

Composing Relations

Spectro-morphological composition in differentiated layers within a holophonic framework: a typology of morphological relations derived from compositional practice (2010–2026)

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Abstract. This article asks how morphological and spectral materials can be related in composition, and whether those relations can be systematised as the compositional material itself. It proceeds by research through practice. Six works composed between 2010 and 2026 are read as a sequence of experiments, each of which isolated one problem: *LHC* (2010), *Punts de llum a les ales dels insectes* (2012), *Matar el sol* (2014), *Holofonia* (2015), the electroacoustic opera *IB: le cornu ancestrale* (2022) and the interactive work *Cicada Killer* (2024–26). The theoretical frame combines Schaeffer’s typo-morphology, the micro-temporal thinking of granular composition (Gabor, Xenakis, Roads, Truax, Vaggione), Rebecca Saunders’ notion of a finite sound palette, Smalley’s spectromorphology and Kokoras’ holophonic texture. The article argues that these theories respectively describe the object, its inner time, a finite set of objects, the behaviour of objects in time, and the perceptual whole. None of them, however, provides a compositional account of the relation between morphologies as something written and operative at every time scale. From the works, the article derives (1) six scales at which relations act (object, sequence, trame, phrase, section, work); (2) four families of relations (continuity, transformation, superposition, articulation) with twelve types; (3) six parameters with which a relation can be written; and (4) a six-step compositional method. The article closes with two open lines: interactive systems that relate morphologies in real time, and the cognition of sound.

Keywords: spectromorphology; sound object; holophony; morphological composition; sound palette; granular synthesis; graphic notation; interactive music; mixed music; research through practice.

Companion material. This article is the written counterpart of the lecture-concert *Towards a Morphological Composition* (形態から考える作曲), given at Nagoya College of Music, Studio C403, on 29 September 2026 within the FLEXUS PROJECT (5th edition, *Morphologies of Sound*). The lecture is published as an HTML presentation with audio, video, score excerpts and spectrograms (Bagés 2026a), freely available at <https://www.joanbages.com/research/composing-relations/presentation/>. Every reference of the form “(Presentation, slide 30)” is a live link and resolves to

<https://www.joanbages.com/research/composing-relations/presentation/#30>, where that example can be heard and zoomed.

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1. Introduction

A composer who works with sound morphologies soon discovers that materials alone do not make a piece. A catalogue of well-defined sounds (a tonic note, a frullato, a key click, a breath, a friction on a drum head) remains a catalogue until something happens *between* its elements. Some sounds fuse. Some persist as separate layers. Some cause other sounds or turn into them. Some interrupt or contradict each other. Such events belong neither to the sounds nor to the composer’s intention alone. They are relations, and they are what the listener actually follows.

The research question of this article is therefore: **how many ways are there to relate morphologies, and how can those relations be composed?**¹ A second question follows from the first: do those relations depend on the time scale at which they occur, or does the same logic operate inside a sound, between sounds and between the sections of a work?

The name I give to this approach is *spectro-morphological musical composition in differentiated layers within a holophonic framework*. Each term stands for a commitment. *Spectro-morphological* means that materials are defined by the shape of their spectrum in time, not by pitch and duration. *In differentiated layers* means that a musical moment is conceived as a superposition of distinct morphologies. *Within a holophonic framework* means that these layers are composed so as to be perceived, finally, as one whole sound.²

The method is research through practice. The six works analysed in §4 were not written to illustrate a theory. Each of them started from an extra-musical premise and a concrete technical problem. Read in chronological order, however, they form a series in which each work isolated one aspect of the relation between morphologies: fusion by a shared grain (*LHC*), the notation of morphology and its trajectory (*Punts de llum*), translation and causality between heard and produced sound (*Matar el sol*), the construction of a whole from opposed morphologies (*Holofonia*), relations between large superposed layers at the scale of the section (*IB*), and relations formalised as data that decide the form (*Cicada Killer*). The results of §5 were obtained by abstracting what these works have in common. The aim of the article is to show that path explicitly: from the compositional process to

¹The formulation corresponds to the research question as it is presented to students (Presentation, slides 5 and 47). An earlier formulation opposed “instrumental” and “electronic” sound. It was abandoned because, in the works discussed here, the relevant distinction is between morphologies, not between sources (see §2.6 and §3).

²The term “holophonic” is taken from Kokoras (2005a; 2007); see §2.5. It is used here in his textural and perceptual sense, not in the audio-engineering sense of holographic sound reproduction.

the conclusions.³

2. Theoretical framework

The frame combines five bodies of work. Each of them contributes one dimension of the problem. In outline: Schaeffer tells us *what* is related (objects and their criteria). The granular tradition tells us that relations also exist *inside* the sound. Saunders shows the power of a *finite palette* whose relations are composed. Smalley describes relations *in time*. Kokoras describes relations that produce *a whole* (Presentation, slide 47).

2.1 Schaeffer: the sound object and its morphology

Pierre Schaeffer's *Traité des objets musicaux* (1966) provides the vocabulary on which everything else rests.⁴ Five concepts are needed here (Presentation, slide 9). *Reduced listening* is listening to the sound for itself, as a sound object, independently of its cause and meaning.⁵ The *sound object* is the unit of perception that this attitude reveals. Schaeffer compares its size to a breath or an instrumental gesture. *Typology* classifies objects by their global shape (sustainment, balance, originality). *Morphology* describes their internal features by means of seven criteria: mass, dynamics, harmonic timbre, melodic profile, mass profile, grain and allure (Presentation, slide 10).

Two aspects of the *Traité* are decisive for composition. The first is that the criterion of mass is ordered. Schaeffer distinguishes classes of mass from the pure sound to the complex, noisy one: *son pur*, *tonique*, *groupe tonique*, *cannelé*, *groupe nodal*, *nœud*, *frange*.⁶ This order will later become a compositional path (§4.6). The second is that each criterion is described along several dimensions, which the *Tableau récapitulatif du solfège des objets musicaux* (TARSOM) sets out in a single grid (Presentation, slides 11–12).⁷ With that grid, a morphology can be written as a set of values on criteria and not only named.

The limit of the *Traité*, from a compositional point of view, is that it describes objects more than the relations between them. Its categories (*structure*, *contexture*, *texture*) do address the placing of objects in context, but they are not developed into a theory of how objects act on one another in a work.

³Readings of my own scores in §4 are analytical reconstructions made after composition. They describe what the scores write and what the recordings let one hear. They are not claims about how every listener perceives the music. Where perception is invoked, it is the author's listening, checked against spectrograms included in the companion presentation.

⁴Schaeffer 1966. English translation: Schaeffer 2017. The standard companion is Chion 1983 (English translation, Chion 2009), which reorganises the *Traité* as an alphabetical glossary. For performers of the scores discussed in §4.2 and §4.6 these two books are the recommended reading (Presentation, slide 33).

⁵"Reduced listening is the listening attitude which consists in listening to the sound for its own sake, as a sound object, by removing its real or supposed source and the meaning it may convey" (Chion 1983, as quoted in Thoresen 2007, §2.1).

⁶I use Schaeffer's French terms because they have no stable English equivalents. Smalley's "note–node–noise" continuum (1997, §3) is a condensed version of the same axis. In the lecture the classes are demonstrated with six spectrograms of sounds recorded for my own works (Presentation, slide 13), since Schaeffer's original examples are not reproduced.

⁷The TARSOM is reproduced in Schaeffer 1966 and discussed in Chion 1983. For grain, for example, the *Traité* distinguishes resonance grains (*frémissement*, *fourmillement*, *limpide*), friction grains (*rugueux*, *mat*, *lisse*) and iteration grains (*gros*, *net*, *fin*). This gives a composer three families of granular texture with graded sizes.

2.2 Grain and micro-time

“Grain” has two meanings, and the works of §4 depend on both. In Schaeffer it is a *perceptual criterion*: the microstructure of a sustained sound, heard as a texture of density, size and colour rather than as individual particles (Presentation, slide 14). In the granular tradition it is a *constructive unit*: the sound is built from very short events. Gabor proposed in 1947 that sound can be analysed into “acoustical quanta”.⁸ Xenakis made the idea compositional: “all sound, even continuous musical variation, is conceived as an assemblage of a large number of elementary sounds adequately disposed in time”.⁹ Roads produced the first computer implementation in 1974 and later gave the field its general theory in *Microsound*.¹⁰ Truax made granular synthesis work in real time in 1986.¹¹

For the approach developed here, the decisive contribution is Horacio Vaggione’s. His insistence that operations at micro-time have consequences at every level of form, and that no time scale is privileged, is the direct ancestor of the “same logic at every scale” proposed in §5.2.¹² Two other teachers gave this thinking a practical shape. José Manuel López López insisted on the scientific and philosophical nature of sound, and José Manuel Berenguer connected electroacoustic practice with the idea of systems and emergence.¹³ From this lineage comes the first premise of the research: relations exist not only between sounds but *inside* them.

2.3 Rebecca Saunders: the palette

From my studies with Rebecca Saunders in Berlin comes the second premise: a work begins with a *finite palette* of sounds, and what is composed is the way they are placed, recurred and balanced. Saunders describes her working method as that of a painter choosing colours, and she speaks of “a very reduced palette ... shaved carefully off the potential sound mass of the ensemble ... balanced with the surrounding silence”. She also speaks of sounds “that meet the borders of noise and of silence”.¹⁴ Her reduction goes as far as the single pitch. In *Fury II* (2009–10), for double bass and ensemble, bars 35–40 turn an F into a melody of timbres, in which only the mode of production changes.¹⁵

⁸Gabor 1947. Gabor’s quanta are elementary signals localised in both time and frequency. His argument concerned the theory of hearing, but it provided the conceptual basis of granular synthesis.

⁹Xenakis 1992, 43 (first English edition 1971). Xenakis applied the principle in *Analogique A-B* (1958–59), for string orchestra and tape.

¹⁰Roads 1978; Roads 2001.

¹¹Truax 1988.

¹²Vaggione 1996; Vaggione 2001. Vaggione (Córdoba, 1943) taught at the Université Paris 8 from 1989 and supervised my DEA research there.

¹³José Manuel López López (Madrid, 1956), professor at Paris 8, was my composition teacher; see, for example, *Haïkus d’automne* (1997) and *Metro Vox – In memoriam Iannis Xenakis* (2011). José Manuel Berenguer (Barcelona, 1955) founded the Orquestra del Caos. They are named here as the source of a way of working. Their writings are not cited as theoretical sources (Presentation, slide 14).

¹⁴Saunders, interviewed in J. Saunders n.d. [2009]. On the painterly analogy and the “palette” see also Hasegawa (forthcoming). Rebecca Saunders (London, 1967) studied with Wolfgang Rihm, lives in Berlin and received the Ernst von Siemens Music Prize in 2019.

¹⁵Hasegawa (forthcoming) analyses this passage in detail. Saunders herself describes working on “a single tone with different bow speeds, from half a second to 32 seconds”, where “the weight of the bow on the string” becomes a compositional parameter (J. Saunders n.d.).

In *Molly's Song 3 – shades of crimson* (1996), rehearsal number 36 can be heard as the alternation of two sound objects (Presentation, slide 16). Object A (events 1, 3, 4, 6, 7) is an impact followed by a resonance. Object B (events 2, 5, 8) is breath, air and glide. The passage contains almost no other material. Its interest lies entirely in the order, spacing and variation of two morphologies.¹⁶ The lesson for this research is methodological. Fix the palette first, then compose the relations among its elements. This became step 1 of the method in §5.5.

2.4 Smalley: spectromorphology and behaviour

Denis Smalley extended Schaeffer's morphology into a theory of sound shapes in time.¹⁷ Three of his contributions matter here. The first is the *note–node–noise* continuum, a condensation of the mass axis. The second is the temporal articulation of every spectromorphology into *onset*, *continuant* and *termination*. The third, and the most important for this research, is the concept of *behaviour*: “the relationships among the varied spectromorphologies acting within a musical context”.¹⁸ Smalley names relations of *motion coordination* (tight or loose), *motion passage* (voluntary or pressured), *dominance–subordination* and *conflict–coexistence*. He also names *causality*, when “one event seems to cause the onset of a successor, or alter a concurrent event” (Presentation, slide 17).¹⁹

Smalley therefore already treats relations as the object of study. His theory, however, is analytical and descriptive. It was built from listening to acousmatic music and does not propose how a relation should be *written* for performers, nor how a relation defined at one scale can be carried to another.²⁰ That gap is where the present research is situated.

2.5 Kokoras: holophonic texture

Panayiotis Kokoras proposed *holophony* as a fourth historical texture after monophony, polyphony and homophony.²¹ He defines it as “the synthesis of simultaneous sound streams into a coherent whole with internal components and focal points”. He places its emergence around 1950 (Xenakis' *Pithoprakta*, 1955–56, and Ligeti's micropolyphony) and grounds it in perception research: Schaeffer's sound object, Risset's work on spectral fusion, McAdams on fusion and fission, and Bregman on auditory streams.²² The etymology gives the principle: “each independent sound ($\varphi\omega\nu\eta$) contributes equally into the

¹⁶The segmentation of rehearsal 36 into objects A and B is my own analysis, made for teaching purposes (Presentation, slide 16). *Molly's Song 3* is published by Edition Peters (EP 7505) and was premiered by Ensemble Q-02 in Brussels on 20 September 1997. The score is not reproduced here for copyright reasons.

¹⁷Smalley 1986; Smalley 1997.

¹⁸Smalley 1997, §6 (“Behaviour”).

¹⁹Ibid. Smalley's causality is perceived causality: a listening effect, not a physical one. This is the sense adopted for the relation “causality” in Table 4.

²⁰The same observation applies to Menezes 2002, whose “morphology of interaction” between instrumental and electroacoustic sound is organised along an axis from fusion to contrast. That axis is close to the “degree” parameter of §5.4. Menezes, however, frames interaction as a relation between two sources, which is precisely the distinction this research abandons (§2.6).

²¹Kokoras 2005a; Kokoras 2007. Kokoras (Ptolemaida, 1974) studied at the University of York and teaches at the University of North Texas.

²²Risset and Wessel 1999; McAdams 1984; Bregman 1990. Kokoras later tested the concept analytically on *Pithoprakta* (Kokoras 2014) and, in *Morphopoiesis* (Kokoras 2005b), proposed a general procedure for structuring form from morphological units.

synthesis of the total (ὅλος)”. His string quartet *Holophony* (2002–03) aims at “a single abstract sound with internal components and with focal points” (Presentation, slide 18).

Kokoras supplies the *goal*: the layers are composed to be heard as one sound, and the listener’s attention is guided by focal points within that whole. His theory is formulated at the level of texture, however. It does not provide a typology of the relations through which differentiated morphologies produce, maintain or dissolve the whole, nor does it treat those relations at scales other than the textural.

2.6 Unity of material regardless of source

A last premise concerns the sources of sound. Stockhausen observed that electronic means made possible, for the first time, a single continuous field in which timbre, pitch, rhythm and form are aspects of one temporal organisation. In *Kontakte* he aimed at “contacts” between instrumental and electronic sound groups.²³ The works of §4 radicalise that idea. There is no compositional difference between an instrumental sound and an electronic one. The difference that matters is between *morphologies*. A creaking key amplified by a contact microphone and a granulated sample of the same key belong to the same class (*nodal*) and can fuse, contrast or follow each other on the same terms. This is why, throughout this article, relations are defined on morphological and spectral criteria and never on the category of the source.

2.7 The gap

Taken together, the five components describe objects (Schaeffer), the inner time of sound (granular composition), a finite set of objects (Saunders), the behaviour of objects in time (Smalley) and the perceptual whole (Kokoras). What is missing is a *compositional* account of the relation between morphologies. Such an account would name the relations, specify how they are written, and show whether they hold at every time scale. The hypothesis of this research is that such an account can be derived from compositional practice, and that the relation, rather than the sound, is the primary compositional material.

3. Working concepts and scales

Some terms need to be fixed before the works are discussed. A *sound object* is used in Schaeffer’s sense. A *morphology* is the set of values an object takes on the seven criteria, together with their evolution in time. A *layer* is a stream of objects that shares a morphology and is perceived as continuous. A *sequence* is a succession of objects. A *trame* (web) is a superposition of objects in ambient time, forming a fabric whose spectrum changes constantly.²⁴ A *phrase* articulates sequences and trames into a directed gesture. A *section* is governed by a dominant morphology and its field of relations. The *work* is the path between sections.

²³Stockhausen 1962, 40; Stockhausen 1964, 105.

²⁴The term follows Thoresen’s use of “web/trame” for “an object in ambient time with constantly changing spectrum” (Thoresen 2007, §5).

Table 1. The six scales at which morphological relations operate (Presentation, slide 48).

Scale	Order of duration	What is related
Object	ms – s	the internal criteria of one sound: mass, grain, allure, profiles
Sequence	s	objects chained in time
Trame	s – min	objects superposed into one stratified fabric
Phrase	s – min	sequences and trames articulated into a directed gesture
Section	min	a dominant morphology and its field of relations
Work	the whole	the path between sections: a trajectory in morphological space

These scales are not a hierarchy of containers. The same object can be heard as a grain of a trame or as a figure in its own right, depending on density and on attention. What the table fixes is the vocabulary for the question the works will answer: *at which scale is a given relation acting?*

4. The works as a research process

The six works are presented in chronological order, which is also the order in which the problem was clarified. The lecture groups them by concept instead (holophonic composition; the spectromorphological score; the sonorous score; Presentation, slide 20). For each work the article gives the premise, the palette, the notation and the relations explored, and closes with a *finding*: the element it contributed to the results of §5.

4.1 LHC (2010): fusion by a shared grain

LHC, for amplified bass flute and three amplified snare drums, takes its title from the Large Hadron Collider. The piece “creates and accelerates matter and particles”, and the collision of two sound realities generates “figures, lines, accumulations” (Presentation, slide 22). The palette is granular in both of Schaeffer’s senses. The snare drums carry new, highly granular heads, divided into nine zones from the upper rim (1) through the centre (5) to the lower rim (9). They are played with brushes, nails and fingers in vertical and circular rubbing at three speeds. The third drum is turned over and played on the snares. The bass flute uses *jeu voilé*, *frullato*, spoken consonants (SK, PR), singing while playing, slap and multiphonics (Presentation, slide 23).

LHC
three amplified snare drums, amplified bass flute
Joan Bagés i Rubí - Paris 2010

Figure 1. *LHC* (2010), score, page 1: amplified bass flute and snare drums 1–3. The staves are traditional, but the parameters they control are grain and allure: zone of the drum head, speed and direction of rubbing (**P**resentation, **s**lide 23).

The only electronic means is amplification. Snare drum 1 is placed left, snare drum 2 right, snare drum 3 centre, and the flute in both loudspeakers. Amplification acts as a *microscope*: it enlarges grain until it becomes the audible surface of the music. The stated aim was “a balance where the sum of the two instruments generates a new instrument, heard through the loudspeakers”. The result is an analogue granular synthesis, made by hand.

Finding. Fusion between morphologies of different origin occurs when they share a criterion, here the type and size of grain, and when their distance on the other criteria is small. The relation is not produced by technology but by the choice of criterion. *LHC* thus yields the first relation of the superposition family (*fusion*) and the first parameter of any relation (*shared criterion*). It also shows that the scale of the relation can be that of the object: the “new instrument” is a single composite sound object.

4.2 Punts de llum a les ales dels insectes (2012): notating morphology

Punts de llum a les ales dels insectes, for bass clarinet, microtonal accordion and electronics, was premiered at the Festival Eufònic in 2012. Its title comes from a poem by Gerard Vergés (Tortosa, 1931–2014) on the twilight of the Ebro Delta. The piece is granular, built on the sound matter of the Delta: insects, tiny noises, indeterminate

sounds (Presentation, slide 34). The electronics are a Max/MSP patch with three inputs (two accordion microphones, one clarinet microphone), real-time delay, pitch shift and granulation, and 29 presets of fixed samples. It is played by an electronic performer on three faders.

The main contribution of the work is its notation. I call it the *spectromorphological score*: a graphic score based on Schaeffer's morphologies and on the visual language of the spectrogram (Presentation, slide 33).²⁵ Each system consists of lanes: Tempo and Dynamics as relative curves; events in time and register; *M.P.S.* (mode of sound production); *Morfol.*, the morphology symbol (tonic, variable tonic, complex, nodal, fringe); and *ELECTR.*, the state of the electronics (Presentation, slide 35). The performers look for the technique that realises each morphology on their own instrument. The composer fixes the morphology, the gestures, the registers, the order and the dynamic relations. The performer fixes the technique.

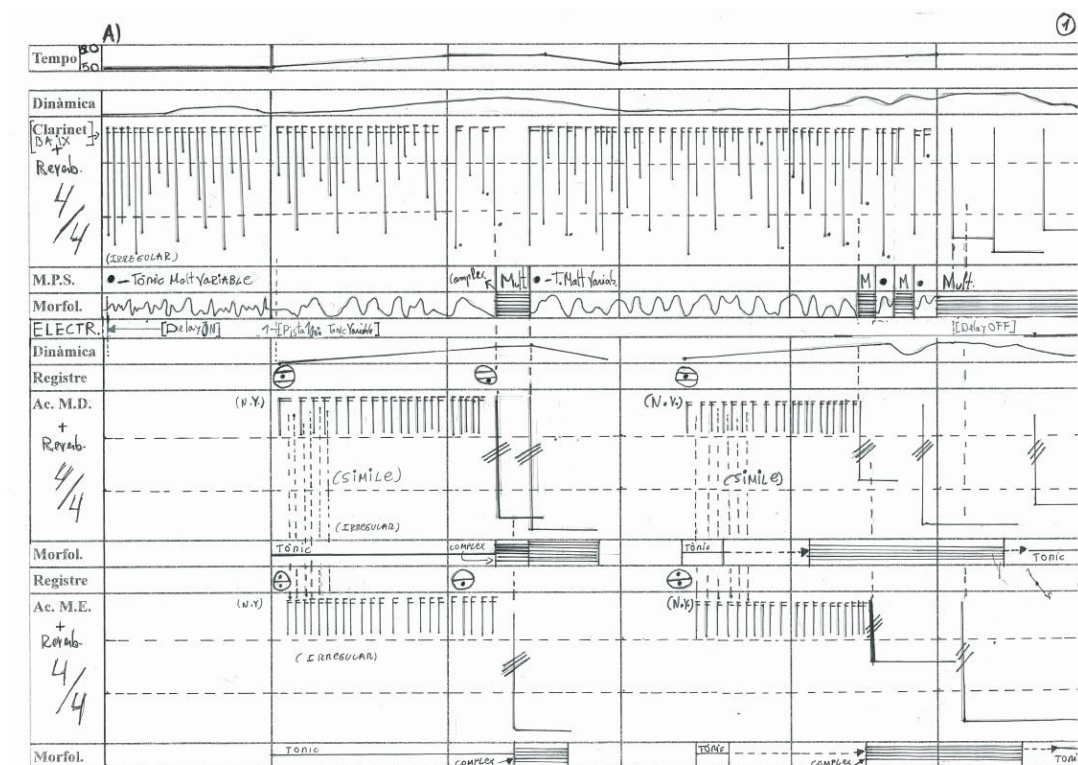


Figure 2. *Punts de llum a les ales dels insectes* (2012), page A of the spectromorphological score. Lanes from top to bottom: tempo, dynamics, clarinet events, mode of sound production, morphology, electronics, accordion (right and left hands). The hatched blocks mark a change from tonic to complex morphology shared by clarinet and accordion (Presentation, slide 35; score-video in slide 36).

Two things became visible in writing this score. First, the morphology lane records

²⁵The concept of the “partitura espectro-morfológica” was first defined in the performance documentation of *Punts de llum* (Bagés 2012). The idea that the spectrogram can be a notation, and not only an analytical tool, is its main premise: the thickness of a line stands for mass, its texture for grain, its undulation for allure.

trajectories: “very variable tonic”, “complex → multiphonic”. What is notated is a morphology in motion, not a static state. Second, when clarinet and accordion receive the same morphology symbol at the same moment, the score writes a *relation* (kinship or fusion) rather than two parts. The three layers (acoustic, real-time electronic, fixed electronic) are notated in the same terms, which is the practical consequence of §2.6.

Finding. A relation can be written if morphologies are written. The spectromorphological score is the notational condition of the method (step 5 in §5.5). The granular material of the piece also introduced the relation of *densification* (grains → stream → cloud) as a transformation acting at the scales of the object and of the trame.

4.3 Matar el sol (2014): translation and causality

Matar el sol, for violin, cello, bass clarinet, electric guitar, electronics and video, was written in Paris for Nou Ensemble. Its title refers to the Russian Futurist opera *Victory over the Sun* (1913), in which to “kill the sun” means to replace natural light with electric light. Electricity is the theme of the piece, as ideology and as energy.²⁶ The work replaces the visual score with a *sonorous score*. The performers wear headphones through which a Max/MSP patch sends a stream of disparate electronic sounds, built on sound morphologies. Overwhelmed by information, they must *select*, and translate what they hear with minimum delay into acoustic energy on their instruments (**Presentation, slide 44**). “Composition with a sonorous score speaks of the transformation of one energy into another.”

The device has three zones: the musicians at the back of the stage; a network of 30 mp3 players at the front, which diffuse fragments of “cut reality” as a continuous, very soft electric flow; and a control zone, where the patch records the performers, redistributes their sound, fires five electronic sequences of four files each, and follows a *virtual score* in six moments (**Presentation, slide 45**). The form is written as actions and listening situations, not notes.

Finding. Here the relation takes place *between listening and playing*. The heard morphology causes the played one, at a variable distance: a performer may reproduce the grain of a sound, its mass profile or only its dynamic envelope. The work thus isolates two relations: *causality* (articulation family) and *kinship* (continuity family, different sounds sharing one criterion). It also shows that the *direction* of a relation (which morphology leads, which follows) can be composed as a parameter in its own right. Finally, since each performer must choose which attributes of a sound to translate, the piece is also a study of how sounds are recognised and named. This opened the line on the cognition of sound discussed in §6.

²⁶Kruchenykh, Matyushin and Malevich 1913.

slide 27).

The definition I wrote for the work is the one that gave this research its frame: “HOLOFONIA is a concept that refers to the construction of a global, unitary sound, based on disparate and opposed morphologies which function as a WHOLE.” Section 1.1 is a small-scale model of it. A nodal layer is *interrupted* by multiphonics (cut), which *lead to* brief objects (causality, chaining). The electronic presets double, prolong or contradict the live morphology. In the spectrogram of the recording (Presentation, slide 28), vertical columns (attacks, key clicks), horizontal lines (tonic sounds) and clouds (nodal and fringe sounds) are visible as distinct layers, while the listening impression is of a single instrument.

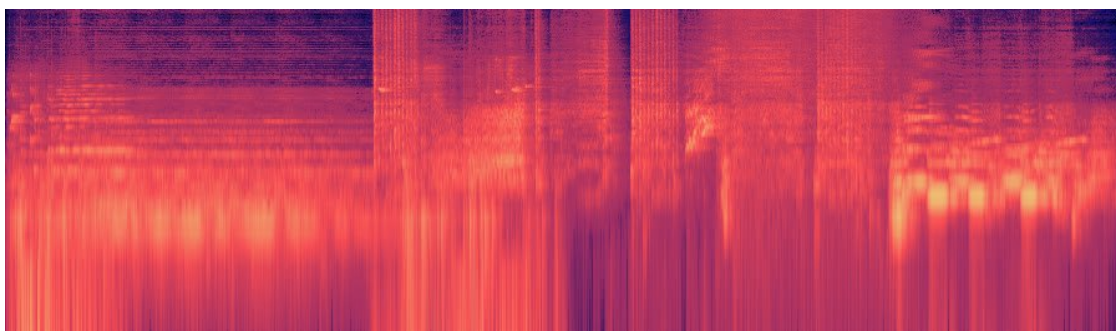


Figure 4. *Hologonia* v1.1, spectrogram of the complete recording (Joan Martí-Frasquier, baritone saxophone). Differentiated layers are visible, yet the listening impression is of one sound (Presentation, slide 28).

Finding. A holophonic whole can be built not only from similar morphologies that fuse (as in *LHC*) but from *opposed* ones, provided their relations are articulated: interruption, chaining, causality, and the passage along the mass axis from node to noise. Contrast, too, is a relation that holds a whole together. The work adds the articulation family and the passage relation (transformation family). It also confirms, through amplification, that a micro-scale event (a key click) can become a macro-scale element of form.

4.5 IB: le cornu ancestrale (2022): relations between large layers

IB: le cornu ancestrale is an electroacoustic opera in concert format for MORPHOSIS Ensemble. It is scored for ten musicians, two soloists (Anna Tobella, mezzo-soprano; Roger Padullés, tenor), an electroacoustic choir, electronics and visuals, with an acousmonium around the audience and Àlex Sansó as conductor. Its six “mental landscapes” go from the question *where do we come from?* to death and the return to the whole, with two characters, H and O, who together form the drop of water (Presentation, slide 29).²⁷ At this scale the question is whether the relations found in chamber works still hold when each layer is itself a group of instruments and voices.

Five pages of the score were analysed as superpositions of morphological layers. Each

²⁷A complete recording is available online (Bagés 2022b).

layer was described by Schaeffer’s classes (tonic, cannelé, nodal, fringe), grain, iteration and allure (Presentation, slides 30–31). Each page turned out to realise one relation predominantly (Table 2).

Table 2. *IB: le cornu ancestrale*, five score pages read as superpositions of morphological layers (author’s analysis; Presentation, slides 30–31).

Page	Dominant	Layers and their morphologies
·	rela-	
bars	tion	
p. 25 · 82– 86	Stratification	A sustained tonic fabric (electroacoustic choir on long vowels; accordion, one tonic with vibrato) under a sparse layer of piano and percussion impulses with long resonance, and a nodal grain in the strings (harmonics, tremolo, sul ponticello). Distinct layers, with focal points on each attack.
p. 69 · 254– 258	Fusion	Every layer iterates at a different speed (flute consonants “t k sh”, trills and multiphonics, choir syllables “n”, “m-eh”, rolls and repeated notes) over one low tonic pedal. The iterations fuse into a single granular cannelé mass.
p. 108 · 409– 412	Transformation	Impulses give way to sustained sounds. The strings move from (pas-ordinario to molto sul ponticello (mass profile tonic → nodal), and the sage) winds from held tones to multiphonics (tonic → complex), while an iterative layer emerges above.
p. 124 · 461– 464	Masking / emergence	The voices’ “Ma-ssa-cre” emerges from, and is covered by, a granular fringe mass that alternates between ff and p.
p. 148 · 546– 549	Dissolution	A static sustained field, harmonic glissandi in the flute, and a spoken text (“Encara ressona el corn del sirgador...”). A single violin line acts as the focal point while the texture thins.

The image displays a musical score for a section of the opera *IB: le cornu ancestrale* (2022), specifically page 69, bars 254–258. The score is written for a large ensemble of instruments, including Flute (Fl.), Clarinet (Cl.), Saxophone (Sax.), Percussion (Perc.), Piano (Pia.), Accordion (Acc.), Maracas (MS), Trombone (T.), Violin 1 (Vln. 1), Violin 2 (Vln. 2), Viola (Vc.), Double Bass (D.B.), and Electronics/Visuals (Electr/Vis). The notation is complex, featuring many staves with various musical symbols, including notes, rests, and dynamic markings like *f* (forte) and *mf* (mezzo-forte). The score illustrates a process of fusion, where individual instruments blend into a single granular mass.

Figure 5. *IB: le cornu ancestrale* (2022), score p. 69, bars 254–258: fusion into one granular cannelé mass (Presentation, slide 30).

Finding. The relations first met inside a single object or between two instruments (fusion in *LHC*, passage in *Holofonia*) reappear between large layers, and govern whole sections of the opera. Stratification, masking/emergence and dissolution complete the superposition and transformation families. The decisive observation is that the *same* relation can be named with the same criteria whether it acts in milliseconds or over minutes. This is the empirical basis of the scale-invariance claim in §5.2.

4.6 Cicada Killer (2024–26): relations as data

Cicada Killer, for horn, trombone, electronics and light, was written for Duo Atem (Sören Hermansson, horn; Ivo Nilsson, trombone) between Flix, Stockholm and Barcelona. Its premise is the cicada and its predator *Sphecius speciosus*, a wasp that paralyses the cicada and stores it alive for its larva. The cycle is interrupted but not finished, as an image of our relation with the planet. The cicada’s cycle intact corresponds to pure and tonic sounds; the predator’s collapse to nodal and fringe sounds (Presentation, slide 37).

The form is Schaeffer’s mass axis turned into a path. Section A goes from pure to tonic sound, B is cannelé (vibrato, tremolo, frullato), C nodal group and node, D fringe (air, friction, distortion), E decrease or bifurcation, and F dissolution. The score continues

the spectromorphological notation of *Punts de llum*: staves divided into high, middle and low frequency plus rhythm, and a “morphology electronic” lane under each instrument (Presentation, slide 38).



Figure 6. *Cicada Killer* (2024–26), score, page A1. Thickness, texture and colour of the line indicate the morphology; tempo and dynamics are relative; green blocks indicate the contact microphone (Presentation, slide 38).

In version 2 (completed in August 2026) the morphology becomes data. Each section is a point in a seven-dimensional space whose axes are density, noise, attack, width, movement, tempo and dynamics, each scaled from 0 to 1 (Table 3). The same file drives the formal decisions and the light (Presentation, slide 39).

Table 3. *Cicada Killer*, sections as points in a seven-axis morphological space (values from the work’s configuration file; Presentation, slide 39).

Section	Density	Noise	Attack	Width	Movement	Tempo	Dynamics
A · pure/tonic	0.10	0.05	0.05	0.15	0.10	0.25	0.30
B · cannelé	0.40	0.40	0.35	0.45	0.95	0.55	0.55
C · nodal/noeud	0.65	0.40	0.85	0.55	0.35	0.55	0.70
D · frange	0.95	0.95	0.90	0.95	0.20	0.75	0.80

Section	Density	Noise	Attack	Width	Movement	Tempo	Dynamics
E · decrease	0.25	0.30	0.10	0.40	0.25	0.35	0.25
E · bifurcation	0.45	0.50	0.50	0.50	0.70	0.50	0.60
F · dissolution	0.15	0.70	0.00	0.30	0.15	0.25	0.10

Some values record compositional decisions about perception. Frullato counts as noise, not as movement. D does not undulate, it breaks. F is “air without sound” (noise 0.70, density 0.15). The noise axis carries more weight in the distance measure because, without it, beginning (A) and end (F) would be almost identical.

The instruments are captured with four microphones (clip and contact). Five descriptors are extracted ten times per second: density (inter-onset interval), noise, attack, internal movement and dynamics.²⁸ Noise is measured as spectral flatness, the ratio of the geometric to the arithmetic mean of the energy in seven octave bands from 100 Hz to 6.4 kHz. A clean note measures 0.065, a note with frullato 0.449, air and friction 0.990. Unlike a high-frequency ratio, the measure keeps a clean high note tonic ([Presentation, slide 41](#)).²⁹

A decision engine then answers two questions: *when* to change section and *which* section follows. Every second it makes a draw whose probability depends on density and on whether the material is developing or stagnating. The choice of section combines a transition matrix (the written grammar $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$), the distance in the seven-axis space, and recognition of what is sounding.³⁰ Nine rules constrain it: for example, A, B, C and D happen exactly once, F always closes, E may return at most twice and never twice in a row, and the piece never exceeds 30 minutes. The result is 300 valid paths through the piece, with a median duration of 10–19 minutes depending on the performance. Nobody operates the computer during the piece. The performers steer the form by the way they play: “A duo that stagnates provokes changes; a duo that develops the material makes the system wait” ([Presentation, slide 40](#)).

The light is a third performer: 150 LEDs on a five-metre strip, modelled as a population of coupled oscillators.³¹ Each instrument owns a territory (horn LEDs 0–47, contact zone 48–102, trombone 103–149). Tonic electronics firm up the scene; fringe makes it dim and tremble; before a change of section the colony becomes restless and loses unison

²⁸Onset and pitch tracking use the objects *bonk~* and *sigmund~* (Puckette, Apel and Zicarelli 1998).

²⁹Spectral flatness, also called Wiener entropy, is a standard descriptor (Johnston 1988; Peeters 2004). Computing it on octave bands rather than on FFT bins makes it robust to register, which is necessary when the same axis must classify a horn in its low and high registers.

³⁰The engine is a Markov decision process in the tradition surveyed in Ames 1989, constrained by explicit rules. Its design principle is that the electronic output is analysed but excluded from the decisions, so that the system does not react to itself.

³¹Kuramoto 1984. The order parameter r measures synchrony: 1 when the whole population moves together, 0 when it is scattered.

(Presentation, slide 42). The same axis, note $\rightarrow$ noise and synchrony $\rightarrow$ collapse, runs through sound, formal decision and light.

Finding. When morphologies are data, a relation becomes a measurable *distance* between points in a space of criteria, and its trajectory can be followed in real time. The formal consequence is that *morphology can decide form*. The succession of sections is a relation at the scale of the work, and it is chosen by the same criteria that define an object. *Cicada Killer* thus gives the parameters *distance*, *degree* and *trajectory* of §5.4 an operational form.

5. Results

5.1 The relation is the compositional material

Across the six works one result is constant. The palette is chosen once, at the beginning. Everything else that is composed concerns how the elements of the palette relate: which criterion they share, how far apart they are, whether they fuse or contrast, which leads and which follows, and how all of this changes in time. The general result is therefore that, in spectro-morphological composition in differentiated layers, **what is composed is the relation between morphological and spectral materials, from the object to the whole work, and the evolution of that relation in time** (Presentation, slide 47). Each component of the frame supplies one dimension of it: the terms related (Schaeffer), the interior of the sound (granular composition), the finite set (Saunders), time (Smalley) and the whole (Kokoras).

5.2 The same logic at every scale

The works show the same relations at different scales. Densification occurs inside a single object in *Punts de llum*, where grains condense into a cloud within one sound, and across a whole section in *IB* p. 69. Passage along the mass axis occurs within a gesture in *Holofonia* §1.1, across four bars in *IB* p. 108, and across the whole form in *Cicada Killer*. Dissolution closes an object, a phrase and a work. Hence the second result: **the same logic of relation operates at every time scale** (Table 1): inside one object (milliseconds), between objects (seconds) and between sections (minutes) (Presentation, slides 48–49).³² This is what unifies the approach. A composer can design the form with the same concepts used to design a sound.

5.3 A typology of morphological relations

Generalising the relations met in the works gives four families and twelve types (Table 4). All are defined on morphological and spectral criteria, never on the source of the sound. The right-hand column indicates where each type was first isolated.

³²The claim extends Vaggione's position that no time scale is privileged (Vaggione 2001), from the domain of signal operations to that of perceived morphological relations. It does not claim that perception is identical across scales. Fusion over minutes involves memory, fusion over milliseconds does not. The claim is that the relation can be *defined and written* with the same criteria.

Table 4. Four families of morphological relations ([Presentation, slide 49](#)), with the work in which each relation was first isolated in this research.

Family	Relation	Definition	First isolated in
Continuity <i>materials share a criterion</i>	Identity	same class of mass, same grain	<i>Molly's Song 3</i> (model); <i>LHC</i>
	Variation	one criterion changes, the others stay	<i>Holofonia</i> ; <i>Cicada</i> <i>Killer B</i>
	Kinship	different sounds, same spectral region or grain type	<i>Punts de llum</i> ; <i>Matar el sol</i>
Transformation <i>one morphology becomes another</i>	Passage	note → node → noise along the mass axis	<i>Holofonia</i> ; <i>IB</i> p. 108; <i>Cicada</i> <i>Killer</i>
	Densification	grains → stream → cloud	<i>Punts de llum</i> ; <i>IB</i> p. 69
	Dissolution	the spectrum thins into air, into silence	<i>IB</i> p. 148; <i>Cicada</i> <i>Killer F</i>
Superposition <i>morphologies at the same time</i>	Fusion	they merge into one object	<i>LHC</i> ; <i>IB</i> p. 69
	Stratification	a frame with distinct layers and focal points	<i>IB</i> p. 25
	Masking / emergence	one hides or reveals another	<i>IB</i> p. 124
Articulation <i>morphologies in succession</i>	Causality	an attack produces a resonance; a heard sound produces a played one	<i>Matar el sol</i> ; <i>Holofonia</i>
	Chaining	the end of one object is the onset of the next	<i>Holofonia</i> §1.1
	Cut / contrast	opposed palettes side by side	<i>Holofonia</i>

The families are not exclusive. A superposition can be in continuity (two layers share a grain) or in contrast, and a transformation can be heard as a causality. What the typology offers is not a classification of passages but a set of questions the composer asks at each scale. What do these morphologies share? Are they simultaneous or successive? Does one become the other?³³

³³The typology is related to, but distinct from, Smalley's behaviour categories (Smalley 1997). Smalley's coordination and dominance describe how relations are *perceived*. The present families describe what a composer *writes*. The two meet in the parameter "coordination" (§5.4), which is taken directly from Smalley.

5.4 How a relation is written

If the relation is the material, it needs parameters in which it can be written. The works suggest six (Presentation, slide 50):

- **Shared criterion:** mass, grain, allure, dynamic or melodic profile, spectral region.
- **Distance:** how far apart two morphologies are on those criteria (made numerical in *Cicada Killer*).
- **Degree:** from fusion to contrast.
- **Direction:** which morphology leads, which follows or is caused.
- **Coordination:** tight or loose, in simultaneity and in succession.
- **Scale:** object, sequence, frame, phrase, section, work.

A relation also has a *trajectory*. Two morphologies plotted on the mass axis over time may converge (fusion), diverge (contrast) or follow each other with a lag (causality). Composing a relation means writing both its parameters and its trajectory.

5.5 A method in six steps

The results can be stated as a compositional method (Presentation, slide 51):

1. **Define a palette:** a finite set of sound objects, described by their morphological and spectral criteria (Saunders; *Holofonia*'s four banks).
2. **Choose the scales** at which the relations will act (Table 1).
3. **Choose the relations**, from the four families, and their shared criteria (Table 4).
4. **Write their trajectories:** how each relation moves between fusion and contrast over time.
5. **Notate morphologies and relations** in a spectromorphological score. The shape and its relations are written; the performer finds the technique (*Punts de llum*, *Cicada Killer*).
6. **Listen to the whole:** verify that the differentiated layers are perceived as one holophonic sound, with focal points (Kokoras; *Holofonia*, *IB*).

The sounds are chosen once; the relations are composed all the way through. The method does not prescribe an aesthetic. It prescribes an order of decisions, and it makes explicit a level of composition (the relation) that is usually left implicit.

5.6 Contributions in relation to the frame

In relation to the theories of §2, the research contributes five points. (1) It treats the relation, rather than the object or the texture, as the primary compositional material. (2) It claims that the relation can be defined with the same criteria at every scale, from the object to the work. (3) It shows that morphology can decide form: in *Cicada Killer*,

formal succession is governed by distance in a morphological space. (4) It proposes a notation that writes morphologies and relations rather than techniques. (5) It shows that amplification can act as a microscope: micro-scale sounds become elements of form without any processing (*LHC*, *Holofonia*).

6. Conclusions and open lines

The path of this research runs from the problems posed by individual works to a general proposal. *LHC* showed that fusion depends on a shared criterion. *Punts de llum* showed that a relation can be written once morphology is written. *Matar el sol* made the direction of a relation, from heard to played sound, compositional. *Holofonia* showed that opposed morphologies can form a whole if their relations are articulated. *IB* showed the same relations governing large layers and sections. *Cicada Killer* turned relations into data that decide form. The conclusions of §5 (six scales, four families, six parameters, six steps) are the abstraction of that path. They are offered as a proposal for composers and as a set of analytical questions for listeners, not as a closed system.

Two lines remain open. The first is **interactive music and artificial intelligence**. In *Cicada Killer* the system listens and learns to take formal decisions, relating the morphological materials in real time. The form is no longer fixed; it emerges from performance. The next step is to let the system learn relations (not only recognise sections) from the performers' playing, and to study how a typology like that of Table 4 can serve as the vocabulary of such a system (Presentation, slide 37). The second is the **cognition of sound**. *Matar el sol* is also about how we perceive and recognise sounds, and which attributes we give them (Presentation, slide 44). When performers must choose what to translate from a sound, they reveal which criteria are salient for them. Systematic study of those choices could test, empirically, the perceptual weight of the criteria on which the relations of this article are built.

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