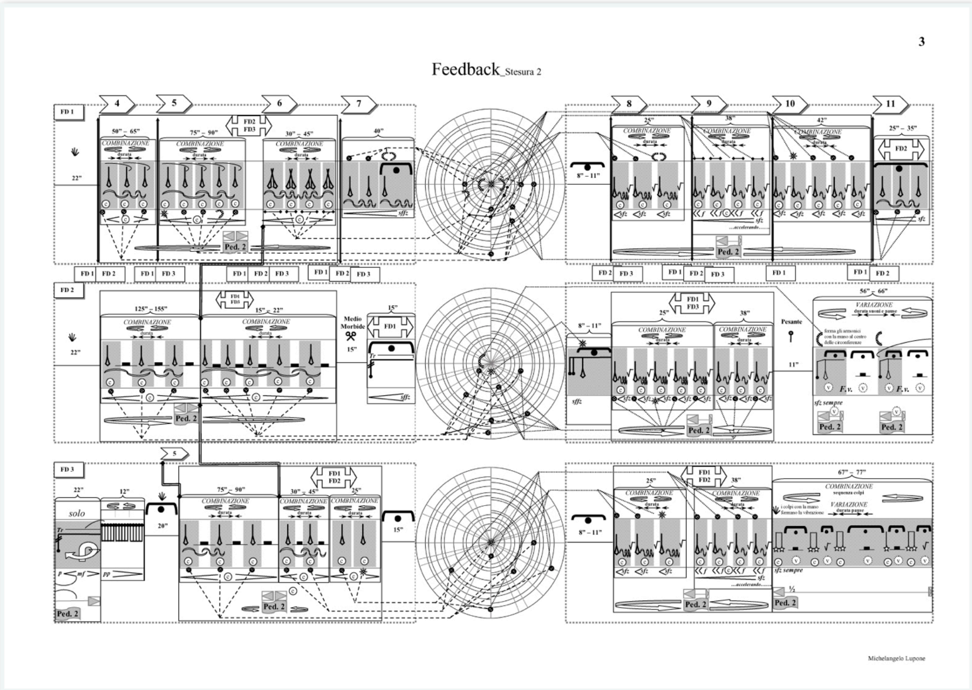

Figure 6.5, *Feedback* (2002)
Excerpt from the score of Lupone’s work (from Lupone and Seno, 2006). © Edizioni Suvini Zerboni

The “electronic conditioning of the instrument” preserved its topology and primary acoustic characteristics while significantly enhancing the range of vibrational parameters and the precision of their control. This was exploited to facilitate the distinction of “the different pitches of various modes, to obtain the emission of long notes which could be modulated as those emitted by a stretched string and to adapt the acoustic energy independently of the emitted frequencies.” (p. 151)

Modes of Interference (2006) by Agostino Di Scipio

Modes of Interference (2006) is described as "a work conceived as an audio feedback system, performed with trumpet and electronics" (Di Scipio, 2010, p. 1). In this composition, a trumpet player interferes "in and with" (p. 2) the self-regulating audio feedback system—a nonlinear coupling between a microphone and two speakers—in ways specific to the characteristics of their instrument. Transformations applied by the digital signal processing (DSP) to the feedback loop, combined with the performer's control, complete the system underpinning *Modes of Interference.*

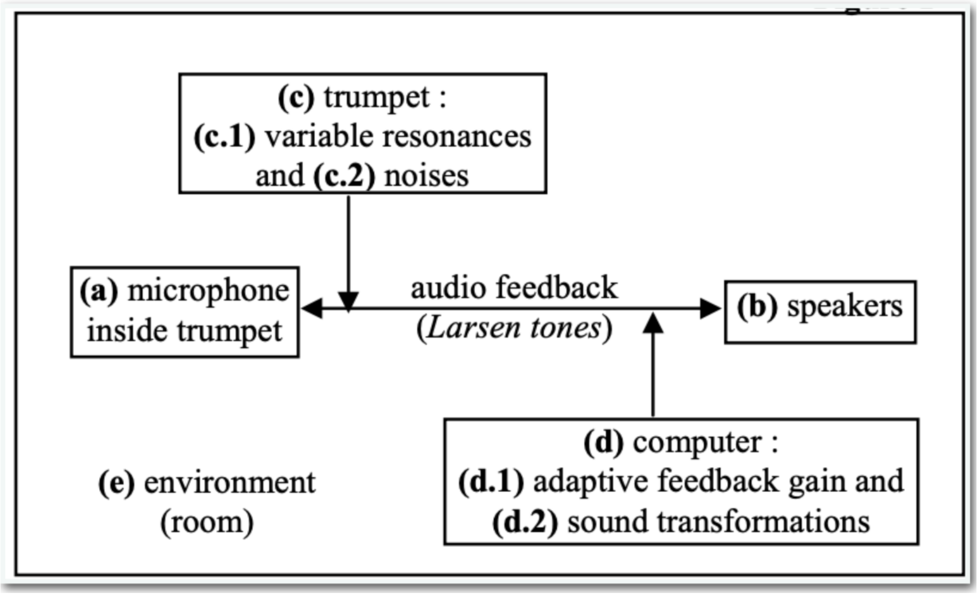

Figure 6.6, *Modes of Interference*
System infrastructure (Di Scipio, 2010, p. 2)

The feedback loop occurs between the miniature microphone inside the trumpet **(a)** and two or more loudspeakers **(b)**. To generate audible Larsen tones, a high input gain is required. Two agents mediate between these two ends: the cylindrical tube of the trumpet **(c)** and a computer processing the signal **(d)**. The 1 cm trumpet's niche on which the microphone is placed acts as a resonator, reinforcing the captured sound, adding to it a "peculiar spectral colouration" with its resonant frequencies, and increasing gain to the feedback loop.

The instrumental actions **(c.1)** involving the piston valves (without the need for blowing) alter the length of the trumpet's tubing and, consequently, its resonances.

The trumpet's acoustic properties become "a kind of variable filter internal to the feedback loop" (p. 2).

Other instrumental actions **(c.2)**, such as "percussive effects, *air* sounds, etc." (p. 2), are required to introduce noise into the system. All these instrumental actions affect the actual state of the feedback loop, changing the pitch, amplitude and onset time of the Larsen tones. Furthermore, these actions govern signal processing operations by modulating key parameters within the DSP patch.

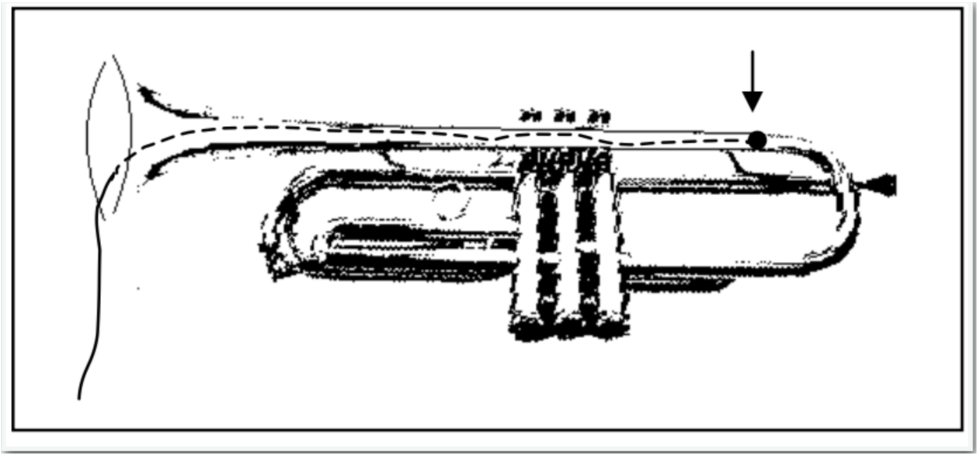

Figure 6.7, *Modes of Interference*
Microphone placement into the trumpet (Di Scipio, 2010, p. 2)

The first task of the signal patch is to calibrate the feedback gain dynamically **(d.1)** to preserve the balance of the system during the whole performance. Di Scipio developed an adaptive process that depends on the total dynamic level at any given time, assuring enough feedback gain to produce Larsen tones but avoiding too high levels, which may result in digital signal clipping or saturation of the analogue components of the dispositive.

The patch also applies transformations **(d.2)** to all sounds evolving within the loop process. These transformed sounds, diffused through the speakers, subsequently re-enter the audio feedback loop, interfere with the audible output, and influence the amplitude or pitch of the Larsen tones.

Threshing Floor (2014) by Mauricio Pauly

This composition for amplified tenor saxophone, amplified percussion, and electronics explores Larsen tones as musical material within a positive audio feedback system. Each instrument employs a distinct method for generating these tones through feedback loops between microphones and loudspeakers, mediated by the resonant modes of the saxophone and the tambourine's skin, modulated by the percussionist's hand.

The percussionist produces Larsen tones primarily through the interaction of the tambourine with two attached contact microphones and their hand. The microphones capture the instrument's vibrations, which are modified by the position and pressure of the hand on the tambourine's skin. In conjunction with a suitably positioned loudspeaker, this interaction yields stable feedback tones, supported by the use of a limiter and compression applied via the mixing console.

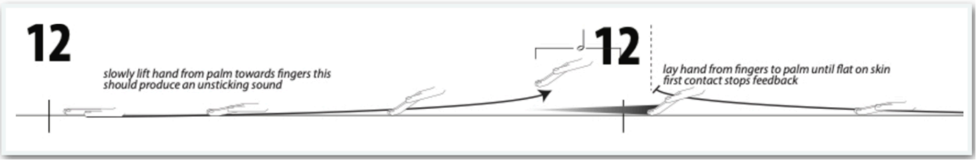

Figure 6.8, ***Threshing Floor***
Indications to produce and mute Larsen tones in the unpublished score (Rodríguez, 2021, p. 21)

The second method by which the percussionist produces Larsen tones involves manipulating an encapsulated omnidirectional microphone within a radius near the loudspeaker while adjusting the gain to achieve the "dovetailing between consequent pitches" and dynamic levels specified by the composer (Pauly, 2014, indication note in *Threshing Floor*'s score).

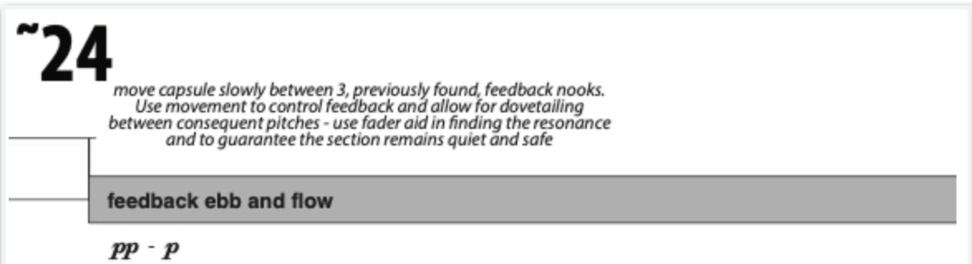

Figure 6.9, ***Threshing Floor***
Indications for microphone's movement to produce and control Larsen tones in unpublished the score (Rodríguez, 2021, p. 21)

The method for generating Larsen tones on the saxophone involves adjusting the distance between the instrument's bell and a dynamic microphone and adapting the positioning to the specific equipment and performance environment. The interaction of the microphone, instrument, and performance space, in conjunction with a strategically positioned loudspeaker, facilitates the generation of controlled Larsen tones. The instrumentalist's movements govern the onset and decay of the sound, while a limiter and compression applied via the mixing console contribute to signal stabilisation.

The excerpt from the score reproduced below illustrates the composer's instructions to insert the dynamic microphone into the bell to induce a Larsen tone, and then gradually withdraw it to bring about a controlled cessation of the sound.

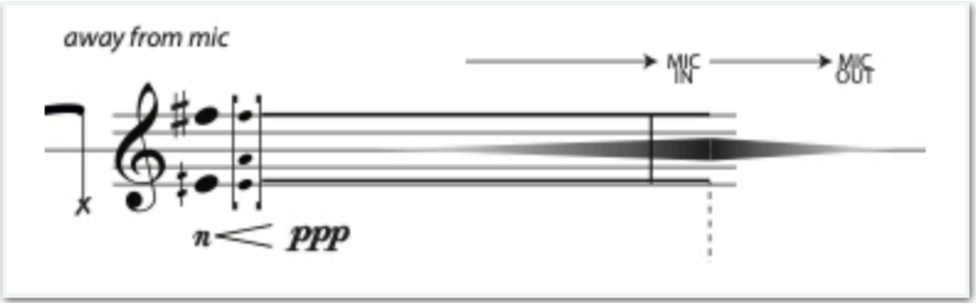

Figure 6.10, *Threshing Floor*
Indications for saxophone’s movement to produce and mute Larsen tones in the unpublished score (Rodríguez, 2021, p. 21)

Instrumental Feedback

In this section, I will address instrumental feedback as an object of artistic inquiry and its use as a dynamic tool for generating and transforming sound, in the specific context of five different works composed between 2016 and 2023.

I will first examine two works that use Larsen tones as musical material within a positive feedback system. I will then explore the functioning of their respective feedback systems, including their components and modes of interaction. I will also examine the contexts in which these works were created, their implementation processes, and the specific roles they fulfil within each composition. The following works will be discussed in chronological order: *Fabulae* (2016), for video, ensemble and electronics; and *Allegretto: Dynamogramme* (2019), for ensemble and electronics.

In closing, two recent works—*Cada trozo/cada ganglio* (2022), for video, five instruments, and electronics, and *Mutante* (2023), for four instruments and electronics—will be examined together, following the same methodological approach as in the previous analyses. Both compositions use the Feed-Timpani, a hybrid instrument designed to produce Larsen tones in a positive feedback system.

Electric Guitar and Bass Clarinet in *Fabulae* (2016)

This work offers a reinterpretation of the classic fairy tale *Cinderella*, as recorded by the Brothers Grimm, through the lens of French writer Emmanuel Adely. It combines pre-recorded voices with on-screen text and features an original video by visual artist Eduardo Martinez Imasaka, composed of repurposed images animated in real time.

Larsen tones are employed by three of the seven amplified instruments in the ensemble throughout the piece. Two distinct feedback techniques are utilised by the electric guitar: proximity feedback, achieved by positioning the pickup microphones near the speaker with a distorted signal and controlled by orientation and a volume pedal; and E-Bow feedback, generated by rapid agitation of the E-Bow near the pickup microphone, also with a distorted signal that is subsequently modulated and filtered by a whammy pedal.

The bass clarinet feedback system incorporates an omnidirectional condenser microphone placed inside the instrument, two analogue pedals, a compact mixer, and a speaker positioned in close proximity to the performer. The system operates via a positive audio feedback loop established between the internal microphone and the nearby speaker. This feedback loop is mediated by the instrument's bore, the aforementioned pedals, and the mixer and is subject to influence from factors including the performer's orientation relative to the speaker, the acoustic characteristics of the performance venue, and prevailing environmental conditions (e.g., temperature, humidity, and occupancy). The system's function is independent of the performer's exhaled airflow.

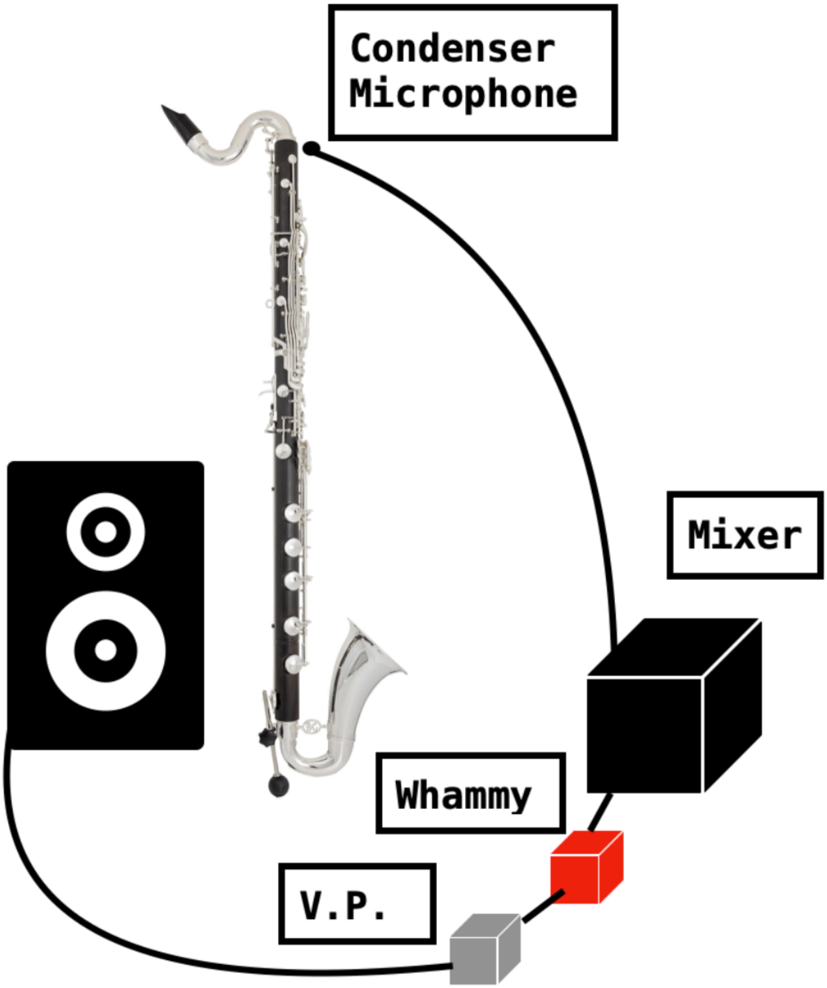

Figure 6.11, ***Fabulae***
Bass Clarinet feedback system from BabelScores (2016)

The conical bore of the clarinet poses a greater challenge to the generation and control of Larsen tones in comparison to instruments with cylindrical tubes. Consequently, the placement of the microphone within the instrument is a pivotal consideration for this feedback system. Through empirical experimentation conducted in collaboration with clarinettist Anne Gillot, who premiered the work and performed it subsequently, the optimal placement was determined to be within the instrument's neck. The small niche housing the microphone functions as a resonator, reinforcing the captured sound, imparting a distinct spectral colouration determined by its resonant frequencies, and augmenting the gain of the feedback loop. While the orientation between the microphone and the speaker ultimately triggers the Larsen tones, factors such as the mixer's gain and the instrument's bore length significantly influence their production. Signal stabilisation is achieved through a combination of the performer's positioning, gain control, limiting, and compression applied via the mixing console and a whammy pedal. Control over the dynamic envelope of the Larsen tones is achieved through the microphone's orientation relative to the speaker, the mixer's gain and a volume pedal configured with a minimum audible threshold. The Whammy pedal, configured as a transposer in the lowest octave, simultaneously shifts the pitch of the input signal and emphasises or attenuates specific frequencies within the spectrum, thereby functioning analogously to a spectral filter by shaping the timbral qualities of the sound.

When the clarinet's bore length is insufficient, generating and manipulating Larsen tones becomes significantly challenging without any DSP mediation. Consequently, empirical experimentation determined that only three low fingerings (resulting in longer bore lengths) were suitable. The lowest C, D, and E fingerings yielded the most effective and sonically compelling Larsen tones, generally producing overtones with varying degrees of beating. These Larsen tones are incorporated into both quiet and noisy textures in the later sections of the work and, in some instances, form trios with the smooth, wave-like Larsen tones produced by the Feed-Tom and the sustained E-Bow sounds of the electric guitar.
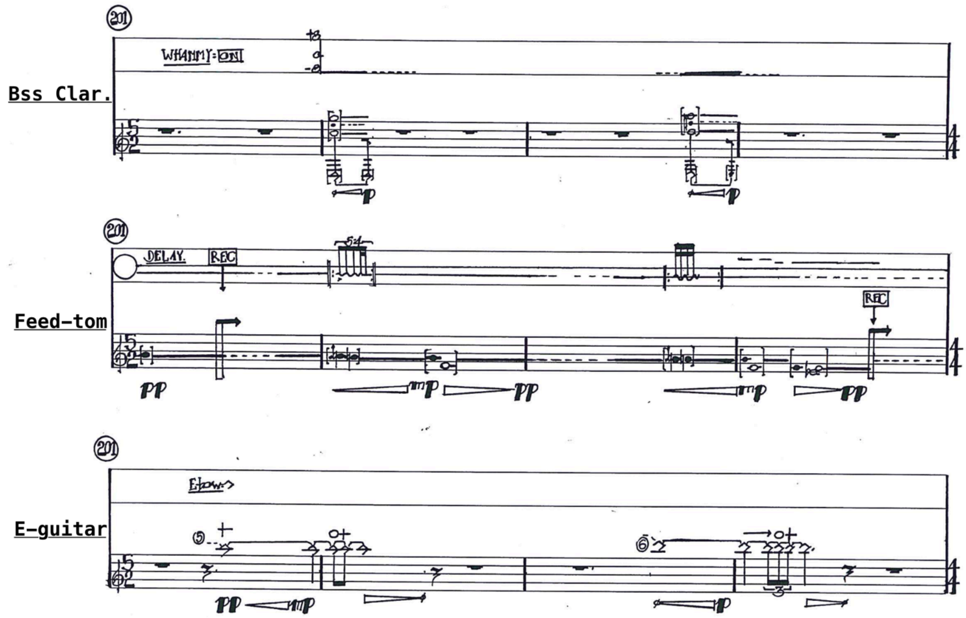
Figure 6.12, *Fabulae*
Detail of the Bass clarinet, Feed-Tom and E-guitar parts. Bars 201-204 from BabelScores (2016)

Feed-Tom in *Fabulae* (2016)

The third instrument employing Larsen tones in this work is the Feed-Tom, performed by the percussionist. This hybrid instrument is created by coupling several devices with a tenor tom-tom drum. A contact microphone is affixed to the drum's membrane and connected to a small mixer positioned near the performer. From the mixer's output, four analogue pedals are connected in the following sequence: Whammy, Distortion, Delay, and Volume Pedal. These pedals are routed to a small amplifier, which drives two outputs: a mobile woofer, manipulated by the performer, and a loudspeaker.

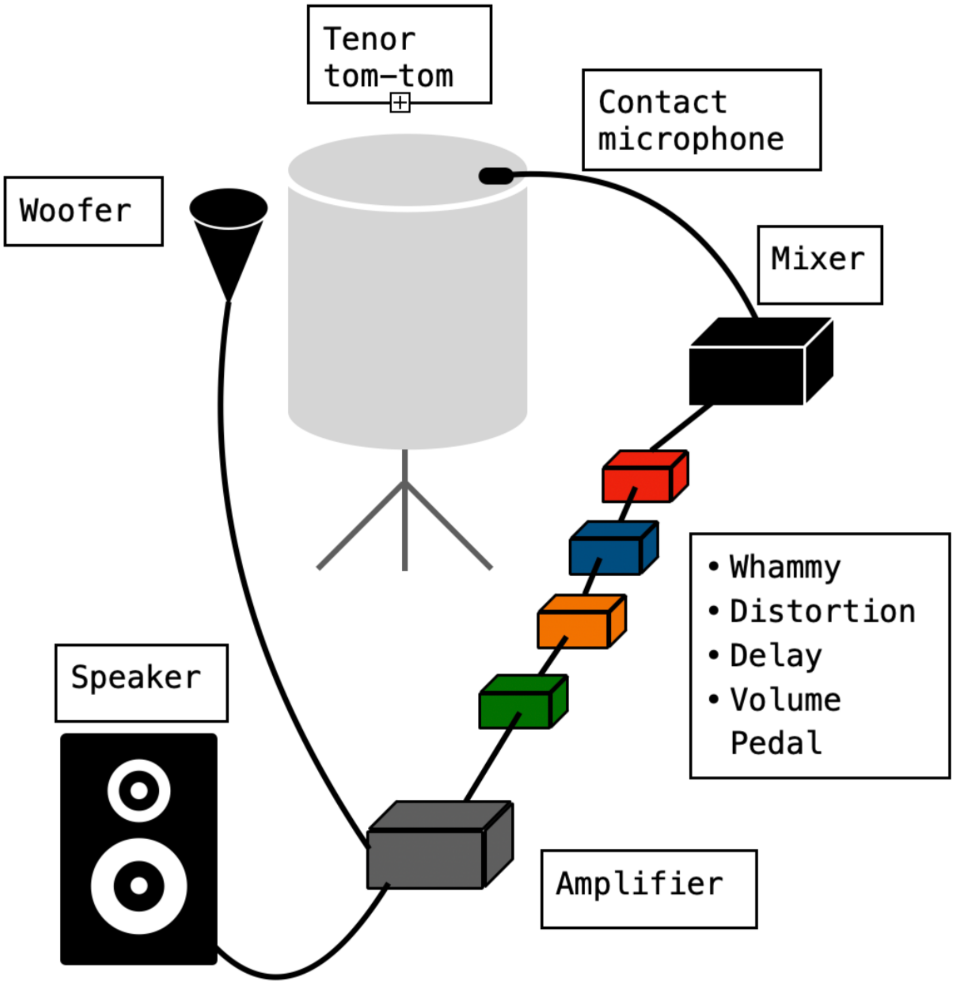

Figure 6.13, *Fabulae*
Feed-drum set-up, BabelScores (2016)

The system's audio feedback loop operates in two distinct manners. The first involves a feedback loop between the contact microphone and the mobile woofer, mediated by the drum's membrane, the resonating shell, the aforementioned pedals, and the mixer. This loop is influenced by various factors, including the current position of the woofer, the woofer's cone orientation, the acoustic properties of the performance space, and the current environmental context. The second method for producing Larsen tones involves applying the feedback principle: the signal generated by exciting the skin manually is redirected to it as acoustic pressure, resulting in a sustained sound.

Each method of generating Larsen tones with the Feed-Tom in this piece involves specific configurations. In the first method, both the distortion pedal and the Whammy pedal (in transposition mode) are engaged. The distortion pedal initiates continuous, spectrally rich, noisy Larsen tones, which are then transformed by the performer's manipulation of the woofer's movement and, optionally or concurrently, modulated by the Whammy pedal, dynamically shifting the pitch and filtering the spectrum. These Larsen tones evolve within quiet but noisy and dense sonic textures.

The following figure illustrates the score's notation for the woofer's horizontal (on the staff), vertical (above the staff), and transverse movements. The dotted lines below the staff indicate the woofer cone's orientation, which exerts a decisive influence on the pitch, loudness, and spectrum of the resulting Larsen tones.

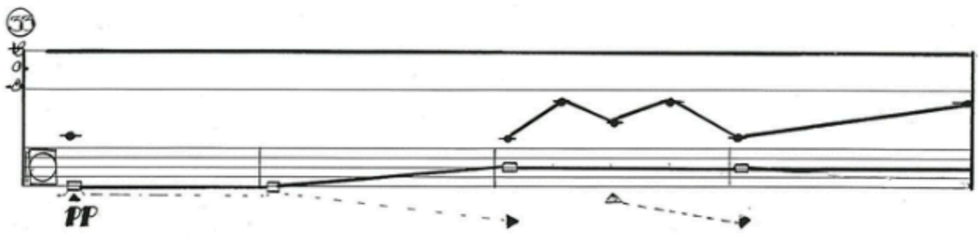

Figure 6.14, *Fabulae*
Feed-drum notation in an excerpt of the score's percussion part. Bars 33-36 from BabelScores (2016)

In contrast to the first method, the distortion and Whammy pedals are deactivated in the second method for generating Larsen tones in *Fabulae*. In this configuration, the delay pedal plays a crucial role in superimposing wave-like sounds generated by smooth Larsen tones. As in the previous configuration, the volume pedal controls loudness and shapes dynamic envelopes, but it also serves to mitigate potential clipping and saturation in real-time. Although the triggering of Larsen tones can prove more challenging in this configuration, the performer's preliminary hand movements (including position and pressure) and the woofer's position are pivotal. The woofer should be kept stationary on the floor with its cone oriented upwards, near or beneath the instrument's shell. This final position is determined by various factors, but ultimately by its potential to facilitate the triggering and control of Larsen tones.

The performer's hand pressure and positioning influence the excitation of various oscillatory modes of the membrane, affecting both the resultant pitch and the sound's decay rate. These actions are also employed to produce pitch bending and vibrato at varying speeds. These smooth Larsen tones evolve within quiet, sustained, wave-like sonic textures and, as previously illustrated, form drone-like trios with the bass clarinet's Larsen tones and the ethereal sounds produced by the E-Bow on the electric guitar.

The following figure illustrates the notational representation in the score of the performer's relative hand positions on the membrane (indicated in the upper staff), along with indications for increased pressure to achieve pitch bending and the required vibrato speed.

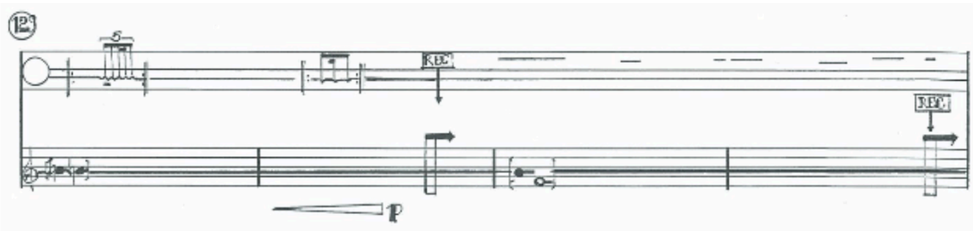

Figure 6.15, *Fabulae*
Feed-drum notation in an excerpt of the score's percussion part. Bars 129-132 from BabelScores (2016)

Feed-Sax in *Allegretto : Dynamogramme* (2019)

In this work for thirteen amplified instruments, a multi-dimensional sound diffusion system, feedback, real-time electronics, and tape, the amplified tenor saxophone fulfils a dual function. It serves alternately as a component of a modular hybrid instrument for Larsen tone generation—the Feed-Sax—and as a conventionally amplified instrument.

The hybrid instrument is composed of an omnidirectional condenser microphone, a volume pedal, an active loudspeaker positioned in close proximity to the performer, and a computer running DSP. The system's operation is predicated on a positive audio feedback loop generated between the capsule microphone, either positioned close to or inserted within the instrument's bell, and the adjacent loudspeaker. This feedback loop is mediated by the instrument's bore, the volume pedal, and the computer's DSP processing and is influenced by factors such as the performer's orientation, the acoustic properties of the performance space, and environmental conditions.

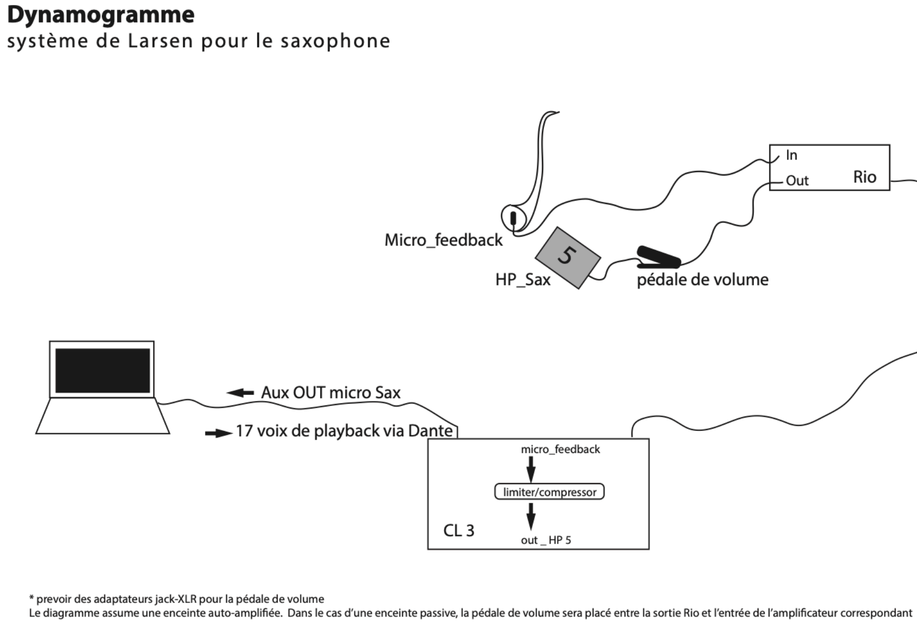

Figure 6.16, ***Allegretto : Dynamogramme***
Feed-Sax system. BabelScores (2019)

The Larsen tones are obtained by approaching the bell until encapsulating the condenser microphone with it, the airflow from the performer's exhalation does not contribute to the system's operation. The saxophone player's movements control the audio signal's triggering, dynamics, stabilisation, and extinction within the feedback system, while the volume pedal provides real-time control of the dynamic envelope, sound extinction, and system deactivation. This contrasts with the use of a separate amplification mode for conventional instrumental performance.

The manipulation of keys without breath actuation results in alterations to the saxophone's bore length, and consequently its resonances. This, in turn, renders the saxophone's acoustic properties an internal variable within the feedback loop. The impact of this is twofold, affecting both the pitch and the loudness of the Larsen tones, in addition to shaping their spectral content.

In this feedback system, the mediating DSP performs several functions. The audio signal is initially delayed within a Max module before being reinjected into the feedback loop, thereby reinforcing the Larsen tones. Subsequently, a multi-band compressor and limiter, housed within a separate module, prevent signal clipping and saturation. This module also includes a multi-band equalizer and filter to shape the spectral characteristics of the generated Larsen tones, along with an adjustable notch filter for attenuating recurrent room modes.

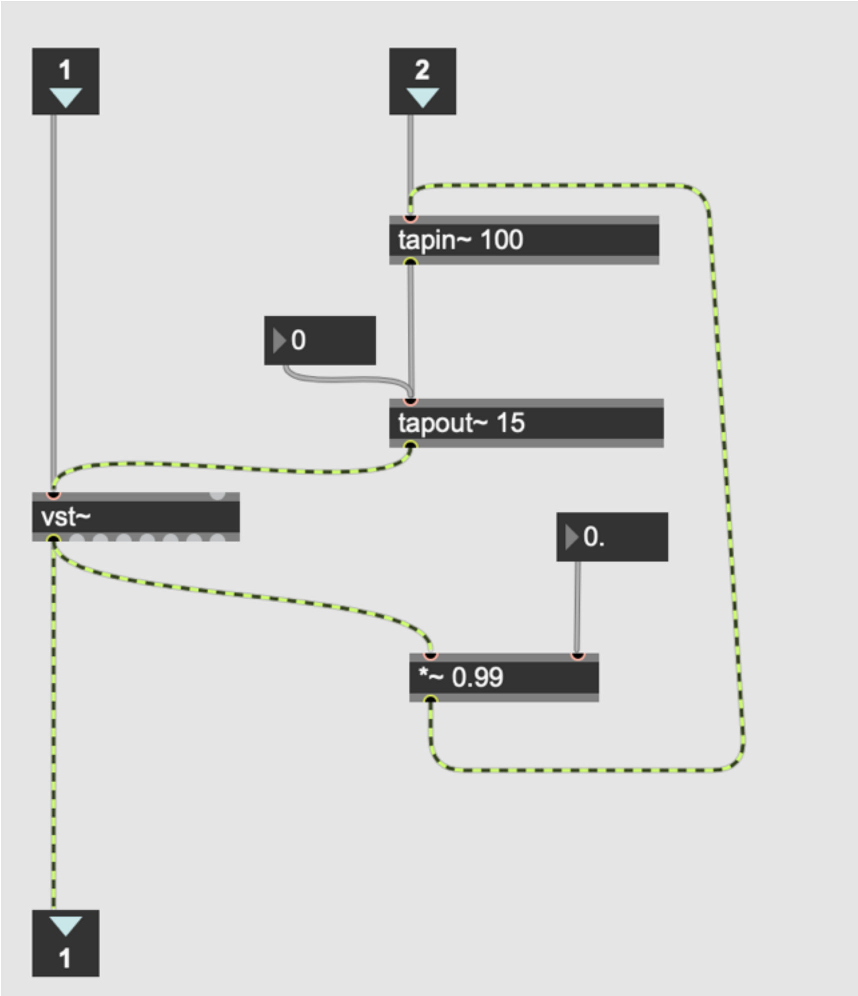

Figure 6.17, ***Allegretto : Dynamogramme***
Feed-Sax module in the Max patch. BabelScores (2019)

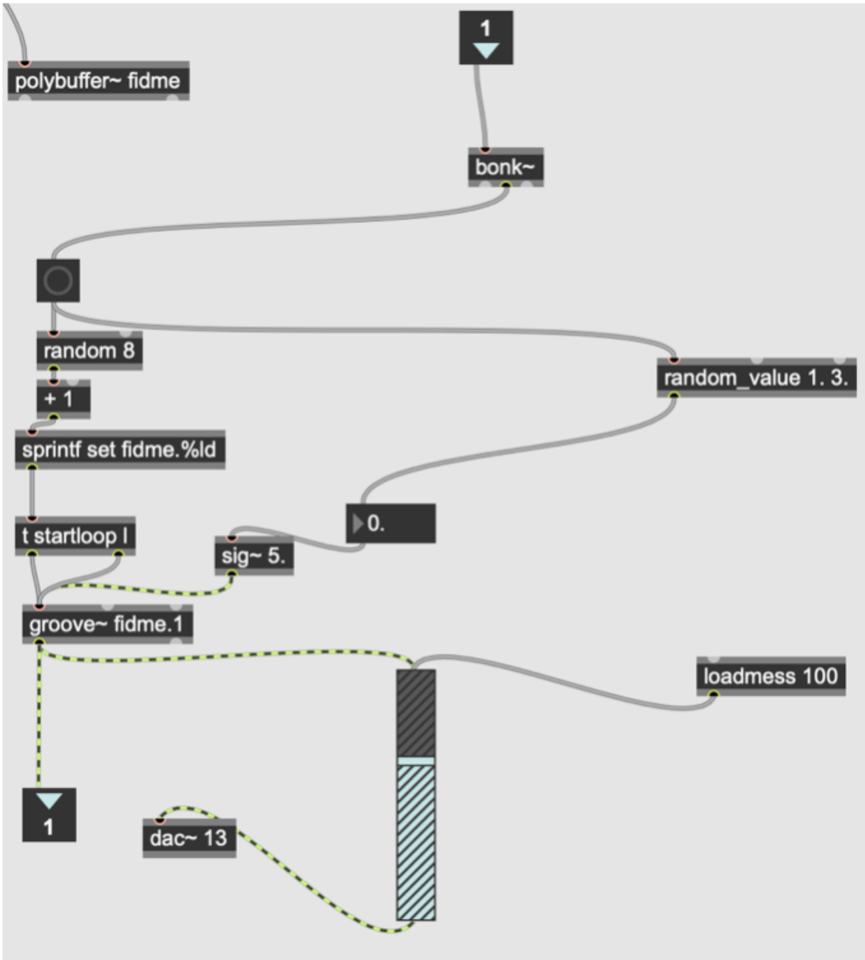

Figure 6.18, *Allegretto : Dynamogramme*
Envelope follower and audio file triggering. BabelScores (2019)

The score requires five principal and six secondary fingerings, without specifying their precise identity. Consequently, the performer is responsible for selecting these eleven fingerings in each performance, which necessitates adaptation to the specific performance context, making the musical material inherently situated. It is advisable to avoid certain right-hand fingerings, as the size of the keys for low C, D, E, and F presents a risk of signal saturation and clipping during the attack.

The selection of the five primary fingerings is based on their reliance and stability, with the objective of achieving a desired pitch and timbre contrast. The remaining secondary six are used to alter the principal ones without needing stable response or pitch and timbral contrast. They are used for rapid instrumental actions such as *trills, mordenti,* rapid *appoggiature* or *grupetti.*

Other instrumental actions involving Larsen tones play a significant role in this piece, such as *vibrato* produced with small movements towards and away from the microphone and key noises followed by feedback resonance. This last one is digitally augmented by an envelope follower system that detects sudden loud attacks and randomly triggers one of eight short, pre-recorded Larsen tone sound files generated by a Feed-Sax instrument.
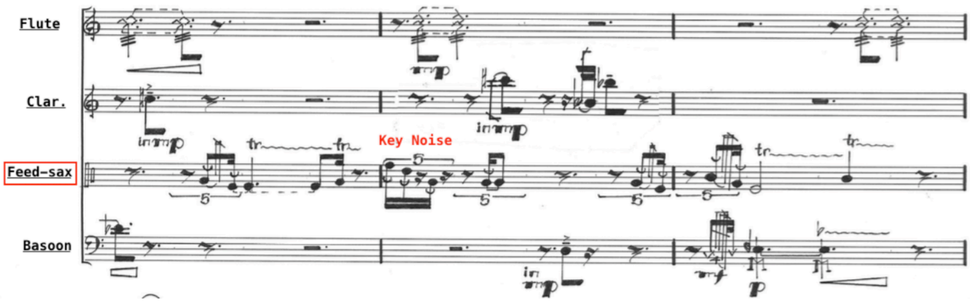
Figure 6.19, ***Allegretto : Dynamogramme***
Bars 94-96 from BabelScores (2019)

These figures illustrate notated examples of these instrumental actions and provide information regarding the diverse musical contexts in which they primarily occur, characterised by shifting, contrasting textures and generally subdued dynamics. The Larsen tones are frequently combined with woodwind multiphonics, motor-driven rapid *tremoli* on percussion or stringed instruments, glissandi on the strings of the piano produced with a hard plastic box, and E-bow feedback on the electric guitar, among other contrasting instrumental morphologies.

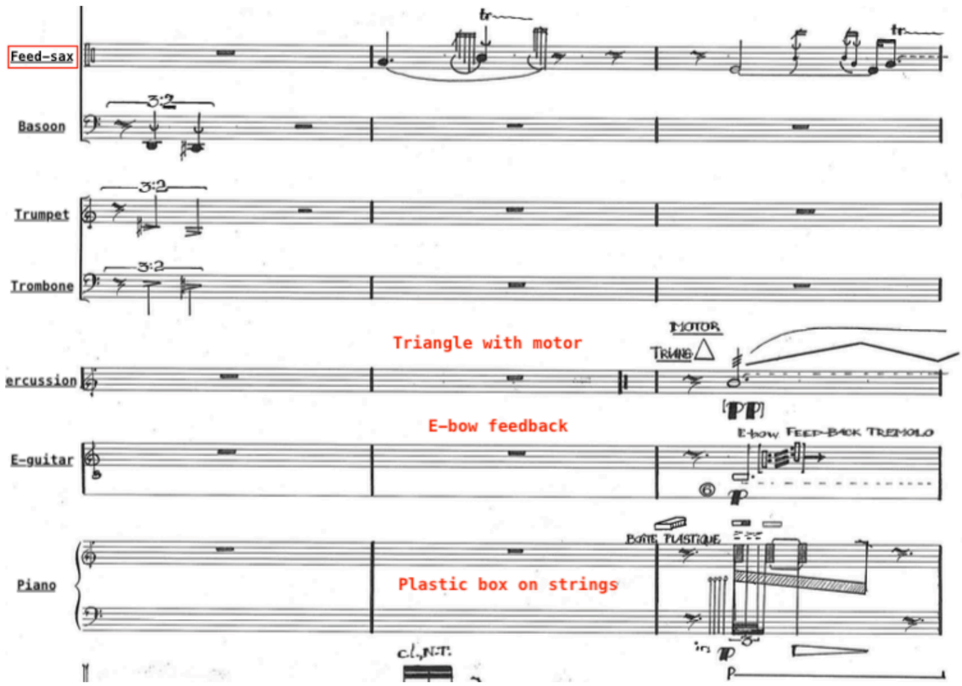

Figure 6.20, *Allegretto : Dynamogramme*
Bars 202-205 from BabelScores (2019)

Feed-Timpani in *Cada trozo/cada ganglio* (2022) & *Mutante* (2023)

Between 2022 and 2023, I conducted several experiments, initially with David Joignaux and subsequently with Guy Frisch, percussionists from the French ensemble Cairn and the Luxembourgish ensemble Lucilin, respectively. These collaborations contributed to the joint development of the hybrid instrument we named Feed-Timpani, which, like the Feed-Tom, was inspired by Lupone's Feed-Drum. The Feed-Timpani played a central role in the percussion setup of two of my recent works: *Cada trozo/cada ganglio* (2022) and *Mutante* (2023), both premiered and subsequently performed by the aforementioned ensembles.

This instrument comprises a core set of modules: a timpani (which may vary in size), an omnidirectional condenser microphone, at least two active loudspeakers, and a computer running DSP. A positive audio feedback loop is established between the condenser microphone and the loudspeakers, mediated by the timpani's membrane, resonating shell, pedals, and the DSP. This feedback system is subject to influence by factors such as microphone orientation, the acoustic properties of the performance space, and prevailing environmental conditions.

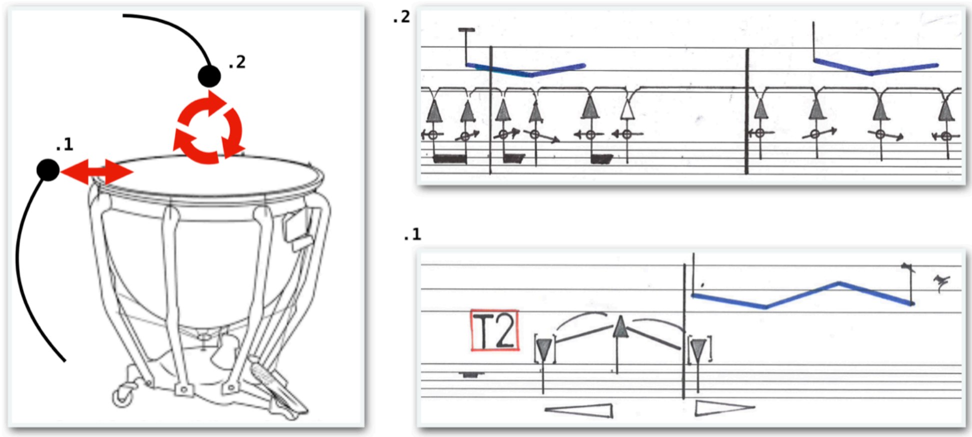

Figure 6.21, ***Cada trozo/cada ganglio***
Excerpts of the unpublished score

Two instrumental actions are required to obtain distinct Larsen tones, contrasted by dynamic envelope and spectral colour:

- The first method **(.1)** is the most sensitive due to the risk of signal clipping and saturation, requiring the performer to be highly reactive and aware of the prevailing acoustic conditions. It involves positioning the microphone close to the membrane's edge at a low height to initiate the Larsen tone and then rapidly withdrawing it. Due to the numerous factors influencing its production, it is sometimes necessary to pre-excite the membrane with a brief stroke or rubbing motion. The excitation of an oscillatory mode within the instrument produces a resonance of moderate duration, which the percussionist must utilise to manipulate the timpani pedal and thus transform the resonating Larsen frequencies. The score employs a relative rhythmic notation, requiring interpretation by the performer in consideration of the feedback system's responsiveness. Bracketed noteheads indicate microphone movements toward or away from the instrument, while triangular noteheads signify the occurrence of Larsen tones. Pedal manipulations are depicted in the score's upper staff.

- In contrast to the first method, the second method **(.2)** involves performing circular movements with the microphone at varying speeds. The microphone is positioned at a greater distance from the membrane to avoid undesired phenomena while maintaining a continuous Larsen tone. These movements generate small dynamic oscillations, the cycle of which is determined by the movement's speed, producing vibrato and pitch bending. This greater distance significantly reduces the risk of clipping and saturation compared to the first method, albeit at the cost of reduced volume. This instrumental action, designated *pendulum feedback*, is accompanied in both pieces by short, rapid pedal movements that further accentuate the pitch bending and dynamically filter the prevailing sound spectrum. The arrows associated with the notes indicate the speed of the microphone movement. A leftward-pointing arrow denotes a slow movement, while a rightward-pointing arrow denotes a faster movement. Ascending arrows indicate an *accelerando*, and descending arrows describe a *rallentando*.

While the instrument's membrane and resonant shell are integral components of the feedback loop, the pedal plays a crucial role in shaping the sonic output of the Feed-Timpani. By modulating the membrane's tension during resonance, the pedal functions both as a mechanical dynamic pitch shifter for the resonating Larsen tones and as a dynamic filter, influencing the frequencies, amplitudes, and decay rates of the overtones in real time because of its cascading effect.

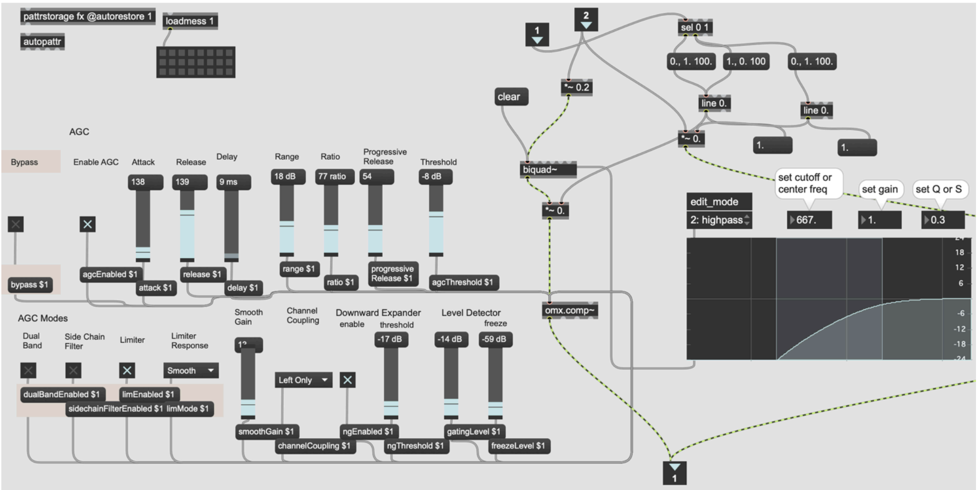

Figure 6.22, *Mutante (2023)*
Abstraction inside the Max patch

The Max patch, positioned between the signal input and output, is another important mediator within the feedback loop, essential for controlling Larsen tone sustain, spectral characteristics, and amplitude. Its modules include a multi-band compressor/limiter with adjustable parameters and a bipolar filter that amplifies high frequencies and attenuates room modes.

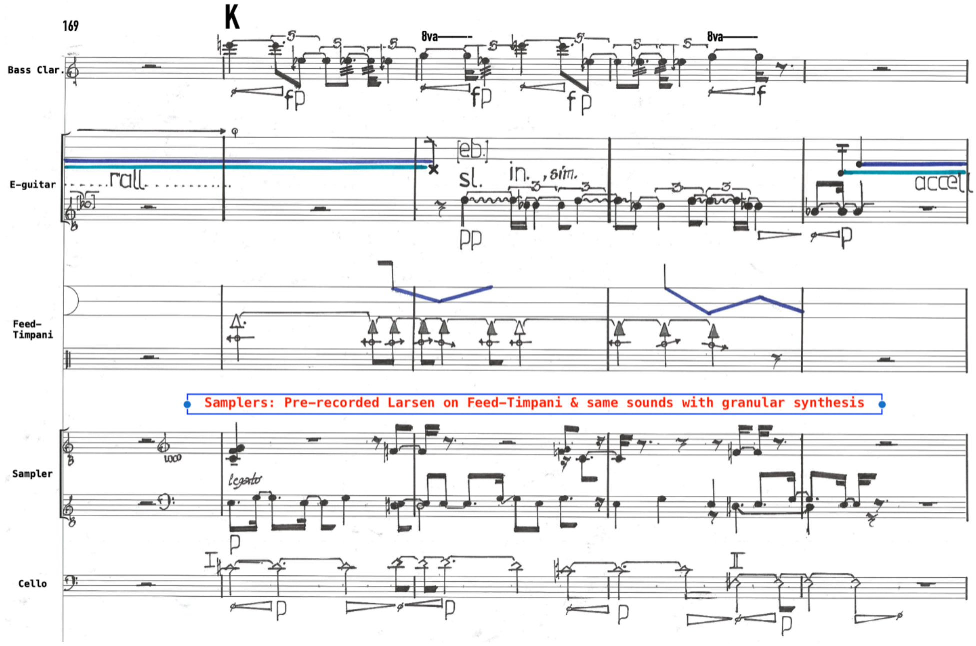

Figure 6.23, *Cada trozo/cada ganglio*
Bars 169-173 from the unpublished score

The preceding image serves as an illustration of the types of sonic contexts in which the Larsen tones of the Feed-Timpani develop. Within this section, the 'pendulum feedback' constitutes a component of an ethereal texture crafted through mixed techniques, which encompass instrumental additive synthesis, orchestrated from unaltered or slightly modified recordings of the Feed-Timpani via granular synthesis played by the keyboard. These two types of similar sounds are complemented by harmonics from the cello and soft bass clarinet sounds that double the existing frequencies with others that are slightly lower or higher, alongside sustained notes produced with the e-bow on the electric guitar.

In contrast, the primary method of Larsen tone production generally serves as a component of musical articulation, sometimes accompanied by brief sonic events during its gradual onset, such as samples of glitches and amplified clarinet inhalation sounds, among others. These transient events obscure the precise moment of timpani membrane vibration. These modulated feedback resonances frequently blend with sustained sounds from the electric guitar, which are enhanced by a sustain pedal used in conjunction with a tremolo pedal, the rate of which is manually adjusted by the performer.

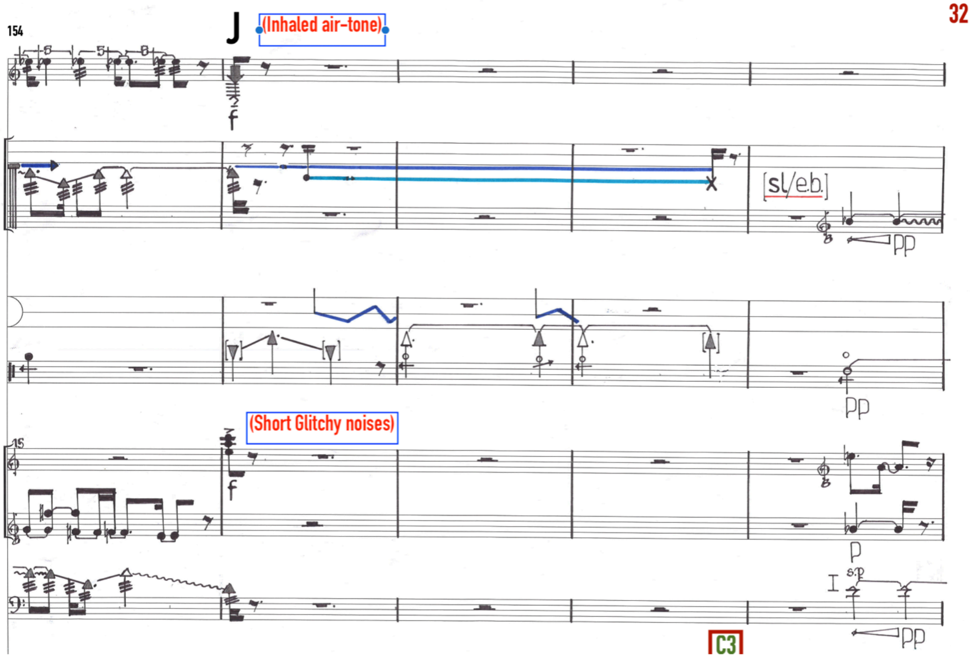

Figure 6.24, ***Cada trozo/cada ganglio***
Bars 154-158 from the unpublished score

Campo amniótico (2021)

This section discusses instrumental feedback within a self-regulated system, which was central to the compositional process of *Campo amniótico* (2021).

I will begin by presenting the dispositive and tracing its emergence through a process of experimentation, observation, and the iterative problematisation of digitally controlled negative feedback systems. This will include reflections on its final configuration, shaped through successive performances and evolving versions. I will then examine the operational mechanisms of the feedback system itself, outlining its structural components and modes of interaction. Additionally, I will analyse the various performance contexts and the work's developmental trajectory.

Second, I will address the central question that underlies the entire compositional process: how can we compose and perform with a phenomenon as chaotic and unpredictable as feedback? I will discuss how the relationship between the self-regulated feedback system and performer agency ultimately shaped the experimental and creative process. I will examine the compositional strategies and operations, the situated instrumental actions, and the juxtaposition of two musical temporalities within the work.

Finally, I will discuss the particular negative feedback system of *Campo amniótico*, the compositional operations encapsulated and sequenced in the Max patch, and the central issue of composing emerging sound objects.

About the Dispositive

Commissioned by the French ensemble L'Imaginaire and the Italian festival *Musica in Prossimita*, the first version of Campo amniótico premiered in Strasbourg in July 2021. A second version was performed twice in Switzerland in 2021 and 2022 by Ensemble Vortex, and the following year by Ensemble Lucilin at the Philharmonie de Luxembourg. Lucilin also premiered its final version in Malmo in 2023, as part of the *Inter Feral Arts* Festival.

As mentioned earlier in this chapter, my experiments with Larsen tones as musical subject matter began several years ago; however, all of my works prior to *Campo amniótico* developed only positive feedback systems. At the time of its composition, I was in residence at the French Academy in Rome, in the midst of the health crisis caused by the COVID-19 pandemic. For these exceptional reasons, this work is the one in which I was able to devote the longest period of time to the experimental process. This phase was characterised by an iterative problematisation of the subject of negative feedback systems to produce self-regulating Larsen tones that could be manipulated by performers with acoustic instruments. As the original commission was for flute and saxophone, I concentrated my research solely on wind instruments made of cylindrical tubes. The material at my disposal included a C flute, an alto saxophone, two Naiant XX omnidirectional condenser microphones, a computer, an RME Fireface UCX-II sound card, a Boss FV-50 analogue volume pedal, and two Rokit speakers. The experiments involved the creation of a digital negative feedback system as well as the creation of a hybrid instrument resulting from the coupling of the microphone with a similar instrument or object. I quickly concluded that the best approach would be to insert the microphone into the tube of the instrument or object so that the latter would act as a mediator in the feedback loop between the microphone and the loudspeaker. In this way, the tube provides Larsen tones with their spectral characteristics and resonance modes and allows for the mechanical manipulation of the feedback. Throughout the process, I tried to make as many contrasting experiments as possible by changing the patch, microphones, speakers, audio interface, locations and configurations of the hybrid instrument. I experimented with two different DPA omnidirectional condenser microphones (the 4060 and the 6061 models), a small Behringer Xenyx 802 S mixing board, a Behringer FCV100 volume pedal, two Yamaha DBR12 active loudspeakers, a bamboo flute, a cardboard tube in which I drilled five holes, a plastic toy saxophone, and finally, two corrugated plastic tubes, one flexible and one rigid, in which I also drilled five holes. I exhausted all possible combinations between the components I had available in as many spaces as possible. The device, the system and the work were gradually shaped by this largely empirical process of experimentation, together with analysis of feedback systems in the works of other composers, reading on the subject and my own observations.

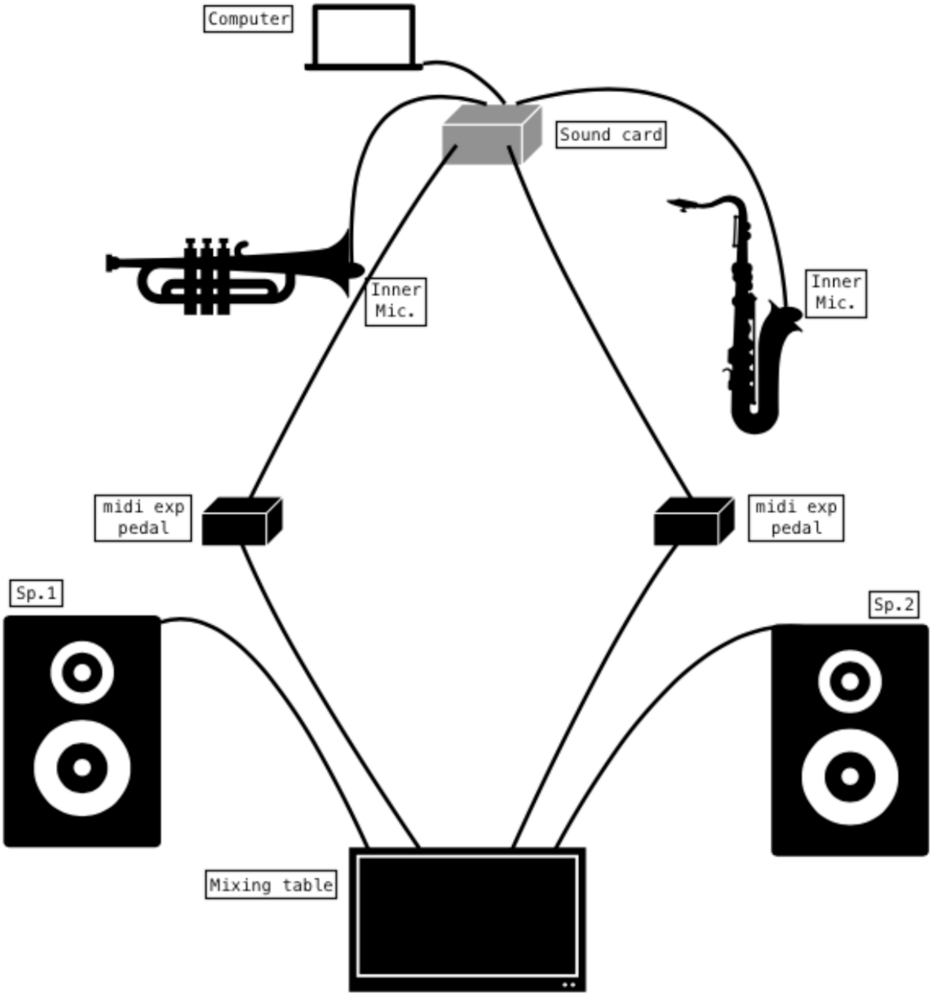

Figure 6.25, ***Campo amniótico (2021)***
Dispositive

Campo amniótico's final dispositive consists of two hybrid instruments, each created by coupling a cylindrical instrument—or any cylindrical tube of variable length—with an omnidirectional condenser microphone placed inside. The setup also includes two MIDI expression pedals, which control volume and were the final components added to the dispositive. The setup also incorporates a computer running a Max patch governing the real-time electronics—which includes the self-regulating feedback module, ring modulation and the triggering of pre-recorded audio files—, a sound card, a mixing table, and a minimum of two speakers positioned at the sides of the stage and ahead of the performers. The system operates via a negative audio feedback loop established between the internal microphone and the nearby speaker. The instrument's bore, the MIDI expression pedals, the mixing table, and the sound card mediate the feedback loop, which is influenced by factors including the performer's orientation relative to the speaker, the acoustic characteristics of the performance venue, and prevailing environmental conditions (e.g., actual weather conditions at the performance venue, occupancy, humidity, etc.). The system's function is independent of the performer's exhaled airflow, which this work never requires.

Composing with the Unpredictable

This work emerged from an artistic preoccupation that has preoccupied me for over a decade, taking concrete form in 2016's *Fabulae*. Since then, my artistic practice has been permeated by a recurring question that defies a single definitive answer: How can one compose with an unpredictable acoustic phenomenon such as Larsen feedback? How can one compose the sonic emergences resulting from the coupling of microphones, speakers, and instruments? These questions have driven the development of several of my works since then. However, the composition discussed here was the first (and to date, the only) piece in which feedback serves as the primary sonic material, played by performers and modified through real-time electronics. This work represents the personal challenge of composing exclusively with feedback to be played by live performers on acoustic instruments.

The acquired knowledge since *Fabulae* and the insights that emerged during the experimental stages of composing *Campo amniótico* formed the foundation upon which I defined the general approach and strategies for composing with this chaotic phenomenon as musical raw material. This global approach was characterised by integrating instrumental feedback experiments and physical device design with the development of an operative field, alongside the progressive refinement of concrete musical ideas shaped by poetic intuition and aesthetic inclination. In this way, I sequentially or simultaneously constructed a network of inter- and retroactive relationships within the composable space.

Guided by this global approach, I was able to establish compositional strategies. Initially, these strategies focused on creating a framework for the temporal articulation between the composed emergent objects—composed from the raw material of Larsen tones—and the pre-recorded synthetic voices that fragmentarily recite the text of Bruce Nauman's two-monitor installation *God boy, Bad Boy* (1985/86). Subsequently, I organised the ring modulation operations on the self-regulated Larsen tones on a global scale. Finally, I focused on distributing the density of instrumental actions and sound events. In other words, the strategies that guided the compositional process of *Campo amniótico* concentrated on musical time, emergent timbre, and the density of sonic activity. The initial decision derived from these strategies was to set the analogue volume pedals to a minimum audible volume, subsequently reproducing this in the expression pedals concerning the change of scale between the MIDI values and volume control values of the signal. This resulted in the suppression of silence as a musical resource, replaced by a barely audible, constant sonic activity that creates an almost hypnotic, suggestive effect—particularly present in the work's first and last sections. In this way, a haunting silence precedes or follows the instrumental actions and the appearances of the synthetic voices, functioning as a spectral presence.

Once the global approach and compositional strategies were defined, I began to outline the central parameters of the sonic material on which to perform local operations. These operations were articulated across two supports: the score and the Max patch.

Regarding the score, its two main operations concern frequencies and timbre, and duration and rhythm. These were executed on the changes in the length of the tubes of the instruments, primarily determined by the distributive strategy of density. These alterations in length produce unpredictable changes in the frequency or frequencies present in the actual sound, as well as in its timbral qualities and volume, the latter occurring within the framework of the negative feedback system that regulates it. Other local operations of considerable importance relate to the duration and rhythm of the two instrumental performed actions: the change in the length of the instrument's tube and the dynamic envelopes produced by pedals, which control the appearance and (almost) extinction of Larsen tones.

The automated and sequenced local operations in the patch relate to changing the parameters of the ring modulation, distributing the appearance and speed of the samples of the synthetic voices of Nauman's text diffused in stereo, and their progressive phase shift. The diffusion of each synthetic voice through its respective channel is in turn subordinated to the control of the volume pedals, and depending on the changing agogic of the performers, its emergence is somewhat haphazard. Voices may remain at a barely audible level, or they may emerge, in whole or in part, at a higher volume.

The information provided by the score is deliberately concise. It suggests a reference pulsation of 60 BPM, a value that can vary depending on the dispositive's responsiveness, the manner of realising the dynamic envelopes with the pedal, the agogic, and ultimately, the artistic decisions made by the performers. The notation is limited to indicating the rhythm of the occurrences of the Larsen tones and the current relative length of the tube. Only five positions are indicated in the score, which do not represent absolute fingerings. These positions that determine the length of the tube are relative and must be situated each time. Performers must select these five specific positions at the location where the piece is performed. They can change these positions from one stave of the score to the next based on the immediate response they observe. The key factors in making this choice include the stability of Larsen's tones, the potential noise created by the system that adjusts dynamically the length of the tubes, and the emerging timbral characteristics. Ideally, these positions should be arranged from the lowest to the highest frequencies, though this is not mandatory. All these attributes are ultimately unpredictable. The negative feedback system guarantees a continuous sound without excessive peaks or clipping, while the hybrid instrument can alter frequency or timbre, but it does not provide predictable results.

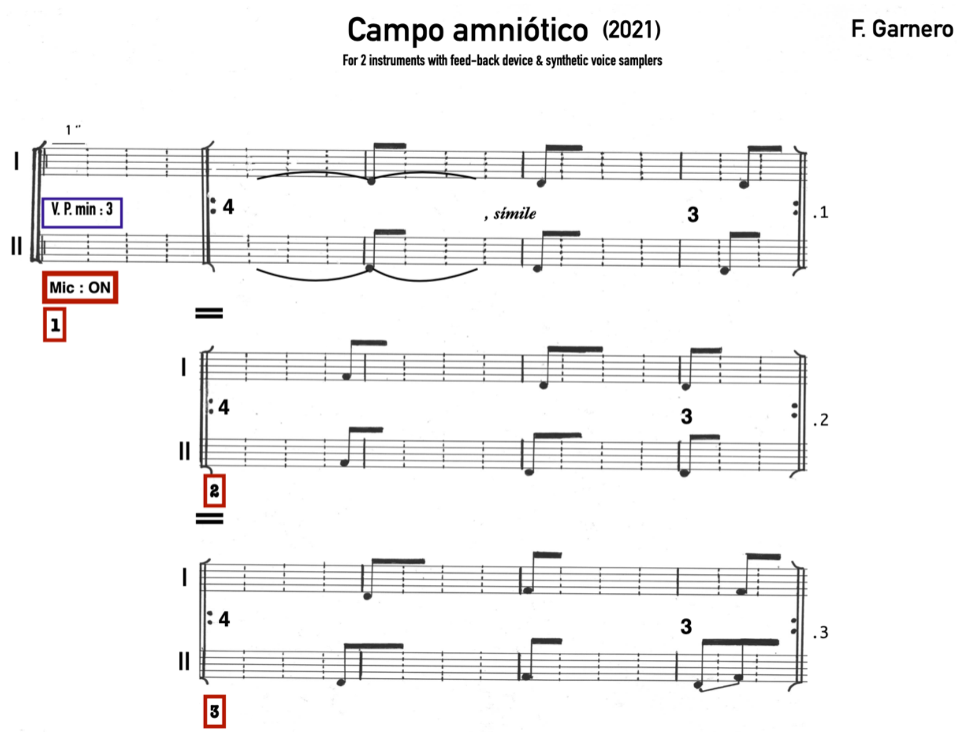

Figure 6.26, ***Campo amniótico (2021)***
Page 1of the unpublished score

Performing with the Unpredictable: Rewiring the Performer's Body

During the experimental stages of the compositional process, as well as in my discussions with the performers of *Campo amniotico,* a series of questions about the complex relationship between self-regulating feedback systems and the performers ' agency gradually emerged. These questions form the foundation for my future projects related to this subject:

What kind of agency could a performer have within a given self-regulated feedback system? In this context, how wide can the performers' margin of agency be? And how can we determine the role of the performers when they no longer embody the technologically enhanced human/musician who iteratively internalises the body's haptic and cognitive circuits into actions, codes, and protocols as represented in specialised new music performance?

Figure 6.27, *Campo amniótico*
Photo of Mauricio Carrasco and Rada Hadjikostova (from ensemble Vortex) during its rehearsal in 2022 at Villa Médicis

A central aspect of *Campo amniótico* lies in the conception of a dispositive that puts the interpreters in trouble, requiring from them a constant state of vigilance, deprived of their performative instrumental mastery, that must be replaced for an acute awareness of the environment. The reflexes developed through years of study must be reconfigured and transformed, engaging different parts of the body. Acquired knowledge should give way to a more situated and emergent understanding. Previously developed technical skills and sensorimotor prediction need to be recalibrated. According to researcher Mauricio Carrasco, who performed this work several times:

> Overwhelmed by the technological and environmental changes they face, in *Campo amniótico* the performers seek for autoethnographic confirmation, to reach of an affective embodiment (Wilde, 2020), between human and non-human, between the sounds we produce technologically assisted and the synthetic voices, with the composer, the audience and with the background and constitutive feedback. (Carrasco, forthcoming)

A Specular Form Encompassing an Opposition and Two Temporalities

In the case of *Campo amniótico*, the central act of composition transcends mere writing; it evolves into the conception of the dispositive and the feedback system. This shift emphasises the opposition between the inherently unpredictable nature of frequencies and latency of this negative feedback system —often resulting in a floating pulse—and the fixed timeline of the tape containing the voices. The work thus brings together two interacting musical temporalities: the fluctuating pulse of the instrumental Larsen tones and the chronometric temporality of fixed sounds. The mirror-like form—an arc expressing a symmetric process of accumulation and rarefaction—that encompasses this opposition remains secondary to the compositional process. As explained earlier, very few parameters enter into the symbolic field of the score in this work: five positions for each instrument (which do not guarantee five stable, recurring frequencies), and the rhythms of the dynamic envelopes produced by the pedals. The rhythms of the envelopes generated by the MIDI expression pedal at a local level, along with the arc shape—the global envelope—merely constitute the articulated foundation upon which the interaction between human, machine, and physical space unfolds.

In parallel, this arching form represents a singular manifestation of a compositional strategy oriented primarily toward arranging the density of contrasting sonic material: the emerging Larsen tones and the recorded audio files of voices. The number of Larsen tones and their duration increase in a cumulative process that culminates at the apex toward the middle of the work, then symmetrically undertakes a process of rarefaction until the end—a process doubled by a similar progression of ascending and then descending positions. The score deploys a specular form that also reflects this strategy, although this configuration operates only in the symbolic order, given the unpredictability of the resulting morphology of the Larsen tones.

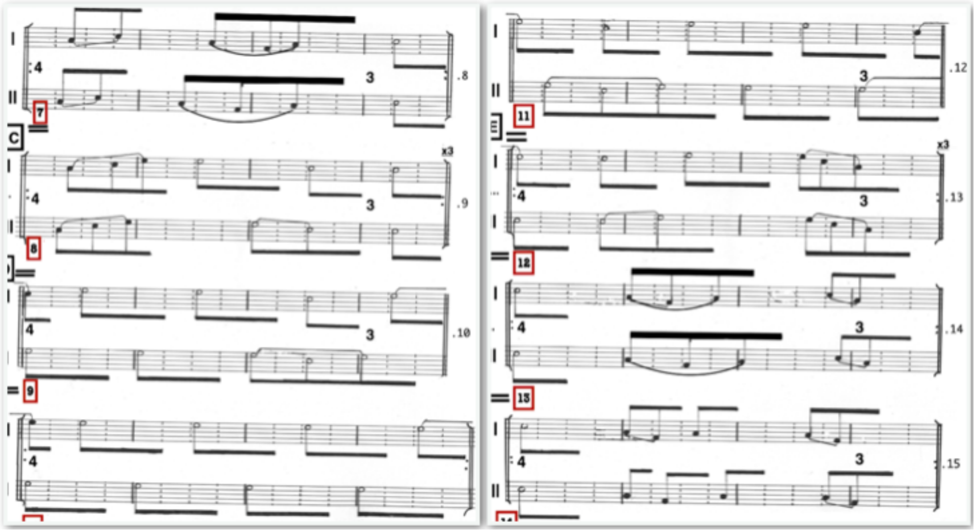

Figure 6.28, ***Campo amniótico (2021)***
Miniaturised reproduction of pp. 3 and 4 of the score. On this last page starts the mirroring procedure

An analogous process governs the distribution of the recorded voice audio files: the number of phrases and their duration increase almost linearly up to the apex and then decrease symmetrically until the end. However, their volume follows an inverse exponential process. At their climax, when the pedals afford them the greatest presence alongside the Larsen tones, their barely audible volume relegates them to a sonic background. A similar phenomenon occurs with the playback speed of the audio files with synthetic voices, which, within margins that consistently preserve their intelligibility, progressively accelerates up to their moment of greatest presence and then inversely decelerates until the end. The recorded synthetic voices thus transform their function in this symmetrical global process: they transition from being objects of temporal articulation with punctual appearances situated in the sonic foreground—beyond their actual volume—they become material of constant presence positioned in the background.

Composed Emergents: Sequencing Objects & Operations in the Patch

The Larsen tones that inhabit the work are sound objects whose changing morphological characteristics are the result of unpredictable factors integrated into the compositional process and precise compositional operations; they are composed emergents. If the score symbolises the operations on the Larsen tones (their duration, their dynamic envelope, the length of the tube mediating the feedback loop) and the respective instrumental actions required, the patch sequentially encapsulates the ring modulation operations on them and the diffusion of the audio files containing the recorded synthetic voices.

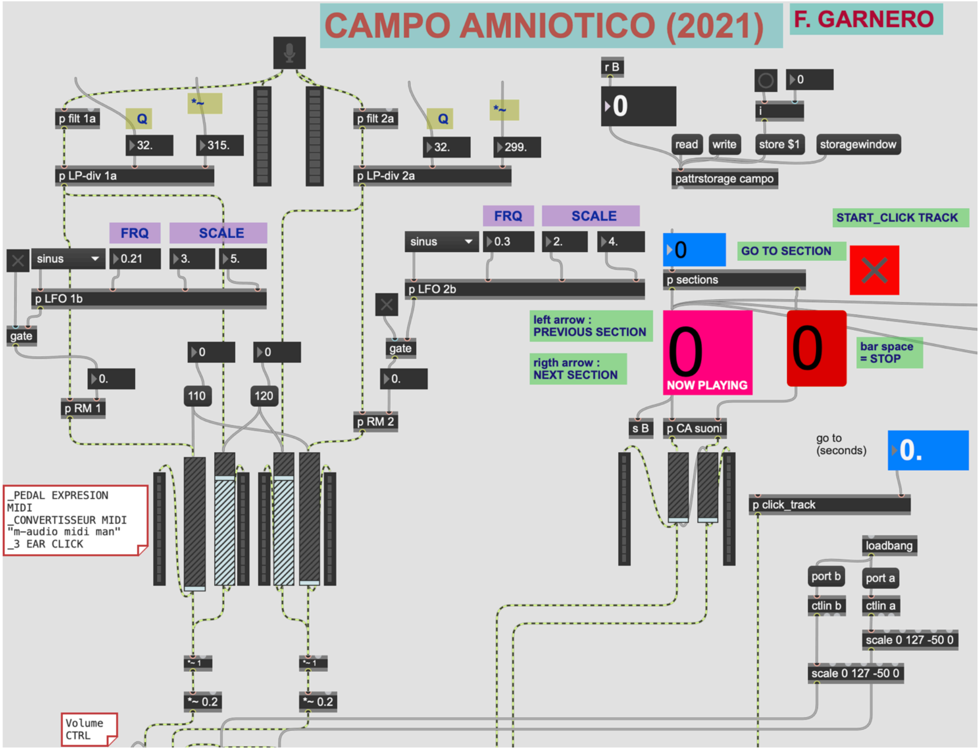

Figure 6.29, *Campo amniótico (2021)*
The first level of the patch for performing *Campo amniótico*

Both the local operations embodied in the score and those encapsulated in the patch follow the iterative form that articulates the musical time of *Campo amniótico* in similar-length repeated cycles. Within these loops resides the automated process that follows the specular form, articulated in successive operations that trigger the sound files and sequentially instantiate the process of acceleration and subsequent deceleration of the frequencies of the low-frequency oscillators governing the ring modulation. This process of changing the modulating signal frequency significantly impacts the timbre of the Larsen tones, which begin in their emergent form as a result of the negative feedback system, transition to slow beats that accelerate to produce sidebands in the form of glissandos, returning finally to their initial state. The selection of this audio processing technique as the sole real-time digital compositional operation responds to the observation of the rather recurrent phenomenon of beats in Larsen tones.

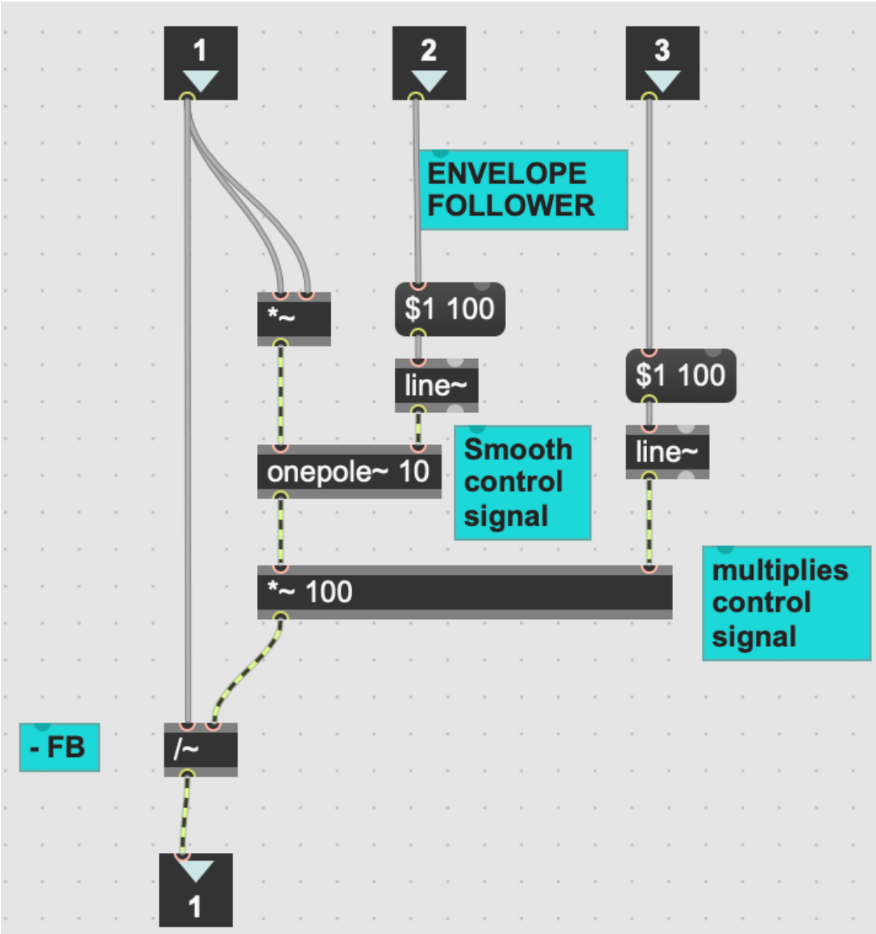

Figure 6.30, *Campo amniótico (2021)*
The module for feedback self-regulation within the patch for performing *Campo amniótico*

The final configuration of the negative feedback module that regulates the Larsen tones was completed with the invaluable assistance of composer and sound designer Andrea Agostini, following several personal tests that I found unsatisfactory. The incoming signal is monitored by an envelope follower every 100 milliseconds, with its raw amplitude smoothed by a unipolar low-pass filter. This procedure is repeated in parallel to increase the gain of the control signal by multiplying the two processes. The resulting signal is constantly divided by the frequency of the same incoming signal, which produces the homeostatic stabilisation of the system while performing a compressor-like function.

Summary

This chapter has examined the use of audio feedback—specifically Larsen tones—as a central tool for composing and performing within the composable. I have highlighted the various methodologies and artistic approaches that inform the integration of feedback into musical practice, drawing on a range of works that incorporate feedback systems. The discussion focused on technical configurations, artistic considerations, and the interplay between audio feedback systems and the performer's agency in creating compositions that use Larsen tones as musical material.

The importance of materiality in shaping the compositional process is one of the key findings of this research. Feedback systems, by their very nature, are deeply intertwined with the physical properties of the instruments, the acoustic environment, and the electronic devices used to generate and manipulate sound. This materiality not only influences the sonic output but also redefines the role of the performer, who must navigate the unpredictable and emergent nature of feedback. In works such as *Campo amniótico*, the performer's agency is reconfigured, requiring a heightened awareness of the environment and a shift from traditional instrumental mastery to a more situated and adaptive form of engagement.

The works discussed in this chapter illustrate the versatility of feedback as a musical resource, showcasing its capacity to generate emergent sonic textures and dynamic interactions between performers, instruments, and electronic systems. From the historical repertoire, which includes seminal works by John Cage, Alvin Lucier, and Nicolas Collins, to my own compositions such as *Fabulae* (2016), *Allegretto: Dynamogramme* (2019), and *Campo amniótico* (2021), feedback has been used in a variety of ways, challenging established notions of musical composition and performance. Each work describes a distinct approach to feedback, including the use of hybrid instruments, self-regulating or positive feedback systems, and unique conceptualisations of human performance. A common thread uniting these pieces is their exploration of the artistic potential of feedback systems, with each work utilising unique configurations and methods to integrate feedback into musical expression. Yet each has notable differences that emerge on closer inspection.

Collins' work *Pea Soup* uses a self-stabilising feedback network with nested positive and negative feedback. It employs phase shifting to emulate microphone movement and explores the resonant frequencies of architectural spaces.

The work of Michelangelo Lupone features a hybrid instrument, the Feed-Drum, which is a bass drum coupled with an electronic skin-conditioning system. Feedback is generated on the drum membrane and manipulated by the player.

Di Scipio's *Modes of Interference* employs a self-regulating audio feedback system with a non-linear coupling between a microphone and two speakers. A trumpet player interacts with the system, and digital signal processing is used to transform the feedback loop.

Mauricio Pauly's piece *Threshing Floor e*xplores Larsen tones as musical material within a positive audio feedback system. It involves amplified tenor saxophone and percussion, with both instruments generating Larsen tones through distinct methods.

Alternatively, my work *Fabulae* combines pre-recorded voices, on-screen text, and real-time animation with feedback. It employs Larsen tones within diverse positive feedback systems generated by electric guitar, bass clarinet, and a hybrid drum, the Feed-Tom.

In *Allegretto : Dynamogramme*, the amplified tenor saxophone functions both as a component of a hybrid instrument for Larsen tone generation (Feed-Sax) and as a conventionally amplified instrument. The feedback loop is mediated by the instrument's bore and DSP processing.

The works *Cada trozo/cada ganglio* and *Mutante* feature the Feed-Timpani, a hybrid instrument designed to generate Larsen tones. The system involves a positive audio feedback loop between a condenser microphone and loudspeakers, mediated by the timpani.

While *Campo amniótico* focuses on instrumental feedback within a self-regulating system. It employs a negative audio feedback loop and explores the use of the unpredictable morphology of Larsen tones as the primary sonic material.

Collectively, the works in this chapter illustrate feedback's transformative potential as a compositional resource. They show how feedback systems can be used to create dynamic and unpredictable sonic textures, where materiality, technology and human agency interact to produce particular forms of musical expression. It offers a fertile ground for experimentation, challenging us to rethink the relationship between sound, space and musical time in the composable, as feedback continues to be explored and reimagined in contemporary and experimental music.

Conclusion

Discussion

Composition as an Epistemic Act

This research has approached composition not as a fixed process of organising sound events, but as an open-ended, exploratory activity that functions as a site of knowledge production. The question that has guided this investigation—*how does composition function as an epistemic act?* —has been addressed through a constellation of artistic methods, theoretical engagements, and concrete works. What emerges from this investigation is an understanding of composition as a mode of inquiry in which knowledge is generated through material interactions, embodied gestures, technical experimentation, and recursive reflection.

As I have experienced and theorised, the compositional process often begins with uncertainty, with partial intuitions, and with tools or materials whose behaviour cannot be fully predicted. Rather than beginning with a fully formed idea to be realised through sound, composing becomes an epistemic activity because it operates in a space of not-knowing, hence understanding emerges through the act of making. Each artistic method—whether symbolic granulation, sonic translation, or the use of feedback systems—serves as a means of producing music and as a way of interrogating and uncovering the potentials of sound, gesture, technology, and perception.

In works such as *Mutante/Amniótica*, the integration of hybrid instruments within a multidimensional dispositive has foregrounded the idea that the compositional apparatus is rather than a neutral conduit, a co-constitutive element in the emergence of musical thought. Similarly, in *Les sons ne sont pas des hommes*, the site-specific dispositive becomes an epistemic agent that shapes the sonic material and the conditions under which it is perceived. In both cases, the composable space is not a passive container but an active framework within which relationships—between performer and system, environment and listener, sound and structure—are continuously renegotiated.

The epistemic dimension of composition is thus inseparable from the material, technological, and spatial contexts in which it unfolds. This resonates with Hans-Jörg Rheinberger's notion of the experimental system, where knowledge is not the result of a linear process; instead, it emerges from iterative encounters with material resistance and conceptual openness. In my work, the composable behaves in a similar way: it is a space where technical objects, epistemic things, aesthetic decisions, and performative gestures intersect and produce new insights—not always in a planned or hierarchical manner, but often through unexpected resonances.

Furthermore, this research has shown that composition generates knowledge not only about sound, as well as about listening, context, and subjectivity. In *Trans-étude #4: Intérieur/Extérieur* and *Neon Frog*, sonic translation becomes a way of exploring how meaning is constructed and deconstructed in the auditory realm. These works do not simply reflect the world; they transform it through sound, proposing listening as a critical and speculative mode of engagement. Here, composition enacts a form of epistemic friction—bringing together the symbolic and the material, the abstract and the referential, in a process that resists resolution.

Ultimately, the findings of this research suggest that composition functions as an epistemic act when it is understood as a recursive and material practice—one that does not simply express knowledge but produces it through the entanglement of thinking, making, and listening. It is precisely through the very uncertainties and instabilities of the composable space that musical understanding emerges not as a set of fixed answers, rather as an evolving set of questions, propositions, and forms of awareness.

Composition, then, is not just about shaping sound—it is about shaping thought through sound. It is a way of discovering what music can be and what it can do: how it can make visible (or audible) the structures of experience, the politics of perception, and the potentials of imagination. In this light, the composable is not simply a place where music happens—it is a space where knowledge is enacted, challenged, and continually redefined.

The Composable as a Dynamic Space

The shift from seeing the composable as a framework or system to understanding it as an evolving space—unstable, porous and continually redefined by practice—has been one of the central outcomes of this research. This rethinking has profoundly influenced how I conceive, construct, and reflect on my compositional work. Rather than treating composition as the application of methods within a pre-established structure, I have come to understand each work as a singular negotiation between tools, contexts, materials, and concepts—a process in which the composable itself takes form.

By abandoning the idea of the composable as a fixed container, I have been able to open up my practice to forms of instability and emergence. In *Campo amniótico*, for instance, the feedback system functions not as a linear instrument to be controlled, but as a living ecology whose behaviour continuously modifies the performer's role, listening strategies, and the sound material itself. What unfolds among multiple forces—technical, physical, performative, and spatial—is what constitutes the composable here, rather than the score or the dispositive.

This evolving understanding has also allowed me to think compositionally across and beyond the work itself. In *Mutante/Amniótica* and *Contraccolpo*, the hybrid instruments developed for each piece are not just tools but propositions, material constructs that invite new kinds of sonic thinking. They reflect a mutated composable space in which the apparatus is no longer secondary to musical content but constitutive of it. The space of composition thus includes design, gesture, feedback, error, and even the contingency of the environment.

Recognising the composable as evolving has also influenced my relationship with artistic methods. Approaches such as symbolic granulation or sonic translation are not applied as fixed models but are revisited, reconfigured, and sometimes contradicted from one project to the next. Each method unfolds differently depending on the work's context, collaborators, and materials. This flexibility fosters a form of recursive experimentation in which knowledge is not extracted from the work but generated within it—through friction, resonance, and revision.

In *Les sons ne sont pas des hommes*, the composable extends beyond the sound diffusion system to encompass the site itself—the vineyard—along with the ambient conditions and the position of the listener. It becomes clear that the composable is not an isolated entity: it is a space of entanglement—between sound and place, composition and installation, listening and inhabiting. The composable evolves not only from project to project but within the work itself, resisting closure nor standardisation.

Such an understanding of the composable has implications beyond the individual piece. It transforms composition into an inquiry—into the conditions that make a work possible, into the knowledge that is produced through making, and into the multiplicity of interactions that define what a piece is or can be. Each work becomes a site where the composable is not implemented but constructed, not defined but discovered. It is through this process of construction—always singular, always situated—that the composable reveals its epistemic and aesthetic force.

In this light, the composable is not simply a theoretical concept; rather, it is a way of practising: a lens through which composition can be understood as a dynamic, embodied, and reflexive space. One that accommodates instability, divergence, and emergence, and that allows each work to unfold its own logic—its own version of what it means to compose.

Mutations in the Composable Through the Exploration of Artistic Methods

The exploration of specific methods—multidimensional dispositives, sonic translation, feedback systems, and symbolic granulation—has played a central role in revealing how the compositional space is not static but subject to constant mutation and expansion. Rather than being simply technical approaches or stylistic tools, these methods have functioned as *epistemic things,* each offering a different angle through which to observe and engage with the evolving nature of the composable. These methods do not operate in isolation, nor do they apply uniformly from one piece to the next. Rather, they form a shifting constellation of techniques, gestures, and conceptual strategies that respond to the context, medium, and material of each work.

Working with multidimensional dispositives has allowed me to think of compositional space as something distributed—across bodies, objects, loudspeakers, and architectures. These setups—acoustic objects coupled with transducers, microphones, and electronic systems—have challenged traditional distinctions between source, processing, and diffusion. Works such as *Contraccolpo*, *Campo amniótico*, and *Mutante/Amniótica* demonstrate how hybrid dispositives can generate a compositional space that is not only sonic but also physical, responsive, and unstable. Here, the composable becomes a space of encounter—between gesture and resistance, signal and resonance—shaped by the particularities of bodies, instruments, and architectures. In *Les sons ne sont pas des hommes*, for example, the vineyard setting, the Ambisonic system, the spatial diffusion, and the site-specific recordings do not serve a central compositional idea but become compositional forces in themselves. The dispositive emerges as a network, a physical and conceptual field through which sound is articulated, perceived, and transformed. This approach has shown how compositional space can extend beyond the confines of the score or the studio—becoming relational, environmental, and performative.

Sonic translation is a central methodology, an approach in which extramusical material (speech, environmental sounds, animal calls, field recordings) is reinterpreted or re-situated through composition. In sonic translation, the composable space is expanded through the encounter between sound and external phenomena—images, gestures, texts, memories. In works such as *Trans-étude #4: Intérieur/Extérieur* or *Neon Frog*, translation is not about faithful representation, but about friction and reinterpretation: how sounds derived from the world (urban environments, sirens, satellite signals) can be transfigured through compositional processes. These transformations reveal the permeability of the composable space, its capacity to absorb non-musical material and rearticulate it through sound. This has provided a deeper understanding of how meaning, context, and listening can co-inhabit and reconfigure the compositional terrain. Sonic translation reframes the composable by introducing meaning-laden materials that resist neutrality, compelling the space to accommodate ambiguity, memory, and context. Rather than stabilising, this practice invites slippage—between source and imitation, between signal and symbol.

The engagement with feedback systems, especially in *Campo amniótico*, has drawn attention to the unpredictable dimension of compositional processes. Feedback resists full control, requiring negotiation, adjustment, and embodied presence in response to an unpredictable field of interaction. These systems generate unstable sonic environments in which the performer's actions become part of a self-regulating circuit. Working with feedback has taught me to compose with instability, and to treat the compositional space as a system in motion—responsive, fragile, and contingent. The feedback loop produces a composable space that is constantly shifting, where form is not inscribed in advance but emerges from a live, embodied dialogue with the apparatus and with dynamic systems that evolve in real-time.

Symbolic granulation—a strategy of decomposing and recomposing notated material using granular principles—has provided a framework for thinking about time, scale, and structure as emergent rather than predetermined. By applying granular logic to notated material, as in *Mutante/Amniótica* or *Neon Frog*, I have explored how micro-units of musical information can generate complex temporal architectures through iteration, filtering, and transformation. Operating at both structural and micro-articulatory levels, this method has revealed how compositional space can unfold across layers, where detail and form co-emerge through recursive manipulation. Rather than imposing hierarchical organisation, symbolic granulation activates the composable space through the internal behaviour of figures—how they circulate, mutate, accumulate, and dissolve. It proposes a view of time as fluid, multi-scalar, and stratified, where meso- and macrostructures are not designed from above but emerge from the dynamic interplay of smaller elements.

Finally, I would like to point to the development of phono-biographical approaches that have begun to take shape in works engaging with voice, memory, and testimony. This method—still in its early stages—introduces a personal and historical dimension that expands the composable space beyond its formal or sonic constraints. By working with archival recordings, site-specific ambiences, or spoken voices tied to lived histories, the composable becomes a vessel for fragmentation, for resonance with the past, for the staging of absence. The space no longer serves only sonic exploration; it becomes a space of ethical, cultural, and affective density.

Across these different methods, it becomes clear is that the composable space is never singular. It mutates according to the material conditions, the methods employed, the questions asked, and the listening situations imagined. These methods have shown that composition is not about stabilising a space, but about creating the conditions for it to become—stretching its boundaries, unsettling its definitions, and allowing it to be reshaped by every new engagement. Each project has not only produced a musical work but has also redrawn the contours of what the composable can become.

In this sense, method and space are not separate: the very use of these methods performs the mutations and the expansion of the composable space. They do not simply fill the space with content; they change its scale, its internal logic, and its epistemic and aesthetic possibilities. The composable is thus understood as mutable precisely because these methods activate it—not as a container, but as a zone of tension, emergence, and articulation. Taken together, these methods do not merely populate the composable space—they transform it. They complicate its boundaries, introduce new epistemic pressures, and invite the composer to navigate spaces that are provisional, layered, and resistant to closure. Each method brings with it not only sonic consequences, but new conditions for thought. Over time, their cumulative effect has been to expand the very notion of composition—from a discipline of structuring sound to a practice of constructing environments for listening, experimentation, and reflection. The composable, in this view, is not simply a space in which music happens—it is a space that is itself shaped, stretched, and sometimes undone by the methods through which the work is made.

Articulations Oriented Toward Futures

Prospects for Future Experimentation

This final section outlines possible directions for future experimentation in my compositional practice, building on methods already employed such as instrumental feedback, multidimensional dispositives and hybrid instruments, granular strategies, sonic translation, and open-data composition. These areas remain fertile ground for further investigation—particularly in the refinement of self-regulated feedback systems, the integration of sonic environments, and the development of sound installations and video-based works. Alongside these ongoing investigations, I would also like to imagine and begin to shape new methodological perspectives. In particular, the concept of *sonic realism* offers a framework for engaging sound's referential and contextual weight, while *sonic materialism* continues to inform my work through its emphasis on immanence, instability, and material agency. In parallel, I envision the development of a *phono-biographical* method, a compositional approach that foregrounds memory, voice, and fragmented personal or collective histories through sonic practice. These methods, whether already underway or still in formation, form a constellation of tools and perspectives through which I seek to expand the epistemic and expressive potential of the composable space.

Sonic Materialism

Sonic materialism is an emerging artistic method in contemporary and experimental music that treats sound not as a symbol or expression but as a material force that is active, relational, and shaped by its interaction with space, time, and technology. Drawing on post-humanist and new materialist epistemologies, this approach moves away from symbolic or narrative-driven composition and instead focuses on the physical behaviours of sound—its texture, resonance, instability, and capacity to evolve.

In practice, this means working with processes such as feedback, granular synthesis, or spatial diffusion not to illustrate ideas but to engage directly with the dynamics of sound itself. The composer becomes a listener and facilitator, navigating a field of sonic intensities where meaning emerges through interaction rather than predefinition. Composition becomes a space of negotiation, between body and machine, performer and environment, where form is not imposed but discovered.

In my own work, this perspective takes shape through what I call Sonic Translation. While sonic materialism often sees sound as a pre-linguistic flux, I'm interested in how sound can carry traces of context—voices, places, environments—and still resist stable meaning. My works, such as *Trans-étude #4: Intérieur/Extérieur* and *Neon Frog*, engage with recorded sounds not to represent the world but to reshape and re-situate it through compositional experimentation. These translations are not imitations, but transformations—ways of making audible the tensions between reference and abstraction.

Rather than contradicting sonic materialism, Sonic Translation extends it. It builds compositional situations in which sound is both shaped and shaping—a medium that carries history, presence, and instability all at once. This approach is in dialogue with Salomé Voegelin's (2019) *arche-sonic*, Christoph Cox's (2011) *sonic flux*, and Marcel Cobussen's (2022) *auditory ontoepistemology*. What unites these perspectives—and what my own practice seeks to develop—is a way of thinking through sound itself: not as something to be decoded, but as something that generates meaning through its resistance, its friction, and its unfolding in time.

Sonic Realism

Sonic realism is an emerging artistic method in contemporary and experimental music that treats sound as a meaningful and situated material, capable of carrying memory, context, and cultural weight. Rather than using sound as a neutral or abstract form, this approach works with real-world sources such as field recordings, voices, or environmental sounds, not for their acoustic properties alone, but for how they reference and intervene in broader social, ecological, or political discourses.

This method builds on Christoph Cox's (2011 and 2018) argument for a sonic realism that sees sound as embedded in the world—external, perceptual, and material—rather than something reduced to mental representation. Freeing sound from visual and linguistic models allows us to engage with it as a way of knowing and encountering reality through listening.

Unlike documentary or narrative strategies, sonic realism does not seek linearity or coherence. It explores how sound can shift between recognisability and abstraction, revealing the complexity of the real rather than simplifying it. Works such as Joanna Bailie's *Trains* or Carola Bauckholt's *Doppelbelichtung* make this tension audible—layering recorded and instrumental sound to blur the line between imitation and transformation.

In my own work, such as *Trans-étude #4: Intérieur/Extérieur* and *Neon Frog*, I explore this space of ambiguity. Urban and natural sounds are reworked into instrumental and electronic textures that resist clear identification. These pieces invite critical listening, asking not only what is being heard but how sound constructs and distorts meaning.

While sonic realism shares some common ground with sonic materialism, their emphases differ. Sonic materialism focuses on the physical behaviour of sound—its grain, force, and affective intensity—often detaching it from meaning or reference. Sonic realism, by contrast, maintains the tension between sound as material and sound as sign, embracing its power to signify, disrupt, and reframe experience.

In my compositional practice, I see these two methods not as opposites but as complementary. Within the composable space, they converge—producing works in which the meaning and materiality of sound interact, collide, and transform. This space becomes not only a site of artistic production, but also one of epistemic and aesthetic exploration, where listening becomes a way of critically, reflectively and imaginatively engaging with the world.

Phono-biographical Method

The phono-biographical is an artistic method that I am in the process of imagining—an emergent perspective that I intend to explore more fully in future work. It arises from a desire to engage with sound at the intersection of memory, identity, and storytelling—not through established narrative forms, but through the layering, distortion, and transformation of sonic traces that are biographically or historically charged. I envision this approach as one in which spoken testimonies, archival recordings, oral histories, domestic ambiences, or site-specific sonic residues serve not simply as material but as epistemic agents—as carriers of symbolic weight, cultural intimacy, and embodied knowledge.

Instead of producing linear biographies or documentary representations, phono-biographical compositions would propose spaces where fragments of lived experience circulate and resonate, where the instability of memory, the ambiguity of voice, and the porosity between fact and fiction are not problems to be solved but tensions to be activated. Rather than illustrating life stories, the aim is to invite listening into the affective and epistemic dimensions of personal and collective histories—where sound evokes presence and absence, rupture and continuity, belonging and dislocation.

This future method would align itself with artistic practices that foreground subjectivity, migration, and cultural hybridity—fields in which sonic material is not only expressive but also politically and historically charged. In this imagined framework, the voice is often central—not as the expressive outlet of a unified self but as a discursive and sonic phenomenon through which identities are enacted, questioned, and displaced. In this sense, sound is less a window into the past than a medium of reactivation—one that reshapes how memory is embodied, transmitted, and heard.

Although not yet fully formulated as a method, the phono-biographical has already emerged in my practice as a latent impulse—a recurring mode of articulation that surfaces when I use sound to engage with the layered, fractured textures of cultural inheritance and personal history. What I hope to develop further is a compositional logic that does not seek coherence or completeness but embraces the fragmentary, the contingent, and the intimate. Rather than being declared, subjectivity in this imagined method is sounded—dispersed across gestures, textures, and resonances that invite new ways of listening to the past, and new spaces for critical and poetic engagement in the present.

As this phono-biographical method continues to take shape, I anticipate that it will become a vital thread within a broader inquiry into how sound mediates the construction, fragmentation, and transmission of subjectivities. Future research is likely to deepen this line of investigation through interdisciplinary dialogues—with archival studies, oral history, postcolonial theory, and psychoacoustics—while remaining grounded in compositional practice. Rather than static portraits, I envision these works as dynamic dispositives that reframe biography through sonic thinking. The phono-biographical thus opens a way of composing with and through memory—not to preserve the past but to listen to its ruptures, inhabit its echoes, and imagine its possible futures.

Perspectives for Future Creative Work

Over the next few years, I will be engaged in a series of creative projects of various kinds, through which I intend to extend my experimentation with various subjects, methods, and techniques of interest; to explore areas I have not yet had the opportunity to address; and to establish a framework within which new enquiries can emerge. Some of these projects are already confirmed, others are in the preliminary stages awaiting confirmation, and some are just beginning to take shape.

Among the confirmed projects are:

- ***With Oscar and Jeannine Wiggli*** **(2025)** collective work for six performers, amplified metal sculpture, amplified metal pieces, a portative organ developed by Oscar Wiggli himself, electronics, and video.
- ***Memoria de pajarito*** **(2025/26).** For four instruments and electronics.
- ***Vera*** **(2026/27)** For five instruments and electronics.
- ***Matter of scale*** **(2026/-).** Studies for piano and electronics.
- ***New work*** **(2027/28).** Large ensemble, video, and electronics.

The works that are in the preliminary stage are as follows:

- ***Les sons ne sont pas des hommes II*** **(2028).** Site-specific sound installation in the vineyard of the Villa Médicis. For a self-regulated digital audio system, 4 Microphones, 140 piezos, and four speakers.
- ***Facial tracking studies*** **(2028/2029).** For one performer, live-video and live-electronics. Facial tracking technology for generating, controlling, and manipulating both audio and video signals.
- ***New work*** **(2029)** For electronics. GPS data from Geneva's public bus network (TPG – Transports publics genevois) to generate, control, and manipulate audio signals.
- ***Trans-étude #5*** **(2029/30)** For large orchestra.

The projects that I am just beginning to think about are the following:

- ***Contraccolpo II*** For four Filter-Saxophones and electronics.
- ***Contraccolpo III*** For four hybrid percussion instruments and electronics.
- ***Campo amniótico II*** Four hybrid instruments, self-regulated feedback system and pre-recorded voices.

Final Thoughts

A Space in Constant Becoming

One of the most significant lessons of this research was learning to observe—and ultimately embrace—the composable as a space in constant mutation. What began as a concept drawn from theory became, through practice, an operative reality: a way of thinking, composing, and listening. Over the years, through successive projects and recursive enquiries, the composable ceased to be a background structure and emerged as the very terrain on which composition happens—not as a static stage but as a shifting ecology of relations.

At the beginning of this research, I often approached composable spaces as if they were latent frameworks waiting to be activated through specific configurations of tools, sounds, and techniques. My early interest in multidimensional dispositives and hybrid instruments stemmed from this impulse to construct systems within which sound could be shaped. In *Mutante/Amniótica* and *Contraccolpo*, for example, the composable space was structured around the material agency of hybrid instruments—an interplay of instrument and apparatus that opened up new territories for sonic behaviour and gestural interaction.

As the work progressed, a shift began to occur. The composable began to appear not as a system to be built or controlled, but as a contingent field that unfolded in the very act of composing. Feedback systems, such as those explored in *Campo amniótico*, played a crucial role in this shift. They introduced instability and unpredictability at the core of the work, requiring not only technical adjustments but a rethinking of the compositional gesture itself. The composable was no longer a stable container but a responsive system—fragile, reactive, and situated.

This transformation was already evident in a project such as *Les sons ne sont pas des hommes* and continued in *Trans-étude #4*, where sonic translation and spatialisation were not merely means of diffusion or representation but became the very conditions through which compositional space was constructed. These works illustrated a mutation of the composable from the material to the relational, from structure to entanglement. The site, the performer, the recording, and the listener—all became active agents within a compositional field that could no longer be fixed in advance.

This mutation is not linear, nor does it resolve into a single model. It is better understood as an iterative deepening: with each work, the composable redefines itself. In some cases, it is architectural and immersive; in others, intimate and textual; in still others, performative and unstable. The diversity of methods—symbolic granulation, sonic translation, audio feedback—has not fragmented the composable, but revealed its multiplicity. Each method acts as a lens, magnifying one layer of the composable while reshaping others.

Looking back, I have learnt that the composable mutates not only through aesthetic or technical choices but also through the questions the work allows me to ask. The research process has become a way to inhabit these questions, allowing the composable to be interrogated, stretched, or even momentarily suspended. The space of composition, then, is never given—it is built through action, doubt, and listening.

These mutations are visible in the works themselves—not as stylistic evolution, but as shifts in how space is occupied, how sound is distributed, and how meaning is produced. From structured hybridity to sonic ecosystems, from translation to the erosion of representation, the composable has become more porous, more relational, and more epistemically charged. What I have found is that to compose is not just to organise sound but also to construct the conditions in which sonic thought can unfold.

In this sense, the composable is less a space I enter than one I continuously remake—each work leaving traces that open new paths, expose tensions, or suggest other ways of listening. The mutation of the composable, traced across this research, is not an outcome to be fixed but a condition to be sustained: a space where thinking and making remain entangled and where each composition is an attempt to question once again what it means to compose.

Composing Through Epistemic and Methodological Tension

Throughout this research, I have come to understand that the mutation of the composable is not simply a matter of aesthetic evolution or technical refinement—it is fundamentally shaped by epistemic and methodological tensions. It is within these tensions—between abstraction and materiality, between concept and practice, and between control and contingency—that the composable space transforms itself, taking shape not as a stable foundation but as a moving ground that adapts, resists, and reconfigures itself through the process of composition.

Rather than seeking to resolve or synthesise these tensions, my work has gradually learnt to inhabit them. Each compositional method explored in this research—symbolic granulation, sonic translation, feedback systems, multidimensional dispositives—carries its own internal logic, temporal sensitivity, and technical vocabulary. They do not align neatly; they produce overlapping, sometimes contradictory demands on the compositional process. But it is precisely this friction that animates the space of the composable. Rather than a field of fixed methods, it becomes one of coexisting intensities and shifting relations.

In this context, compositional choices are rarely the direct application of theory. Instead, they emerge from the encounter between abstract frameworks and the resistant, unpredictable behaviour of sound, gesture, and device. The composable becomes a space where methods are not simply tools but questions in action—

unstable, revisable, and contingent on the unfolding dynamics of each work. Instead of being illustrated, knowledge is produced through listening, failure, negotiation, and doing.

Over time, I have come to see that these tensions are not obstacles to be overcome but productive conditions that activate the work. They provoke mutation, preventing the composable from hardening into formula or habit. Each tension opens up a potential line of flight, a disruption that allows something unexpected to emerge. In this sense, the composable is a space not solely for composing sound but equally for composing thought—capable of holding complexity, contradiction, and transformation without reducing them.

What I have learnt, finally, is that composition—understood as both an artistic and epistemic act—flourishes not in certainty but in negotiation. The composable, as it has emerged in this research, is not a resolved entity but a shifting and responsive site: open to instability, exposed to difference, and capable of absorbing—and being reshaped by—the very tensions that move through it. To compose, in this light, is to linger with these tensions long enough for something new to happen.

From Concept to Condition: Tracing the Composable

Over the course of this research, my understanding of the composable has shifted from a conceptual notion into a lived, operative space—one that is no longer simply thought about but inhabited, constructed, and transformed through practice. Initially, I understood the composable largely through theoretical frameworks: as a spatial and temporal zone shaped by interactions between technical systems, sonic materials, and symbolic structures. It offered a powerful metaphor to frame composition as a site of articulation rather than as a product of fixed parameters.

Through the process of composing, experimenting, failing, collaborating, and listening differently, the composable revealed itself not as a stable or predefined space, but as a mutable and often unpredictable one. I learnt that the composable is never truly given—it emerges in real time, shaped by the tensions between methods and materials, ideas and actions, expectations and accidents. Each work not only brought new insights but also forced me to rethink old assumptions, shifting the concept of the composable from a tool of analysis to a condition of practice.

From this evolving relationship, I have gained a form of knowledge that is not easily reducible to theory. It is experiential, recursive, and grounded in the specificity of artistic practice. I have learnt that methods do not provide answers but orientations—and that compositional knowledge often emerges not from clarity but from dissonance, negotiation, and unresolved complexity. This understanding has deepened my ability to think through sound, listen through form, and reflect through making.

For me, this research has clarified a compositional ethos: one that is not based on control but on attention—on the ability to hold space for emergence, contradiction, and multiplicity. It has taught me to trust the process, to work with instability, and to recognise knowledge not as something to apply but as something to be generated in motion.

Particularly for composers, performers, researchers, and artists working in experimental or hybrid fields, I hope this work offers both a conceptual vocabulary and a set of situated examples that illustrate how artistic practice can become a mode of inquiry. The composable, as it has unfolded here, might serve not as a model to follow but as a space to enter: a way of framing composition as an epistemic and experimental terrain, open to methodological invention and critical reflection. In that sense, the composable is not just mine—it is a shared, evolving space that invites further exploration, transformation, and reflection.

Rethinking Composition

Throughout the process of this research, my understanding of music composition has undergone a profound transformation. What began as a practice centred on organising sound within a given structure has gradually evolved into a broader, more open-ended engagement with composition as a space of inquiry—one that is both epistemic and material, conceptual and embodied.

Early in this research, I still held on to a relatively stable view of what composing meant: a careful shaping of form, gesture, and technique, often guided by predetermined intentions or stylistic orientations. But the sustained encounter with compositional methods such as symbolic granulation, sonic translation, feedback systems, and multidimensional dispositives challenged this view. These approaches do not lend themselves to closure or predictability—they resist being reduced to tools and instead function as dynamic systems, each with its own logic, instabilities, and demands.

I came to understand that composing is not simply about making decisions or crafting forms but about creating the very conditions in which those decisions and forms can emerge. It is an activity that unfolds in dialogue with its own materials, with its technologies, with listening, and with the specific constraints of each work. Composition for me has become less about imposing structure and more about navigating relationships—between sound and space, method and intuition, structure and process.

I also realised that composition is not just a technical practice but a way of producing knowledge: situated, unstable, and often implicit. It is a mode of thinking that happens through doing, through the recursive loop of making and reflecting. This has shifted my focus from what a piece should be to what a piece can ask, reveal, or question. In this sense, composing is no longer the act of giving shape to something already conceived but the unfolding of thought in sound.

This change has affected not only how I compose but also how I listen, how I collaborate, and how I situate myself in relation to my work. I now see each composition less as an object and more as a space—singular, contingent, and alive—where ideas, gestures, and material forces meet. The role of the composer, then, is not to control that space but to keep it open, to listen within it, and to allow the work to become what it needs to be.

In this sense, the research has not only changed the way I think about composition—it has changed how I compose. And this change continues.

References

Ablinger, P. (2005*). Phonorealism. The Reproduction of "Phonographs" by Instruments.* Retrieved from https://ablinger.mur.at/phonorealism.html

Agamben, G. (2010). *La potenza del pensiero*. Neri Pozza.

Akrich, M., Callon, M., & Latour, B. (2006). *Sociologie de la traduction : Textes fondateurs.* École des Mines.

Anderson, V., Bippus, E., Borgdorff, H., Crispin D. M., De Assis, P., Giudici, P., Peters P., Rheinberger, H.-J., Rickli, H., Schwab, M., Scrivener, S., Stallschus, S., Witzgall, S., & White, N. (2013). *Experimental Systems: Future Knowledge in Artistic Research* (M. Schwab, Ed.). Leuven University Press.

Ashby, W. R. (1956). *An introduction to cybernetics*. Chapman & Hall.

Bachelard, G. (1953). *Le Matérialisme rationnel*. Presses Universitaires de France.

Bachelard, G. (1966). *La Philosophie du Non* (4th ed.). Presses Universitaires de France.

Bachelard, G. (1971). *Epistémologie.* Presses Universitaires de France.

Bailie, J. (2017). *Transcribing Reality: how the nature of audio and visual media have affected culture, perception, and the role of the artist.* [Doctoral Dissertation. City, University of London] *Open access*. https://openaccess.city.ac.uk/id/eprint/20257/

Baker, D. (2011). Queering practice-led research: Subjectivity, performative research and the creative arts. *Creative Industries Journal, 4*(1), 33–51. https://doi.org/10.1386/cij.4.1.33_1

Barthes, R. (1964). Éléments de sémiologie. *Communications, 4*, 91–135. Éditions du Seuil.

Bauckholt, C. (2011). *Programme note of Lichtung* [Unpublished manuscript].

Bauckholt, C. (2012). *Programme note of Zugvögel*. Retrieved from https://www.wisemusicclassical.com/work/64656/Zugvogel--Carola-Bauckholt/

Bauckholt, C. (2016). *Programme note of Doppelbelichtung*. Retrieved from https://www.wisemusicclassical.com/work/64319/Doppelbelichtung--Carola-Bauckholt/

Bechtel, W., & Richardson, R. (1993). *Discovering Complexity: Decomposition and Localization as Strategies in Scientific Research*. Princeton University Press.

Benjamin, W. (2012). *L'œuvre d'art à l'époque de sa reproductibilité technique* (M. de Gandillac, Trans.). Folio. (Original work published 1936)

Berlant, L. (2011). *Cruel Optimism*. Duke University Press.

Bernal, A. (2024). *Fuera de tono.* EdictOràlia Música.

Berque, A. (1993). *Médiance. De milieux en paysages.* Reclus.

Bonnardi, A., & Sivinski, J. (2015). Vers une théorie de la composition musicale numérique fondée sur des réseaux d'objets. *Journées d'Informatique Musicale.* http://jim.afimasso.org/jim2015/actes/JIM15_Svidzinski_J_et_al.pdf

Borgdorff, H. (2011). The Production of Knowledge in Artistic Research. In M. Biggs, & H. Karlsson (Eds.), *The Routledge Companion to Research in the Arts* (pp. 44–63). Routledge.

Borgdorff, H. (2013). Artistic Practices and Epistemic Things. In M. Schwab (Ed.), *Experimental Systems, Future Knowledge in Artistic Research* (pp. 112–120). Leuven University Press.

Boude, D., Keogh, R., & Walker, D. (1985). *Reflection: Turning Experience into Learning.* Kogan Page.

Budon, O. (2006). Composer avec des objets, réseaux et échelles temporelles : une Interview avec Horacio Vaggione. In M. Solomos (Ed.), *Espaces composables : essais sur la musique et la pensée musicale d'Horacio Vaggione* (pp. 101–120). L'Harmattan.

Budon, O., Criton, P., Di Scipio, A., Justel, E., Laliberté, M., Mead, P., Méfano, P., Risset, J.-C., Roads, C., Rubio, H., Sédès, A., Solomos, M., Soulez, A., & Vaggione, H. (2006) *Espaces composables : essais sur la musique et la pensée musicale d'Horacio Vaggione.* L'Harmattan.

Campbell, I. (2020). Sound's Matter: 'Deleuzian Sound Studies 'and the Problems of Sonic Materialism. *Contemporary Music Review 39*(5), 618-637. https://doi.org/10.1080/07494467.2020.1852804

Carrasco, M., & Garnero F. (2023). Midnight Reflections about Our Own Northern Ventriloquist's Skills. *Performance Philosophy 8*(1):101-10. https://doi.org/10.21476/PP.2023.81399

Cobussen, M. (2022). The Sonic turn: Toward a sounding Sonic Materialism. *New Sound International Journal of Music 60* (II), 11–24. https://doi.org/10.5937/newso2260011C

Coello Rodriguez, P. (2021). *Sax-feed. Saxofón como controlador de realimentación acústica.* [Master's dissertation, Universidad Nacional de La Rioja].

Collins, N. (2020). *Improvising with Architecture - Pea Soup and Related Work with Audio Feedback*. Retrieved from https://www.nicolascollins.com/aboutpeasoup.htm

Cox, C. (2011). Beyond Representation and Signification: Toward a Sonic Materialism. *Journal of Visual Culture 10* (2), 145–161. https://doi.org/10.1177/1470412911402880

Cox, C. (2018). Sonic Realism and Auditory Culture: A Reply to Marie Thompson and Annie Goh. *Parallax 24*(2), 234–242. https://doi.org/10.1080/13534645.2018.1452448

De Assis, P. (2013). Epistemic Complexity and Experimental Systems in Music Performance. In M. Schwab (Ed.), *Experimental Systems, Future Knowledge in Artistic Research* (pp. 151–165). Leuven University Press.

Deleuze, G. (1968). *Différence et répétition.* Presses Universitaires de France.

Di Scipio, A. (1994). Formal Processes of Timbre Composition. Challenging the Dualistic Paradigm of Computer Music. *International Computer Music Conference Proceedings* (pp. 202–208). International Computer Music Association.

Di Scipio, A. (1998). Compositional Models in Xenakis Electroacoustic Music. *Perspectives of new music 36*(2), 201–243.

Di Scipio, A. (2006). Using PD for Live Interactions in Sound. An Exploratory Approach. *International Computer Music Conference Proceedings.* International Computer Music Association.

Dorschel, A. (2024). *Music and Knowledge: Towards a Systematic Approach*. [Unpublished manuscript]. Idea Lectures. Max Planck Institute for Empirical Aesthetics.

Emmerson, S. (1994). Local/Field: towards a Typology of live electroacoustic music. *International Computer Music Conference Proceedings* (pp. 31–34). International Computer Music Association.

Fletcher, N., & Rossing, T. (1998). *The Physics of musical instruments*. Springer-Verlag,

Foucault, M. (1988). *Politics, Philosophy, Culture: Interviews and Other Writings, 1977-1984* (L. Kritzman, Ed.; A. Sheridan, Trans.; 1st ed.). Routledge. https://doi.org/10.4324/9780203760031

Gabor, D. (1947). Acoustical quanta and the Theory of hearing. *Nature 159*, 591–594.

Garnero, F. (2017). *Programme note of Neon Pig.* [Unpublished manuscript].

Grella, G., & Mincek, A. (2016). *On the Outside Looking Out: Alex Mincek.* Retrieved from https://www.musicandliterature.org/features/2016/5/05/on-the-outside-looking-out-alex-mincek

Grisey, G. (2008). Tempus ex machina, réflexions d'un compositeur sur le temps musical. In G. Lelong (Ed.), *Gérard Grisey, écrits ou l'invention de la musique spectrale.* Éditions MF.

Haseman, B. (2006). A manifesto for performative research. *Media International Australia Incorporating Culture and Policy, Theme Issue 'Practice-led Research' 118*, 98–106.

Hiendl, L., (2023). *Composition and Digitality. Three Meditations on an Entanglement.* [Artistic Habilitation in Composition]. Mozarteum University.

Hume, D. (1739). *A Treatise of Human Nature*. Oxford University Press.

Jacob, F., & Monod, J. (1961). Genetic regulatory mechanisms in the synthesis of proteins. *Journal of Molecular Biology 3*, 316–56.

Joly, A. (2024). Programme note for the installation *Multiverse of a Birdcage.* [Unpublished manuscript].

Khort, M. (1986). The term 'grapheme' in the history and theory of linguistics. In G. Augst (Ed.), *New trends in graphemics and orthography* (pp. 80–96). De Gruyter.

Kubler, G. (1962). *The Shape of Time: Remarks on the History of Things.* Yale University Press.

Lachemann, H. (2009a). De la composition. In, *Ecrits et entretiens.,* selected and prefaced by Martin Kaltenecker (pp. 129–141). Éditions Contrechamps.

Lachemann, H. (2009b). La question du beau aujourd'hui. In, *Ecrits et entretiens,* selected and prefaced by Martin Kaltenecker (pp. 69–70). Éditions Contrechamps.

Lakkof, G. (1983). *Fire and dangerous things*. Chicago University Press.

Latour, B. (2005). *Reassembling the Social. An Introduction to Actor-Network-Theory*. Oxford University Press.

Latour, B., & Woolgar, S. (1996). *La vie de laboratoire. La production des faits scientifiques* (M. Biezunski, Trans.). La Découverte.

Latour, B., 2004. *Politics of Nature: How to Bring the Sciences into Democracy* (C. Porter, Trans.). Harvard University Press.

Lupone, M., & Seno, L. (2006). Gran Cassa and the Adaptative Instrument Feed-Drum. *Computer Music Modeling and Retrieval. Lectures Notes in Computer Science 3902*, 149–163 (pp. 27–36).

Lynch, M., & Woolgar, S. (1990). Sociological orientations to representational practice in science. In M. Lynch and S. Woolgar (Eds.), *Representation in Scientific Practice*. MIT Press.

Massumi, B. (2002). *Parables for the Virtual: Movement, Affect, and Perception.* Durham: Duke University Press.

Maturana, H., & Varela, F. (1998). *The Tree of Knowledge.* Shambhala.

McCulloch, W., & Pitts, W. (1990). A Logical Calculus of the Ideas Immanent in Nervous Activity. *Bulletin of Mathematical Biology 52*(l/2), 99–115.

Peirce, Ch. S. (1955). Logic as semiotic: The theory of signs. In J. Buchler (Ed.), *Philosophical Writings of Peirce* (pp. 98–119). Dover.

Rheinberger, H.-J., & Schwab, M. (2013). *Forming and Being Informed. Hans-Jörg Rheinberger in conversation with Michael Schwab* in *Experimental Systems, Future Knowledge in Artistic Research*. Leuven University Press.

Rheinberger, H.-J. (1997a). Experimental Complexity in Biology: Some Epistemological and Historical Remarks. *Philosophy of Science 64*. The University of Chicago Press on behalf of the Philosophy of Science Association.

Rheinberger, H.-J. (1997b). *Towards a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Stanford University Press.

Roads, C. (1996). *The computer music tutorial.* MIT.

Roads, C. (Ed.). (1992). Harvey Jonathan. Mortuos Plango, Vivos Voco: A Realization at IRCAM. *The Music Machine*, p.92. ISBN 978-0-262-68078-3.

Rosch, E., Thompson, E., & Varela, F. (1993). *L'inscription corporelle de l'esprit : sciences cognitives et expérience humaine*. Éditions du Seuil.

Rose, G. (1997). Situating knowledges: Positionality, reflexivities and other tactics. *Progress in Human Geography 21*(3), 305–320.

Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, Purpose and Teleology. *Philosophy of Science 10*(1), 18–24.

Sanfilippo, D., & Valle, A. (2012). Towards a typology of feedback systems. *International Computer Music Conference Proceedings* (pp. 30–37). International Computer Music Association.

Sanfilippo, D., & Valle, A. (2013). Feedback Systems: An Analytical Framework. *Computer Music Journal 37* (2), 12–27.

Schaeffer, P. (1966). *Traité des objets musicaux.* Éditions du Seuil.

Scholte, T. (2016). "Black Box" Theatre Second-Order Cybernetics and Naturalism in Rehearsal. *Constructivist Foundations and Performance 11*(3), 598–610.

Scrivener, S. (2000). Reflection In and On Action and Practice in Creative-production Doctoral Projects in Art and Design. *Working Papers in art and design 1*(1). Retrieved from http://sitem.herts.ac.uk/artdes_research/papers/wpades/ https://www.herts.ac.uk/__data/assets/pdf_file/0008/12311/WPIAAD_vol2_scrivener.pdf

Sédès, A. (2006). À propos du temps dans la musique d'Horacio Vaggione. In M. Solomos (Ed.), *Espaces composables : essais sur la musique et la pensée musicale d'Horacio Vaggione* (pp. 89–100). L'Harmattan.

Sédès, A. (2013). La notion d'appareil empruntée à W. Benjamin, appliquée à la création musicale en studio électroacoustique, et à sa diffusion. *Revue Appareil 11,* MSH Paris Nord.

Simondon, G. (1958). *Du mode d'existence des objets techniques*. Éditions Aubier-Montaigne.

Simondon, G. (2005). *L'individuation à la lumière des notions de forme et d'information.* Éditions Jérôme Million.

Solomos, M. (1998). L'espace-son. *L'espace: musique, philosophie* (pp. 211–224). L'Harmattan.

Solomos, M. (2006). Une introduction à la pensée musico-théorique d'Horacio Vaggione. In M. Solomos (Ed.), *Espaces composables : essais sur la musique et la pensée musicale d'Horacio Vaggione* (pp. 29–68). L'Harmattan.

Soulez, A., & Vaggione, H. (2006). Composer, écouter... . In M. Solomos (Ed.), *Espaces composables : essais sur la musique et la pensée musicale d'Horacio Vaggione* (pp.155–160). L'Harmattan.

Vaggione, H. (1995). Objet, représentations, opérations. In*, Revue Ars Sonora n°2,* 33–51.

Vaggione, H. (1996). Vers une approche transformationnelle en CAO. Proceedings of *Actes des Journées d'Informatique Musicale* (JIM), *Les Cahiers du GREYC,* CNRS-Université de Caen.

Vaggione, H. (1997). Singularité de la musique et analyse : l'espace d'intersection. *Esthétique et Musique Electroacoustique,* vol. II. Éditions Mnémosyne.

Vaggione, H. (1998a). Transformations morphologiques : quelques exemples. *Actes des JIM*. LMA-CNRS.

Vaggione, H. (1998b). L'espace Composable. Sur Quelques Catégories Opératoires Dans La Musique Électroacoustique. *L'espace, Musique/philosophie.* Archives Karéline.

Vaggione, H. (1998c). Son, temps, objet, syntaxe. Vers une approche multi-échelle dans la composition assistée par ordinateur. In A. Soulez, & H. Vaggione (Eds.)*, Musique, rationalité, langage. L'harmonie : du monde au matériau,* revue *Cahiers de philosophie du langage 3,* 169–202.

Vaggione, H. (2000). Autour de l'approche électroacoustique : situations, perspectives. *Esthétique et Musique Electroacoustique,* vol. I. Éditions Mnémosyne.

Vaggione, H. (2003a). Composition musicale et moyens informatiques : questions d'approche. *Formel/informel: musique-philosophie* (pp. 91–117). L'Harmattan.

Vaggione, H. (2003b). Décorrélation microtemporelle, morphologies et figurations spatiales du son musical. *Espaces sonores, actes de recherche,* under the direction of Anne Sédès. Editions Musicales Transatlantiques.

Vaggione, H. (2008). Composition musicale : représentations, granularités, émergences. *Intellectica 1-2* (48–49), 155–174.

Vaggione, H. (2010). Représentations musicales numériques : temporalités, objets, contextes. In A. Soulez, & H. Vaggione (Eds.), *Manières de faire des son* (pp. 45–82). L'Harmattan.

Van Eck, C. (2017). *Between Air and Electricity. Microphones and Loudspeakers as Musical Instruments.* Bloomsbury Academic.

Van Eck, C. (2017b). *Doppelbelichtung by Carola Bauckholt*. Retrieved from https://microphonesandloudspeakers.com/2017/04/10/doppelbelichtung-carola-bauckholt/

Varela, F. (1989). *Connaître les Sciences Cognitives. Tendances et Perspectives.* Éditions du Seuil.

Varela, F. (1996). *Invitation aux sciences cognitives*. Éditions du Seuil.

Varela, F. (2004). *Quel savoir pour l'éthique ? Action, sagesse et cognition*. La Découverte.

Vázquez Rodríguez, J. (2015). *Arte Interdisciplinar y Multimedia en la obra del compositor Alberto Bernal.* [Master's dissertation, Conservatorio Superior de Música de Oviedo].

Voegelin, S. (2019). *Sonic Materialism: Hearine the Arche-Sonic,* In Grimshaw - Aagaard, M., et al. (Eds.), *Oxford Handbook of Sound and Imagination Vol. 2*, Chapter 27, 559–577. Oxford University Press.

Wiener, N. (1930). *Generalized harmonic analysis*. *Acta Math*. *55* (1), 117–258. https://doi.org/10.1007/BF02546511

Wiener, N. (1948). *Cybernetics: Or Control and Communication in the Animal and the Machine.* Paris: Hermann & Cie, & Camb. Mass: MIT Press. ISBN 978-0-262-73009-9; 2nd revised ed. 1961.

Wiener, N. (1964). *Spatial-Temporal Continuity, Quantum Theory, and Music*. In M.Capek (Ed.), *The Concepts of Space and Time*. Reidel.

Wilde, P. (2020). I, Posthuman: A Deliberately Provocative Title. *International Review of Qualitative Research 13*(3), 365–80. https://doi.org/10.1177/1940844720939853

Winograd, T. (1979). Beyond Computer Programming. *Communications of the ACM*, 22 (7).

Winograd, T. (1993). Heidegger et la conception des systèmes informatiques. (French translation). *Intellectica 17*, 51-78.

Winograd, T. (1997). The Design of Interaction. In, P. Denning & B. Metcalfe (Eds.). *Beyond Calculation, The Next 50 Years of Computing*. Springer-Verlag.

Winograd, T., & Flores, F. (1986). *Understanding Computers and Cognition*. Ablex Press.

Xenakis, I. (1960). Elements of Stochastic Music. *Gravesaner Blätter 18,* 84–105.

Zea, D. (2020). Programme note of *Waïra.* [Unpublished manuscript].

List of Cited Works

Ashley, R. (1964). *The Wolfman,* for Amplified voice and tape. Lovely Music.

Bailie, J. (2011-12). *Harmonizing (Artificial Environments No.7),* for Six voices a cappella and tape. [Unpublished manuscript].

Bailie, J. (2011-12). *Artificial Environments Nos.9a-d (from fast to slow),* for Six instruments and tape. [Unpublished manuscript].

Bailie, J. (2014). *Trains,* for Cello and tape. [Unpublished manuscript].

Bauckholt, C. (2011). *Lichtung,* for String quartet. Thürmchen Verlag.

Bauckholt, C. (2012). *Zugvõgel,* for Five woodwinds. Henry Litolff's Verlag GmbH & Co. KG.

Bauckholt, C. (2016). *Doppelbelichtung,* for violin and samples. Henry Litolff's Verlag GmbH & Co. KG.

Bernal, A. (2013). *Impossible Translations #4 «Suite»,* for Piano and video. Retrieved from https://scores.albertobernal.net/bernal_it4.pdf

Cage, J. (1964). *Electronic Music for Piano,* for Piano and electronics. Peters Edition.

Collins, N. (1974). *Pea Soup,* for analog oscillators, filters, ring modulators, microphones, amplifiers, and speakers. [Unpublished manuscript].

Di Scipio, A. (2006). *Modes of Interference,* for Trumpet, electronics and feedback system. Edition RZ.

Dufourt, H. (1979). *Saturne,* for 22 instruments. Éditions Jobert.

Haas, G.-F. (2000). *In Vain*, for 24 instruments. Universal Edition.

Harryson, B. (2008). *Repetitions in extended time,* for Seven instruments. Retrieved from https://www.neurecords.com/wp-content/uploads/2021/03/Bryn-Harrison-repetitions-in-extended-time-Score.pdf

Hiendl, L. (2021). *In Abeyance,* for Ensemble. [Unpublished manuscript].

Hiendl, L. (2022). *Ray Ray of Light,* for Four voices a cappella. Retrieved from https://lauremhiendl.com/storage/files/rayrayoflight.pdf

Hiendl, L. (2022/23). *Seht meine Wunden und an meinen Beinen, die Narben meiner Wunden (denn wir sind lange gewandert)*, for Ensemble. [Unpublished manuscript].

Garnero, F. (2012). *Ballad-Avoidances I*, for Four instruments and electronics. Babel Scores.

Garnero, F. (2013). *Ojo de buey,* for Large ensemble. Babel Scores.

Garnero, F. (2013/14). *Limae Labor,* for Amplified string trio and e-guitar. Babel Scores.

Garnero, F. (2014) *Bop-Avoidances II* (2014), for Sampler and seven instruments. Babel Scores.

Garnero, F. (2014). *Granite Lip,* for Eight instruments. Babel Scores.

Garnero, F. (2014). *Interlude,* for E-guitar. Babel Scores.

Garnero, F. (2014). *NTPM.* For Two percussions, accordion and electronics. Babel Scores.

Garnero, F. (2015). *Ragtime-Avoidances III*, for Amplified trio and electronics. Babel Scores.

Garnero, F. (2016). *Fabulae,* for Ensemble, hybrid instrument, video and electronics. Babel Scores.

Garnero, F. (2017). *Neon Pig,* for Large ensemble, hybrid instruments and electronics. Babel Scores.

Garnero, F. (2017). *Junkspace,* for Ensemble, hybrid instruments and electronics. Babel Scores.

Garnero, F. (2018). *Mutante/Amniótica*, for Double bass, multi-dimensional dispositive and electronics. Babel Scores.

Garnero, F. (2019). *Dynamogramme : Allegretto,* for Large ensemble , multi-dimensional dispositive and electronics. Babel Scores.

Grisey, G. (1974-85). *Les Espaces Acoustiques*. Different instrumentations. Ricordi.

Grisey, G. (1975). *Partiels, f*or 18 instruments. Ricordi.

Harvey, J. (1980). *Mortuos Plango, Vivos Voco.* For Tape.

Lang, B. (1998-ongoing). *Differenz/Wiederholung (DW) Cycle.* 40 pieces up to 2025 for different instrumentations. Edition RZ & Schott Music.

Lang, B. (1996). *Hommage à Martin Arnold #1,* for Tape.

Lang, B. (1996). *Hommage à Martin Arnold #2,* for Tape.

Ligeti, G. (1969-70). *Kammerkonzert,* for 13 instruments. Schott Music.

Lucier, A. (1975). *Bird and Person Dyning,* for a Performer, electronic birdcall generator, amplifiers & speakers, and optional resonant objects. Lovely Music.

Lucier, A. (1994). *Music for Gamelan Instruments, Microphones, Amplifiers, and Loudspeakers*, for Gamelan ensemble, contact microphones, amplifiers & loudspeakers. Lovely Music.

Lupone, M. (1999-2003). *Gran Cassa*, for Amplified bass drum, contact microphones and live-electronics. Edizioni Suvini Zerboni.

Lupone, M. (2002). *Feedback,* for Amplified bass drum, contact microphones and live electronics. Edizioni Suvini Zerboni.

Manoury, P. (1987). *Jupiter*, for Flute and electronics. Éditions Durand.

Manoury, P. (2010). *Tensio,* for String quartet and electronics. Éditions Durand.

Mincek, A. (2008). *Pendulum II,* for String quartet. [Unpublished manuscript].

Mincek, A. (2010). *Three Studies,* for Piano. [Unpublished manuscript].

Mincek, A. (2011). *Harmonic Materials,* for Ensemble. [Unpublished manuscript].

Morales, H. (2015). *Tonewood II* for Five amplified resonant instruments, transducers and real-time electronics. [Unpublished manuscript].

Mumma, G. (1967). *Hornpipe,* for French horn and live electronics. Smith Publications.

Murail, T. (1980). *Gondwana,* for Orchestra. Éditions Musicales Transatlantiques.

Murail, T. (1982-83). *Désintégrations,* for Large ensemble and tape. Éditions Henry Lemoine.

Pauly, M. (2014). *Threshing Floor,* for amplified Tenor saxophone, amplified percussion, and electronics. [Unpublished manuscript].

Radulescu, H. (1978). *Wild Incantesimo,* for 9 orchestras of 162 instruments. Éditions Salabert.

Reich, S. (1968). *Pendulum Music,* for 3 to 5 dynamic microphones, stands, amplifiers, and speakers. Boosey & Hawkes.

Saariaho, K. (1986). *Lichtbogen,* for 9 instruments. Éditions Wilhelm Hansen.

Steen Andersen, S. (2004). *Amid,* for seven instruments. Edition·S.

Steen Andersen, S. (2007). *Chambered Music,* for 12 instruments and sampler. Edition·S.

Tudor, D. (1973). *Microphone,* for Microphones, Analog modular synthesizers, Amplifiers, speakers, and feedback systems. [Unpublished manuscript].

Tudor, D. (1975). *Tone Burst,* for Custom modular analog synthesizer setup. [Unpublished manuscript].

Xenakis, I. (1955-56). *Pithoprakta,* for Orchestra. Boosey & Hawkes.

Xenakis, I. (1956-62). *ST/4,* for String quartet. Boosey & Hawkes.

Xenakis, I. (1958). *Concret PH*, for Tape. Éditions Salabert.

Xenakis, I. (1958-59). *Analogique A,* for Four channel tape.

Xenakis, I. (1958-59). *Analogique B*, for 9 instruments and tape. Éditions Salabert.

Xenakis, I. (1962). *ST/10,* for large ensemble. Boosey & Hawkes.

Xenakis, I. (1962). *ST/48,* for Orchestra. Boosey & Hawkes.

Zea, D. (2020). *Waïra,* For 9 instruments, multi-dimensional dispositive, real-time electronics, and lights.

Appendix I: Original of Translated Citations

All quotations below are translations by Fernando Garnero.

From Introduction

P. 23. Original in French:

“Le **composable** est l’**articulable** : il est le lieu des émergences, mais celles-ci ne constituent pas des phénomènes “trouvés” ou provoqués par une espèce d’empilement de processus élémentaires, mais le fait d’une **construction** stratifiée d’interactions soigneusement articulées - composées.” (Vaggione, 2008, p. 168)

P. 23. Original in French:

“L'espace est conçu en tant que matériau compositionnel, cela veut dire qu'il est essentiellement un espace de relations.” (Vaggione, 1998b, p. 154)

From Chapter 1. Theoretical Frame

P. 39. Original in French:

“Comment les mutations technologiques, en interaction avec l’époque, transforment l’art, nos manières de faire et de percevoir.” (Sédès, 2013, p. 1)

P. 39. Original in French:

“Vers 1900, la reproduction mécanisée avait atteint un standard où non seulement elle commençait à faire des œuvres d'art du passé son objet et à transformer par la même leur action, mais encore atteignait à une situation autonome parmi les procédés artistiques. Pour l'étude de ce standard, rien n'est plus révélateur que la manière dont ses deux manifestations différentes -reproduction de l'oeuvre d'art et art cinématographique- se répercutèrent sur l'art dans sa forme traditionnelle.” (Benjamin 2012, p. 25)

P. 39. Original in French:

“Au gré des appropriations par les musiciens, en faisant apparaître la multiplicité de ses identités esthétiques a, selon l’expression de Jean-Louis Deotte, appareillé l’époque.” (Sédès, 2013, p. 2)

P. 40. Original in French:

“La guitare électrique n'est plus un instrument de musique au sens traditionnel du terme. C'est un instrument modulaire, un appareillage en réseau, fait d'une guitare à corps plein, équipée de microphones, connecté à un amplificateur qui va ajouter des possibilités de transformation et de traitement du son. Des pédales d'effet vont enfin compléter la chaîne de traitement électroacoustique. De nous jours, cette chaîne peut intégrer les moyens de traitement audionumérique.” (Sédès, 2013, p. 2)

P. 40. Original in French:

“L’instrumentarium aussi bien théorique que pratique, traditionnel ou récemment développé, donc les instruments de musique avec leur construction caractéristique et les techniques d'exécution qui en découlent, y compris la notion courante ; au-delà également, tous les moyens techniques, les outils, les appareils conceptuels, les techniques de travail développées et exploitées au sein de notre conception et de notre pratique de la musique, de même que les institutions et les marchés concernés au sein de la société.” (Lachenmann, 2009a, pp. 69-70)

P. 41. Original in French:

“L’histoire de chaque forme artistique comporte des époques critiques, où elle tend à produire des effets qui ne pourront être obtenus sans effort qu’après modification du niveau technique, c’est-à-dire par une nouvelle forme artistique.” (Benjamin, 2012, p. 45)

P. 42. Original in French:

“Le monde n’est pas quelque chose qui nous est donné : c’est une chose à laquelle nous prenons part en fonction de notre manière de bouger, de toucher, de respirer et de manger. C’est ça que j’appelle la cognition en tant qu’énaction car l’énaction connote cette production par la manipulation concrète.” (Varela 2004, p. 24)

P. 42. Original in French:

“1) La perception consiste en actions guidées par la perception ; 2) les structures cognitives émergent des schémas sensori-moteurs récurrents qui permettent à l’action d’être guidée par la perception.” (Varela, 1993, p. 285)

P. 42. Original in French:

“Les principes communs ou les connexions pertinentes entre les systèmes sensoriel et moteur qui expliquent comment l’action peut être guidée par la perception dans un monde dépendant du sujet percevant. ” (Varela 2004, p. 30)

P. 43. Original in French:

“1) La nature structurée de l’expérience corporelle ; 2) notre capacité imaginative à effectuer des projections vers des structures conceptuelles à partir de certains aspects bien structurés de l’expérience corporelle et interactive.” (Varela 2004, p. 34)

P. 43. Original in French:

“Puisqu’on a dit que la perception et l’action étaient incarnées dans des processus sensori-moteurs (qui s’auto-organisent, ...) il est naturel de postuler que les structures cognitives émergent des schémas récurrents de l’activité sensori-motrice. Dans chacun des cas, il faut bien voir non pas que l’expérience détermine strictement les structures conceptuelles et les modes de pensée, mais qu’elle rend possible et limite tout à la fois la compréhension conceptuelle dans des très nombreux domaines de la cognition.” (Varela 2004, p. 34)

P. 43. Original in French:

“Hautement stratifiée, faite de moments agglutinés, à la manière d'un mille-feuille.” (Vaggione, 2008, p. 166)

P. 44. Original in French:

“Dans une approche multi-échelle, tous les niveaux sont émergents, car ils sont imbriqués, se manifestent à partir d’une réciprocité concernant l’ensemble des relations en jeu dans le réseau compositionnel.” (Vaggione, 2008, p. 166)

P. 44. Original in French:

“On ne saurait donc nullement envisager la macro forme comme quelque chose de prédéfini, ni découlant du “matériau” ni constituant un niveau “supérieur” auquel seraient inféodés tous les autres. (La macro-forme est le) lieu d’une émergence.” (Vaggione, 2008, p. 166)

P. 44. Original in French:

“L’état des choses à composer n’est plus sous-tendu par une hiérarchie préétablie de degrés d’attraction, ce qui constituait la charpente sur laquelle une figuration musicale venait acquérir son sens. Il se manifeste plutôt, dans la perspective du réseau et de l'émergence, par un jeu stratifié d'échelles temporelles qui est lui-même composable, et non pas préétabli." (Vaggione, 2008, p. 167)

P. 44. Original in French:

"Un changement de fonction de la fonction." (Charles, 1978, cited in Vaggione, 2008, p. 168)

P. 45. Original in French:

"Se constitue par un mouvement de généralisation des propriétés de chaque composé." (Vaggione, 2008, p. 168)

P. 45. Original in French:

"Le composable est l'articulable : il est le lieu des émergences, mais celles-ci ne constituent pas des phénomènes « trouvés » ou provoqués par une espèce d'empilement de processus élémentaires, mais le fait d'une construction stratifiée d'interactions soigneusement articulées - composées." (Vaggione, 2008, p. 168)

P. 45. Original in French:

"A faire-émerger un monde non prédéfini." (Vaggione, 2008, p. 160)

P. 45. Original in French:

"On pourrait résumer l'élément commun aux divers avatars de cette critique de la représentation dans une terminologie proche à la fois de l'herméneutique et la systémique, de la manière suivante : une existence située ne saurait se manifester que dans l'interaction (dans la réciprocité, l'asymétrie, l'incomplétude, et ainsi de suite), et non pas dans la fixation et la prédictibilité d'un système fermé." (Vaggione, 2008, p. 161)

P. 46. Original in French:

"Pour Winograd, cela veut dire abandonner ce qu'il nomme la 'rationalité classique', et 'compression' du réel par et dans le calcul." (Vaggione, 2008, p. 162)

P. 46. Original in French:

"Dans le cas de la critique de la représentation, au contraire, ce qui est mis en avant c'est le fait que les représentations n'ont pas de réalité intrinsèque : elles ne sont que des outils qui pointent vers une émergence contextuelle, correspondant à une situation, ou, comme dit Varela, à un couplage structurel." (Vaggione, 2008, p. 161)

P. 46. Original in French:

“Une information déjà existante (…) créer un fait qui est irréductible à cette information.” (Vaggione, 2010, p. 52)

P. 46. Original in French:

“Quant aux représentations opératoires que nous utilisons en musique, (...) nous sommes dans un cas de figure très différent de celui du représentationalisme cognitiviste, car ces représentations opératoires sont des outils crées (construits) afin d’atteindre un champ d’action morphologique, et non pas pour re-présenter ou transcoder de processus mentaux, ni pour élaborer des modèles (des formalisations) du ‘monde'.” (Vaggione, 2010, p. 53)

P. 46. Original in French:

“Le système représentationnel, son instanciation présente et le compositeur lui-même.” (Vaggione, 2010, p. 54)

P. 47. Original in French:

“Comme des instances d’une hiérarchie prédéfinie.” (Vaggione, 2010, p. 46)

P. 47. Original in French:

“Quant aux échelles temporelles sur lesquelles on peut effectuer des opérations musicales : on peut postuler toutes les échelles que l’on veut, car la façon de définir les échelles temporelles est déjà un choix opératoire, un acte compositionnel.” (Vaggione, 2007, pp. 156-157)

P. 48. Original in French:

“Là où la notation musicale conventionnelle n'a plus cours, parce que l'ordre de grandeur de ses symboles ne peut s'appliquer au champ des micro-phénomènes sonores (micro-phénomènes potentiellement présents, pourtant, dans la musique dont cette notation dénote), commence alors, en dessous des notes, le domaine du micro-temps.” (Vaggione, 2010, p. 48)

P. 48. Original in French:

“Le timbre – le son articulé au niveau du micro-temps – constitue bien cette impossibilité de l'écriture, (... Certes) les musiciens se sont aperçus de ceci maintes fois : ce qu'il n'est pas possible d'écrire directement, on peut l'atteindre par ricochet. Il y a un lien entre transposition, registration et intensité qui permet, au moyen de la seule écriture macroscopique, d'agir sur le champ de l'énergie spectrale.” (Vaggione, 1998c, p. 189)

P. 49. Original in French:

“Le pur espace euclidien - (...)- était le cadre des opérations linéaires classiques comme, par exemple, les transpositions terme à terme. Mais il doit être relativisé si nous voulons intégrer des dimensions temporelles différentes (...), dans un réseau compositionnel multi-échelle. Ainsi, nous pouvons relever le défi de la musique électroacoustique en laissant toutes les singularités qui se manifestent à toutes les échelles temporelles émerger comme des produits d'interaction entre des dimensions multiples. Nous pouvons résumer cette situation en termes d'une double articulation. D'une part, du moment où les différents niveaux temporels présents dans un processus musical sont en interaction, les caractéristiques morphologiques peuvent circuler d'un niveau à l'autre. D'autre part, l'établissement d'une telle circulation ne peut avoir lieu qu'à la condition d'assumer que celle-ci ne peut être, dans aucun cas, strictement linéaire. (...). Ainsi, les relations - (...) - sont à définir à travers leur contenu d'interaction qui, contrairement à une relation linéaire d'un à un, n'exclut pas les fractures, les distorsions, les disjonctions entre niveaux temporels.” (Vaggione, as cited in Budon, 2007, pp. 110-111)

P. 49. Original in French:

“À chaque niveau, tout dépend de la définition précise de l’échelle temporelle (postulée) dans laquelle on fixe (temporairement) notre ‘fenêtrage’, notre cadre de référence opératoire.” (Vaggione, 2010, p. 51)

P. 49. Original in French:

“(Tout) processus délibérément orienté multi-échelle est toujours ‘multi-local’.” (Vaggione, 2010, p. 51)

P. 50. Original in French:

“C'est pourquoi l'approche granulaire a pu être considérée comme mode d'engendrement valable pour tout son, car elle incorpore l'aspect ondulatoire comme un état de choses parmi d'autres : un état laminaire (de n'importe quelle durée) obtenu à partir de flux de grains.” (Vaggione, 2008, p. 170)

P. 50. Original in French:

“L’intérêt de l’approche granulaire pour la composition musicale, consiste donc dans la possibilité de réaliser un traitement symbolique opératoire à l’échelle du micro-temps.Et, par extension du principe, de travailler des entités morphologiques de toutes tailles, en les fragmentant, les agglutinant et les projetant partout dans le composable.” (Vaggione, 2008, p. 171)

P. 51. Original in French:

“Une expansion relative des opérations syntaxiques proprement compositionnelles, c’est-à-dire explicitement incluses dans le système de représentations (de notations) de l’oeuvre. Dans ce sens, on peut parler de ‘granularité instrumentale’, car les agglutinations figurales de la partition (toujours macroscopiques, (...), car situées au niveau de la ‘note’, au-dessus de la ‘ligne d’horizon ’du micro-temps) se correspondent structurellement avec la granularité numérique.” (Vaggione, 2007, p. 125)

P. 53. Original in French:

“Quand on dit qu'un objet est transparent, on entend par là que cet objet non seulement se montre lui-même, en tant qu'unité fermée, mais qu'il est capable, essentiellement, de montrer ses méthodes et son code. Ceci reste valable même dans le cas d'un travail sur des sons naturels échantillonnés : ceux-ci ne seront pas des 'objets trouvés' dans la mesure où leur définition numérique permettra de multiples réécritures, à travers de multiples modes de représentation, et par là de les intégrer à une stratégie générale de composition comportant des réseaux d'opérations symboliquement déterminées.” (Vaggione, 1995, p. 35)

P. 53. Original in French:

“Unité multiple.” (Sédès 2007, p. 91)

P. 53. Original in French:

“L’objet, dans mon propos, est une catégorie opératoire, c’est-à-dire un concept technique forgé aux fins de trouver un critère de médiation qui pourrait englober des niveaux temporels différents dans une entité plurielle mais aux bords définis, et par là manipulable au sein d’un réseau.” (Vaggione, 2003a, p. 99)

P. 54. Original in French:

“La clôture correspond à la notion d’encapsulation, un linkage d’un ensemble de propriétés et de comportements en vue de la création d’un objet. L’héritage, se réfère de façon générale à toute relation entre un ensemble et un sous-ensemble (une classe et une sous-classe) d’objets. Enfin le polymorphisme permet que les objets puissent être manipulés d’une telle manière que des objets recevant des messages identiques peuvent produire des résultats tout à fait différents selon les choix d’instantiation.” (Bonnardi and Svindinski, 2015, p. 2)

P. 55. Original in French:

“Afin de produire des figurations multiples.” (Sédès, 2007, p. 92)

P. 55. Original in French:

“Une figure peut être considérée comme le produit d'articulations singulières, véhiculant des propriétés morphologiques, sur lesquelles on peut réaliser des opérations diverses.” (Vaggione, 1998a, pp. 98–99)

P. 55. Original in French:

“On serait en droit, alors, d’affirmer un concept de réseau de type multi-échelle : un réseau est fait d’objets, mais chaque objet appartenant à un réseau est aussi, en lui-même, un réseau. Dans les limites des échelles temporelles auxquelles nous avons accès, tout réseau d’objets est composé par des objets qui sont eux-mêmes des réseaux. Evidemment, ces réseaux ne sont pas “de bas niveaux” ; cependant, ils peuvent recevoir et faire circuler des granularités de toutes tailles.” (Vaggione 2008, p. 157)

P. 56. Original in French:

“Représente un état quelconque d’une situation mobile.” (Vaggione 2003a, p. 114)

P. 56. Original in French:

“Une pluralité d’opérations diverses, plutôt qu’un seul algorithme.” (Vaggione, 2003a, p. 97)

P. 56. Original in French:

“L’émergence d’une approche articulée autour du concept d’interaction généralisée (interne à l’oeuvre) nous permet aujourd’hui d’envisager à la fois l’existence de passages possibles entre dimensions disjointes du temps et la nature des non-linéarités qui découlent de leurs interactions.” (Vaggione 2000, p. 102)

P. 56. Original in French:

“Régionale” (Vaggione, 2003a, p. 79)

P. 57. Original in French:

“Une action locale d'écriture a bien la possibilité de s'intégrer dans un processus algorithmique, de la même façon que, symétriquement, le produit d'un processus algorithmique peut être transformé localement par une action d'écriture directe.” (Vaggione, 1996, p. 24)

P. 57. Original in French:

“Tantôt le local (cas du sérialisme) tantôt le global (composition de masses ou textures) et à poser le passage de l’un à l’autre en termes de ‘déduction’.” (Solomos, 2007, p.41)

P. 58. Original in French:

“L'espace est conçu en tant que matériau compositionnel, cela veut dire qu'il est essentiellement un espace de relations.” (Vaggione, 1998b, p. 154)

P. 58. Original in French:

“Donc, ce qui est à composer n’est pas seulement une disposition d’entités atomiques de surface, mais c’est aussi le contexte multi-strate dans lequel sont placées les notes.” (Vaggione, as cited in Budon, 2007, p. 104)

P. 58. Original in French:

“Le postulat d’une possible convergence, d’une vectorisation commune. Ceci implique bien entendu l’inclusion des sons instrumentaux dans le champ morphologique où se jouent - se composent - des articulations d’ordre spatial (...). Opérer une intégration, voilà l’enjeu des musiques mixtes. (...) Cependant, ceci n’est pas donné automatiquement. Pour accéder à cette intégration, il faut qu’elle-même soit pensée comme faisant partie, à part entière, du champ composable.” (Vaggione, 1998b, p. 165)

From Chapter 2. The Composable as a Space for Experimentation:

P. 77. Original in French:

“La sociologie des techniques se trouve devant un objet qui, bien que clairement défini dans son aspect physique, n’est pas moins curieusement insaisissable : mi-chair, mi-poisson, on ne sait par quel bout les prendre. Ils renvoient toujours à une fin, une utilisation pour laquelle ils sont conçus, en même temps qu’ils ne sont qu’un terme intermédiaire sur une longue chaine qui associe hommes, produits, outils, machines, monnaies. Même l’entrée dans les contenus proprement techniques ne permet pas de faire une mise au point parfaite qui substitue à cette image aux contours mal définis la vision simultanée et détachée de l’objet et du “fond” sur lequel il s’inscrit.” (Akrich, 2006, p. 159)

From Chapter 3. Multidimensional Dispositives:

P. 90. Original in Spanish:

"Ofrecer al oyente la experiencia, mediante pulsaciones y filtraciones, de los dos espacios acústicos en juego: el de la caja de resonancia y el de la sala." (Morales, 2023)

P. 94. Original in Spanish:

"Un exterior sonoro que proyecte la introspección del auditor en la atmósfera de transe que pretende transmitir 'Waïra'." (Zea, 2024).

P. 94. Original in French:

"Cette technologie low-fi dessine des compositions graphiques et reprend certains détails de la facture d'instruments de musique à cordes ou à vent, comme les trous de résonance, les cordes sympathiques, les ouïes, ou par analogie les emplacements de chevilles du piano, les tirants d'harmonium, les frettes de guitares, etc." (Joly, 2024)

P. 95. Original in French:

"Menée par le chaman, la musique ne s'arrête pas de la nuit. Accompagné par ses assistants, le guérisseur construit une enveloppe sonore qui favorise la transe et accompagne les visions produites par les effets de l'ingestion de plantes sacrées." (Zea, 2020)

P. 98. Original in French:

"Reprend la forme du rituel." (Zea, 2020)

P. 98. Original in French:

"Des musiciens spatialisés au milieu d'un forêt de petit-haut-parleurs dorés seront les résonateurs et amplificateurs d'une harmonie enveloppante." (Zea, 2020)

P. 98. Original in Spanish:

"En una masa de sonido que evoluciona a un ritmo deliberado para crear una atmósfera de trance durante media hora." (Zea, 2024)

P. 98. Original in Spanish:

"Reforzando la atmósfera alucinatoria de la obra." (Zea, 2024)

P. 99. Original in Spanish:

"Atmósfera alucinatoria, introspectiva y ritualista." (Zea, 2024)

P. 114. Original in French:

"Le temps du langage et de la respiration." (Grisey, 2008)

P. 116. Original in French:

"Flexibilité dans le niveau du faire et pas dans le niveau du comment." (Varela, 1996)

From Chapter 4. Symbolic Granulation:

P. 136. Original in French:

"La répétition ne change rien dans l'objet qui se répète, mais elle change quelque chose dans l'esprit qui la contemple." (Hume, 1739, as cited in Deleuze, 1968, p. 96)

P. 136. Original in French:

"Le temps ne se constitue que dans la synthèse originaire qui porte sur la répétition des instants. Cette synthèse contracte les uns dans les autres les instants successifs indépendants. Elle constitue par là le présent vécu, le présent vivant. Et c'est dans ce présent que le temps se déploie. C'est à lui qu'appartiennent et le passé et le futur : le passé dans la mesure où les instants précédents sont retenus dans la contraction ; le futur, parce que l'attente est anticipation dans cette même contraction. Le passé et le futur ne désignent pas des instants, distincts d'un instant supposé présent, mais les dimensions du présent lui-même en tant qu'il contracte les instants. Le présent n'a pas à sortir de soi pour aller du passé au futur. Le présent vivant va donc du passé au futur qu'il constitue dans le temps, c'est-à-dire aussi bien du particulier au général, des particuliers qu'il enveloppe dans la contraction, au général qu'il développe dans le champ de son attente (la différence produite dans l'esprit est la généralité même, en tant qu'elle forme une règle vivante du futur)." (Deleuze 1968, p. 97)