Listening and Technique: An Approach to Creative and Perceptual Processes in Live Electronic Music

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Abstract
In this article, we argue that it is possible to establish an approximation and a line of continuity between the techniques used in creative processes of live electronic music (composition and performance) and the processes of listening and perception of these compositions, making them more permeable. Within this approach, we present, as a theoretical reference, concepts elaborated by Gilbert Simondon concerning, on the one hand, to the construction of a technical mentality and, on the other, to the study of perception. In this approach, both concepts are mediated by concepts of individuation and invention, and by the operations of transduction and modulation. We discuss this framework by detailing actions in the creative process of the work *Interstício de tempo* (2020), for flute, live electronics, and video, in relation to synthesis, sound processing, spatialization and video. Finally, we seek to articulate the theoretical concepts presented with the technical and perceptual features of the musical work in question.

Keywords: live electronic music; technical mentality, perception; corporeality; creative processes.

1 Introduction

Many studies associate music with the temporal dimension, approaching characteristics of musical time in different ways (Brelet, 1949; Messiaen, 1994; Ferraz, 2010). In parallel, the spatial dimension in music is relevant in various creative contexts, highlighting its plural nature. This is emphasized nowadays, for example, by the notion of sound immersion, from a perceptual point of view, in addition to the qualities traditionally mentioned as the physical space where music materializes, or even the mental space of representation of musical abstraction in the act of its creation (Solomos, 2013, p. 415). In addition to this context, it is nowadays scientifically proven that listening has analogous temporal and spatial characteristics (Ouzonian, 2020, p. 27-28), as well as the possibility of other psychoacoustic

phenomena arising from the interaction of spatial-temporal aspects in listening (Rossetti; Antunes; Manzolli, 2022).

In the 20th and 21st centuries, Western music of the European tradition introduced the paradigm of producing knowledge through listening which, throughout the 20th century to the present day, went thought different approaches. Among these approaches, we highlight the phenomenological listening and its type-morphological classification (Schaeffer, 1966), the updating of this proposal through a spectromorphological analysis (Smalley, 1996), or even a listening with different levels of depth, from the microphonic to the macrophonic (Grisey, 2008, p. 35). It is found also proposals for active listening practices such as deep listening as a corporeal and conscious experience through the active engagement of the listener (Oliveros, 2005), or the idea of a multiplicity of listening based on multiple acoustic factors that modulate sound and listening, based on potential space-time variables (Criton, 2010; 2016), both of which propose integration between the listener and the environment.

Permeating all these approaches, it is important to emphasize that listening (and any other type of perception) is an individual phenomenon, related not only to the physical phenomenon perceived (in the case of music, the acoustic phenomenon of sound), but also to the individual's memory and personal references, as well as to the affections that this phenomenon can arouse in this same individual. Here, then, we have the production of a multiplicity of images that modulate and interpenetrate each other to build a global perceptual image, referring to the totality of the perceived phenomenon (Bergson, 2010).

Technicality and technology, in a very summarized way, appear in the musical practice in various aspects, such as in singing or in the way an instrument played, in the technology used to produce these instruments, or even, more recently, with the use of analogue and digital electronic equipment (such as computers) that aid this activity (Velloso, 2013). It can be seen that each historical period and each society presents the notions of listening and technique according to its implicit knowledge about these activities, as well as the corresponding scientific knowledge.

Considering the individuality of listening and perception, we can also understand these phenomena as cultural, deriving from a specific society in which certain practices or genres can be based or shared, as is in the subject of study of sound studies (Emmerson; Landy, 2012. Born, 2013). In our approach, we argue that technique is a fundamental dimension of culture. For the philosopher Gilbert Simondon, an oppositional design between culture and technique, or between the human being and the machine, is unfounded. The main cause of alienation in the contemporary would be the insufficient knowledge of the nature and essence of machines' operation. In order to culture regain its general character, it would be necessary to reintroduce machine's conscience of nature and their relationship with human beings, along with the values implicit in these relationships. This conscience would be in the knowledge of

the causality and regulation schemes of an axiomatization of technology, to the extent that technical realities and their meanings correspond to an open plurality of techniques, which can lead to very different scientific domains (Simondon, 2012, p. 9-15).

Analyzing the question of technique in the 20th century, within this problematic, Simondon defended the existence of a technical mentality which is in continuous development. The study of technique would provide us with intelligibility schemes with universal potential, both from a rational and cybernetic point of view. This technical mentality would offer us coherent and usable structures for a cognitive interpretation of processes (Simondon, 2006). Within this discussion, it is important to mention the Simondonian notion of technoaesthetics, on which we have developed in a recent article an analytical approach to the processes of live electronic music, along with the notion of transduction (Rossetti, 2024). Techno-aesthetics differs from traditional aesthetics in that it does not present contemplation (or fruition) as its main category; on the contrary, it is based on action as its stimulus engine, to the extent that the participants in a performance (in this case, musical), through their bodies, perceive and react according to a perceptual-motor-sensory intuition. In techno-aesthetics, it is considered that there is a play of forces involved in artistic practice (Simondon, 1998). For instance, electricity, which is fundamental to the realization of a performance with electronic devices, is mediated by the devices used, transforming, and modulating the sound that arrives to our ears. Electricity is therefore discernible and manipulable by technical objects such as computers, microphones, effects processors, synthesizers, software, patches, speakers, musical instruments, etc.

With this conceptual line in mind, we will address the issue of sound or audiovisual perception in live electronic music as a system. To this end, we are based on Simondon's studies of perception, from the notions of transduction, modulation and corporeality. In a practical way, we discuss the creative process of composition and performance of the work *Interstício de tempo* (2020), describing its synthesis, spatialization and video processes. We emphasize that our intention is not to support all the theoretical and artistic discussion presented in a single artistic work, but to present an example of a creative process in which these discussions can make sense, as well as promoting critical, aesthetic and analytical thinking about musical works that use of technological tools in their processes.

Interstício de tempo is a work composed in 2020 by Danilo Rossetti and dedicated to Cássia Carrascoza. Originally, it was conceived to be played on stage, but as the Covid-19 pandemic happened precisely during the period of the work's creative process, adaptations had to be made so that it could be performed in a telematic system. Once the adjustments had been made, the work was premiered virtually at the NowNet Arts Conference in 2020 (Bomfim; Bazarian; Rossetti, 2020. Rossetti; Bomfim, 2021). Later, in 2022, with the resumption of in-person concerts, *Interstício de tempo* began to ho have in-sight rehearsals, and a video was

added to the performance, which is modulated live by the audio captured from the flute. This version with the addition of the video has already been performed a few times, including a performance at the Mário de Andrade Library in São Paulo, in November 2022, another at the *Unerhörte Musik* series in Berlin, in April 2024, at a concert by the National Association of Flutists (Abraf) in Manaus, in June 2024, and at the International Meeting of the Brazilian Association of Musical Performance (Performus' 24) at the University of São Paulo.

To conduct the discussions on listening, perception, technique and technology, we will present Simondon's theoretical notions on perception and information (Simondon, 2010; 2014), including his notions of transduction and modulation, as well as a vision of corporeality based on transduction. Next, we present some definitions of technical objects and invention, followed by a description of the synthesis and spatialization processes used in the work, as well as the process of generating the video in real time, followed by a discussion of the different issues involved in the performance of *Interstício de tempo* in different media, whether virtual (telematic) or in-sight, and in different configurations of the work, initially without the video and later with its inclusion. Finally, we will conclude with a theoretical-practical discussion of the concepts presented, and how listening and technique can influence the creative process and musical practice, as well as how these possibilities can be expanded, to the extent that music and technology can conceive their own technical and aesthetic diversities through these concepts. The contribution of this article is to promote a approximation between listening and technique in musical practice, concepts that are often thought of as dislocated. We search for an interpretation of musical practice (composition, performance, or analysis) in which both interact and influence each other, creating a fluid and permeable environment between these two tools that we consider essential for the contemporary musician.

2 Perception, Information, and Listening

Here, we will present theoretical references on perception, considering it as an act of individuation and invention, which occurs based on the operations of transduction and modulation. Transduction can also be thought of as a creative method. We will also present a vision of the human body as a transducer, as well as a discussion on virtual and in-sight multiple listening.

For Simondon, the perceived object is dynamic and in constant transformation, so perception is the invention of a form and an act of individuation, or even, to perceive is to organize or to invent an organization (Simondon, 2005, p. 233-235). Human beings can combine forms such as symbols (universals) from a number of indefinable variations, in this sense, bringing a strong and explicit link between perception and abstract thought. This combination of forms would be one of the main strategies of invention, that is, the creation of new realities through the individual act (Simondon, 2013, p. 204).

The perception of forms is essentially differential, and the main source of differentiation is discontinuity, i.e. the simultaneous or successive contrast between structures, for example, in intensity or quality (Simondon, 2013, p. 210-211). We can conceive, in the perception of forms, three categories of apprehension: the first is related to gradients of intensity, since the perceived object is a collection of differential relations that gains an internal and individual coherence, the second is the perception of a topology or a mapping and contour of the perceived structures (such as figure and background) and the third is related to the perception of microstructures and the exploration of details within the apprehended systems (Simondon, 2013, p. 247).

Information is defined by Simondon as an operation that produces a transformation when it achieves a system that receives it, or an operation that allows a form to emerge. Thus, the receiver's local reality is modified by the incident of the information that reaches the senses. The human being receiving information has a mixed zone of interaction between local structures and energies and the incident energy inputs that arrives to the senses. If the receiver is in a metastable state (a state of stability sensitive to external information with an accumulation of potential energy for triggering an action), the external information can be effective in producing transformations in the receiver (Simondon, 2010, p. 160-161). This operation can be amplified by transduction or modulation, according to Simondon's propositions. The example of a transductive amplification of information is the propagation of nerve impulses, while amplification by modulation tends to domesticate transductive propagation.

2.1 Transduction and Modulation

Transduction, according to Simondon, can be understood as the transformation of one energy into a different energy. Transduction would be a physical, biological, mental or social operation in which an activity invades and spreads from little by little within a domain, such as an operation that structures and individuates itself at the same time as its propagation. To the extent that each region is structured, it serves as a principle for the constitution of the next region, with modifications extending progressively (Simondon, 2005, p. 32). Transduction can also be thought of as a creative method in an artistic and technological context, as we intend to detail throughout this article. It is also the name given by Simondon to the operation that molds the process of individuation as a progressive structuring.

Modulation refers to the act of molding (to give a form) in a continuous and always variable manner, i.e. a modulator is a continuous temporal mold in which the transfer of energy is irreversible (Simondon, 2005, p. 47). For modulation to take place, the presence of an energy to be modulated is necessary, i.e., the presence of a system that contains a quantity of potential energy (condition of metastability). The modulator is characterized by the interaction between

the energy to be modulated (potential energy) and the modulating information that enters the system (Simondon, 2010, p. 190).

A modulator is a system that performs the synthesis between information (or form) and energy. This image, according to Simondon, can be attributed to any living being if we consider its input of energy as breathing or feeding, the input of information as perception and the output of an organized energy the action of the living being in its environment. Therefore, living beings can be considered as a series of organized and superposed modulators (Simondon, 2010, p. 196). It may be yet another layer to this system if we consider that an external stimulus usually provokes the emergence of a memory or predefined programming that exists virtually, which can also modulate the potential energy during an action (Simondon, 2010, p. 220).

Perceptual organization occurs through the correlation between transductive and modulating processes. Transductive processes allow a change in the order of magnitude of a modification through a passage from the elementary (micro) to the collective (macro), creating a final homogeneity. Modulation, on the other hand, exerts a complementary and inverse force because the macro structures embraced by a continuous energy mold the general behavior of the micro elements present (Simondon, 2010, p. 171). In our understanding, in a sound process, we can analogically think of transduction associated with the microtemporal (spectral or granular) level of sound, while modulation corresponds to the forces that mold the temporal and spatial interactions of sound objects, resulting in the overall musical form.

2.2 Physical and Virtual Corporeality

Paulo de Assis (2017, p. 710) argues that the human body is the main transducer or interface between innumerable incompatible potentials and musical acoustic realization in the act of composition and performance. The body that, for example, plays an instrument has in itself different layers of information that modulate and give form to musical events. The construction of planes of immanence during composition, through the coupling of new forces and intensities, provokes the movement of the performer's body during the performance. Next, we bring a reflection on the collaborative creation of the work *Interstício de tempo*, in relation to the performative and corporeal difficulties encountered in the elaboration of a telematic performance and, later, in the adaptation of this conception to the on-stage environment.

With social isolation due to the Covid-19 pandemic, the entire composer-performer collaboration process was realized at a distance, from specific consultations of the nature of the instrument (flute) to the performance. The telematic work involved the implementation of a system of musical interaction that redefined our skills in performance mediated by technical devices. Although the authors had a history with live electronic performance, a whole technical adaptation of the work for the telematic environment was necessary, specifically for the live electronic processing, as well as reconsidering some aspects of performance for the virtual

stage (Rossetti; Bomfim, 2021. Bomfim; Ficarelli; Rossetti, 2023). Our potentialities for bodily expression was re-signified, and in this context, from the musical time point of view, we adapted the performance of the work to the network situation.

In the first in-sight performance of the work in a common environment, already with the audiovisual version, we noticed that the performance on stage led to faster *tempi* for the music and its more intense character. In another in-sight performance, with the sound processing conducted by Carrascoza using pedals, the corporeal implications of the performance led to a choreography centered on mastering the technical devices, which generated slower *tempi* and a calmer performance.

In general, musical performance mediated by technical devices raises several questions, such asm, what is the role of the performer in the interaction with the technical system? How do the different perceptions of time, body and expression resulting from this interaction transform the artistic experience?

Returning to the theoretical questions, the notions of transduction, modulation and corporeality can be thought of in different layers of the performance. Energy, of different natures, circulates from the performer's body, with the transformation of the kinetic energy of the instrumental gesture into sound (mechanical energy), sound that is captured by microphones and transformed into electromagnetic energy circulating through the cables. It is then digitized to be processed within a computer in a patch, undergoing different processes, and transformed back into an analogue medium and projected into the diffusion space. Finally, the acoustic mechanical energy reaches the ears of the audience watching the performance. Within this live electronic music performance system, different transduction processes occur, comprising various exchanges of energy between the operators in the chain, who are both human beings and machines. In this system, multiple actions, techniques and listening incur.

2.3 Multiplicity in Listening

It may seem obvious, but it's important to highlight that some important differences exist in the performance and reception of the same work in the telematic environment and its virtual space, and in a physical space, which lead to some differences in the listening experience process. In the telematic environment, each musician and the audience is connected via the internet, through a data transmission and reception environment that is not ideal for making music, and these individuals do not share the same physical space. In reality, they share a virtual performance space with its own characteristics. One of them, for example, is that the reality of listening is not shared, as no individual knows how the other is listening, due, for instance, to the variable latency that is inherent to the network, the equipment that each person uses, whether they are listening with phones or loudspeakers, etc. In a in-sight performance in a concert hall,

both the musicians and the audience share the same space with its own characteristics that unify the listening experience to a certain extent, excluding the particularities of each individual's position within the auditorium, and the issues of individuality of listening already presented. Thus, performances of the same piece in a virtual or physical environment can produce multiple perceptual experiences.

The idea of listening presented by Pascale Criton (2010, p. 120) is based on an acoustic multiplicity that is integrated by a set of factors that mold sound and listening, from a potentiality of spatio-temporal variables that occur in the course of a specific sound event. This multiplicity is related to the fact that, nowadays and since the middle of the 20th century, there has been a “molecularization” of musical material due to the possibility of using technologies that allow access to the “microphonic” dimension of sound (see footnote 1). The multiplicity expands with the possibility of physical, virtual or hybrid performances.

Criton (2016) also defines this listening as plural, as it brings an ecological sensitivity to the relationship between sound activity and the environment, bringing questions about listening from the point of view of multiplicity and interactivity. In this context, each sound signal is inseparable from the conditions of its generation (source) and propagation (medium), involving issues of forces, tensions, energies, materials, as well as the structure of the physical medium, considering the conditions of emission and propagation, types of surfaces, reflections, absorptions, etc.

Relating the ecological issue to listening, Criton brings up the notion of the three ecologies by Felix Guattari (1990), whose dimensions are social relations, human subjectivity and the environment. From the human subjectivity point of view, Criton (2015, p. 21) mentions the importance of reinventing bodily relations such as mixed sensations involving the intercrossing of different sensory organs, such as bodily listening, which is both auditory and tactile. A model of ecological listening is based on instability, or even on the metastability of a system ready to individuate from the acoustic conditions and psychoacoustic emergences determined by technical objects and their interaction with the sound propagation medium, as long as perception would be the invention of a form and also an act of individuation.

The proposal of a multiplicity of listening can be connected to Simondon's principle of individuation, mainly through the notions of transduction and modulation, as well as considering perception as an act of invention and individuation. By the proposition of a multiple listening, we have a unique and subjective listening that depends on innumerous external acoustic factors dependent on space and time, and internal factors derived from the action of the subject that listens in relation to the sound that is proposed to him/her. This listening, which also has an ecological character, therefore supports innumerous ways of contact with sounds.

For Criton (2016, p. 22), listening is mobile, subjective, and operatory, as it actively moves and positions itself based on certain operations, such as amplifications and reductions of focus from the microphonic to the macrophonic, associations, simultaneities, spatializations, temporal decorrelations. It is therefore a non-directional listening, attentive to the variety of modulations, details and transformations based on the mobility of the acoustic field. In this conceptual proposal, we would have a distributed spatial multiplicity defined by a plurality of listening points, trajectories, dynamic profiles, degrees of distance, diffused sound fields, etc. As a mode of existence, these acoustic, psychoacoustic, spatial, and temporal sound varieties require a multidimensional agency of listening (Criton, 2010, p. 133).

But how does the idea of listening as a mobile, subjective and operatory acoustic multiplicity relate to our artistic proposal of live electronic music? In an article in which we presented a proposal for musical analysis based on the emergence of acoustic and psychoacoustic sound features, we produced a framework that intends to systematize our approach (Rossetti; Antunes Manzolli, 2022, p. 7). In this framework, we consider two complementary approaches that can be considered in an analysis: the first refers to the musicological information of the creative processes, which can be found in the score or in the patch (in the case of a live electronic work), containing materials, processes and compositional structures. The second approach is connected to the sound perception of a performance or recording by a listener, based on audio analysis. Here, patterns and repetitions of events can emerge, giving the idea of a musical form arising from these patterns that is revealed in time. This form may not be exactly the form deduced from the score, since emergent phenomena may occur in the moment of the performance, not foreseen at the time of the work's composition. This approach focused on sound and recording has ecological characteristics, as it considers acoustic and psychoacoustic phenomena that can emerge from the interaction of the sound played by the musicians on their acoustic instruments with the rooms, auditoriums and theaters, which have different acoustic characteristics, such as the use of materials in their construction and finishing, size, insolation, etc. In the case of live electronic music, the acoustic and ecological interaction becomes more intricate, due to the use of microphones to capture the sound of live instruments (which can be different in different performances), the number and characteristics of loudspeakers, sound spatialization, etc. We have tried to systematize this interaction between musicians, electronic processing and the environment in figure 1 below.

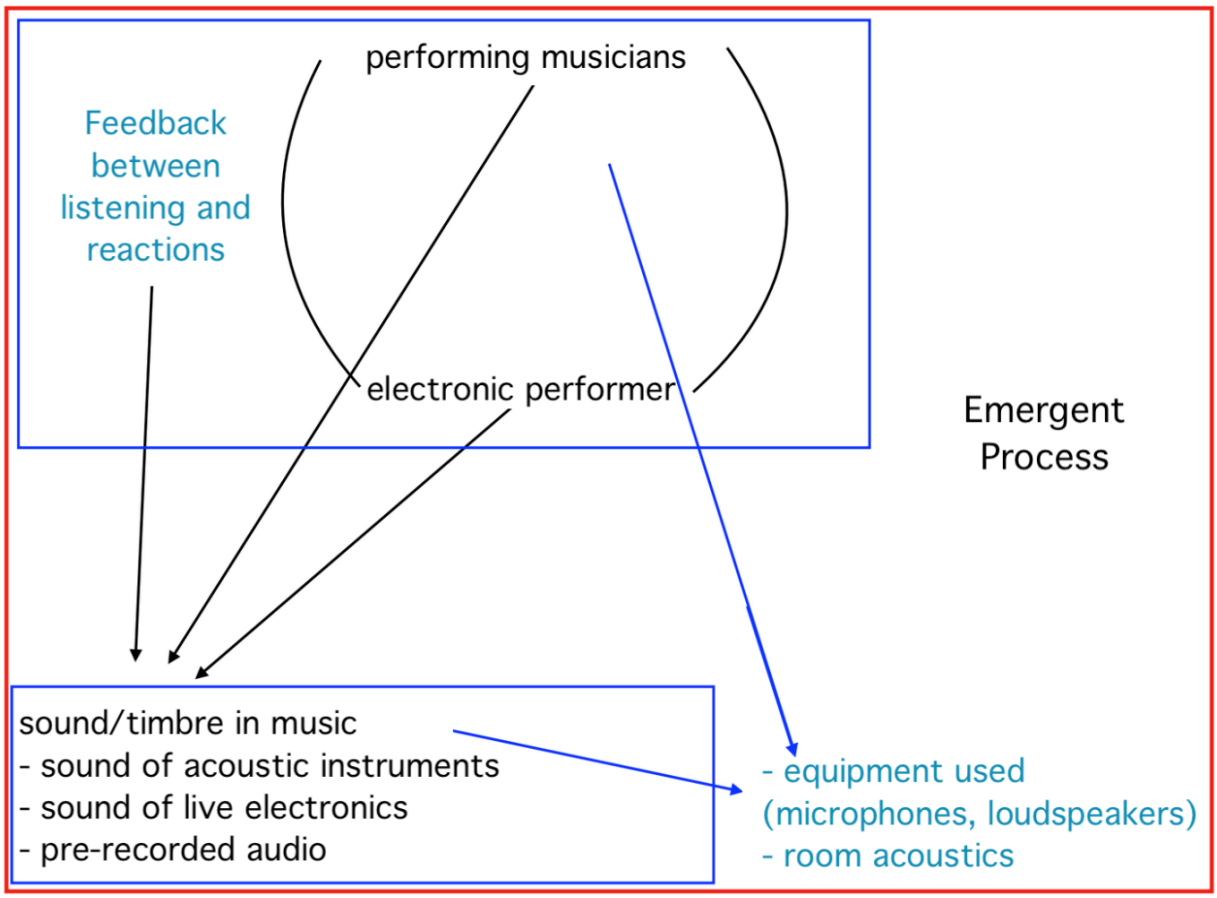

Figure 1 – Systematization of the possibilities of interaction between acoustic performance, sound processing and listening in the performance of live electronic music, configuring an emergent process

The ideas of diffuse sound fields, degrees of distance and dynamic profiles mentioned by Criton are related to an intensive listening, in other words, an individual listening that is the result of a plurality of factors such as culture, memory, affections (as already mentioned in the introduction), as well as acoustic and psychoacoustic factors resulting from the interaction between acoustic instruments, electronic processing and the performance environment. In this context, Simondon's thinking is reinforced when he considers technique as a dimension of culture. As we will discuss in section 3 below, the combination of synthesis, sound processing and spatialization in ambisonics tends to produce a diffused sound field, especially with granular synthesis, due to amplitude modulations and multiple delay lines that influence the perception of grains (Colafrancesco; Guillot; Paris, 2015).

3 Technical Objects and Invention

In the musical context, we can imagine a patch (for example of Max or Pd programs) or acoustic instruments as technical objects (in the sense given by Simondon) that performs operations based on transduction. For Simondon, technique is above all analytical, as a

technical object appears as a mediator between human beings and the world, as well as being carrier of form. Technical thinking brings, in addition to possibilities for action, a relationship between action and technicality, as well as a consciousness between the action performed and the results obtained (Simondon, 2012, p. 236-241).

The presence of an act of invention is the basic condition for the operatory functioning of the technical object. It would be a parity between technical invention and science in its experimental character and in the mental scheme that organizes them. Therefore, technical thought is inventive and connected to processes of individuation, insofar as new forms can be produced (Simondon, 2012, p. 334-335).

An invention is, in fact, a resolution of problems, creating a group of elements integrated into a functional whole. This invention presupposes a metastable and oversaturated initial state containing tensions of incompatible elements, organizing a compatibility and stability through the interconnection of each element of the system. So, there is the formation of an organism or organization with internal resonance, or a flux of communication between each of the elements (Simondon, 2010, p. 83).

In the context of musical creation, we foresee at least three ways in which invention can occur in the sense given by Simondon: 1) by deviation, at the moment when the material used achieves a saturation point, when repetitions, variations and transformations are about to be exhausted; 2) with the fabrication of an instrument, specifically in the case of music connected to technology, an electronic or digital instrument, which solves a creative need or a problem faced by the composer or performer; or 3) through the association between different operators, in the case of mixed music, by connecting and establishing communications between different technical objects (acoustic instruments, microphones, loudspeakers, patches) and agents (performers) participating in the artistic process, resulting in sound and visual art (Rossetti, 2018, p. 5-12). Next, in figure 2, we present the *Interstício de tempo* patch, which is mainly connected to situations 2 and 3 enumerated.

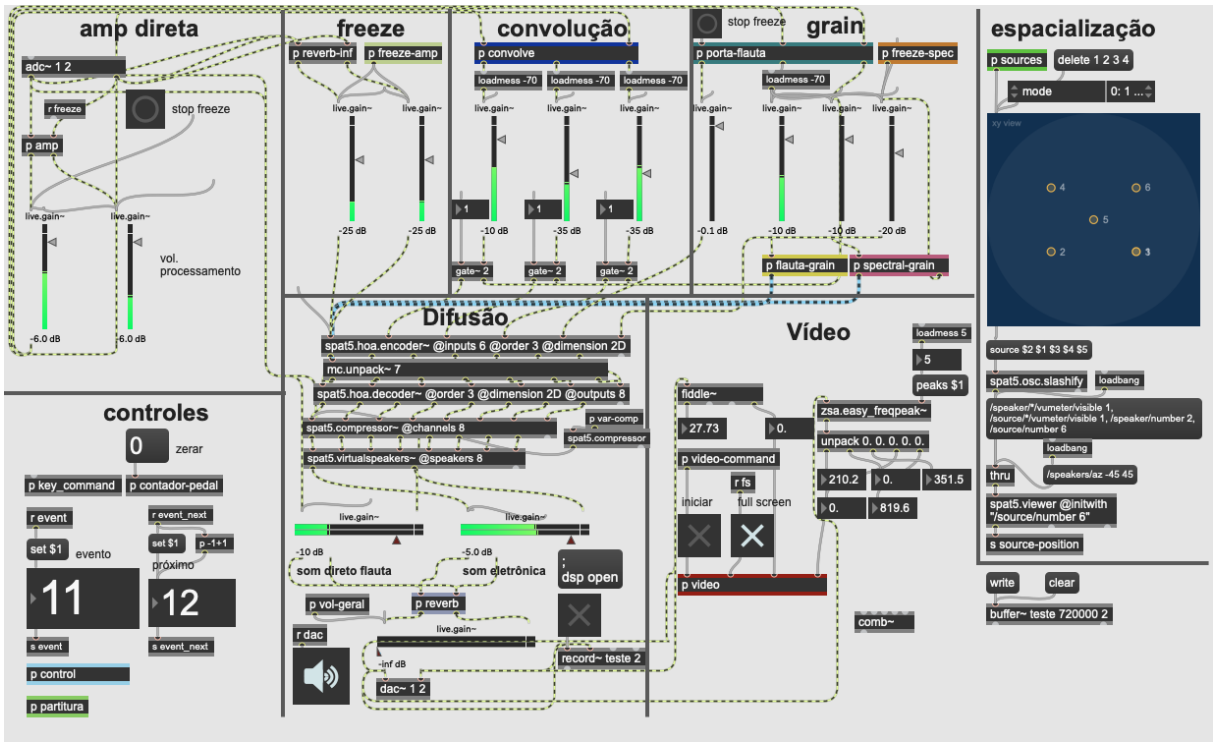

Figure 2 – *Interstício de tempo* patch in Max

Explaining the system created in the patch, in the input we have the flute audio signal captured by 1 or 2 microphones. This signal is sent through different paths, such as: 1. direct amplification and reverb; 2. infinite reverb; 3. real-time convolution; and 4. granular synthesis. All these processes join together to the encoding of signal for the third-order ambisonics system in 2D, which is then decoded into an 8-channel output.

3.1 Synthesis, Sound Processing and Spatialization

The first synthesis process used is infinite reverb applied to the flute sound entering the patch. The second synthesis process used is real-time convolution, or cross-synthesis between the flute's input sound and three different sounds stored in buffers, namely the sound of a cicada, the sound of a flock of birds and the sound of a church organ, all recorded by the composer of the work.

Convolution is an operation that involves multiplying two sound morphologies, which is based on the Fourier transform and correlates the temporal information of one sound, i.e., its dynamic envelope, with the spectral information of the other, i.e., its partials, their respective intensities, and phases (Erbe, 1997). In practice, during the performance of the work, the input sound is filtered by another sound stored in a buffer. Then, so that we can listen to the new sound that contains information from the two initial sounds, the inverse Fourier transform, or sound resynthesis, is performed, seeking to reconstruct the new data obtained in a new resulting audio

file (Jaffe 1987). It is important to emphasize that convolution has no specific control parameters, apart from the intensity of the two sounds involved, and the result depends exclusively on the nature of their morphologies and the time points of each coupling (Vaggione, 1996).

The operation of convolution promotes a modulation between two distinct sounds on two different time scales, one of them providing the temporal contour of the resulting sound (like a mold of a form), as well as the interaction between them in the spectral domain (on a microtemporal scale). Here we can have an interpretation of the principle of individuation as a generator of new forms occurring through the production of a third sound resulting from the interaction between the first two sounds. The temporal mold provides the definition of a formal contour by the modulating force applied at the level of the sound object, in addition to the interaction between the two spectra of sounds involved, in which the transduction operation occurs at the microtemporal level. Here we have, therefore, an individuation operation through the generation of a new sound in time and frequency domains, by means of the patch created, in which we have the organization of interconnected technical objects that constitute an instrumental system that connects operators.

The third synthesis process applied is granular synthesis which, in *Interstício de tempo*, is realized in two layers (from the middle of the piece): in the first, granular synthesis is applied directly to the sound of the flute that enters through the microphones and, in the second, to the sound of the infinite reverb that is sent to the second granulator. Both synthesis processes have different variable values.

It should be noted that granular synthesis in this patch is treated differently from the other synthesis processes used. It is conceived together with spatialization in ambisonics as a single operation, as previously implemented by Wakefield (2006) and Sèdes, Guillot, Paris (2014). As an example, we can approach the granular synthesis applied to the sound captured from the flute (figure 3). It is encoded to the third order of ambisonics in 2D, generating seven circular harmonics (1 central harmonic and two positive and negative harmonics relative to the orders of ambisonics) (Rossetti; Manzolli, 2020, p. 8). After the encoding for the ambisonics system, granular synthesis is applied with different parameters for each of the 7 circular harmonics produced by ambisonics encoding. Finally, the sound produced by the granular synthesis in ambisonics mode is sent to the patch's central decoder for subsequent multichannel projection of the work's sound.

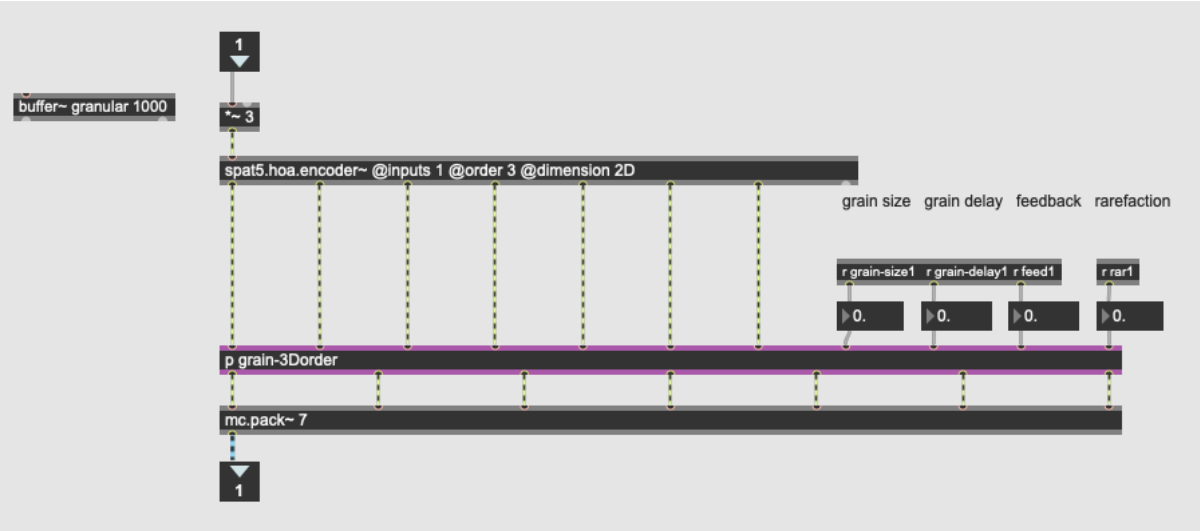

Figure 3 – Subpatch of granular synthesis applied to flute sounds, located between the encoding and decoding processes in ambisonics

The *p grain-3Dorder* subpatch actually performs the granular synthesis in ambisonics (figure 4). It has 7 inlets for the sounds coming from the 7 circular harmonics from the ambisonics encoding, and for each of them the granular synthesis process is applied with different values for the grain size, delay, feedback and rarefaction rate parameters – a parameter referring to the density of the grain cloud created by the synthesis – (inlets 8, 9, 10 and 11). Finally, a pitch shift is applied to each of the synthesis processes with transpositions of up to two octaves for low and high regions in relation to the original sounds. The aim of combining the processes of granular synthesis and spatialization in ambisonics is to create diffuse immersive sound fields of grains with different morphologies that move around in the sound projection space.

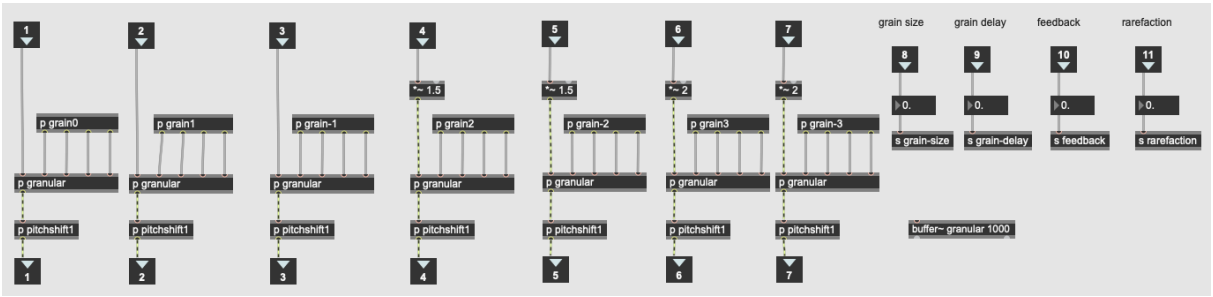

Figure 4 – Subpatch of granular synthesis applied to each of the seven circular harmonics of ambisonics encoding

3.2 Relation between Technical Objects and Listening

We have detailed the granular synthesis in this patch and its combination with high-order ambisonics spatialization conceived as a single operation because it relates both to the

technical issue of the design of the patch and the organization of the objects in its configuration, as well as to the concept of listening approached, with intensive characteristics, having notions of dynamic profiles, degrees of distance and diffused sound fields, as pointed out by Criton. As mentioned, the combination of granular synthesis and spatialization in ambisonics has the property of generating a diffused sound field, with very fast movements of the grains, and the generation of a sensation of sound immersion. In the subpatch in figure 4, different granular synthesis parameter values are assigned to each signal relative to the circular harmonics of the ambisonics encoding. This is one of the reasons why listening is diffusely modulated by variations in intensity, frequency bands, grain size, delay time, feedback, and rarefaction (granular synthesis parameters). As a perceptive result, we found a significant variety of grains with different characteristics moving in the sound diffusion space in multiple layers (Rossetti, 2020, p. 584).

The idea of the presence of circular harmonics in the explanation of the orders of ambisonics is made in analogy to the condition of sounds perceived with a defined pitch, which have a fundamental frequency (relative to a musical pitch) and a series of partials with a harmonic configuration between them, in other words, with proportional relationships close to whole numbers in relation to the fundamental frequency. On this point, we refer to the analogical act, defined by Simondon as a type of transfer of operations with operative relations. Analogy occurs through the definition of structures by the operations involved, revealing the identity of relations with operative characteristics (Simondon, 2005, p. 562).

Spatialization and sound diffusion in ambisonics is performed by the *Interstício de tempo* patch module shown in figure 5 (left). Encoding for the third-order ambisonics system is done by the *spat5.hoa.encoder~* object, and features 6 inputs and a 2D dimension. The six independent inputs are connected to the following effects: input 1: infinite reverb; input 2: convolution 1 (cicada sound); input 3: convolution 2 (bird flock sound); input 4: convolution 3 (organ sound); input 5: pre-recorded sound that divides the two main parts of the piece; and input 6: filtered infinite reverb (high-pass). In Figure 5 on the right, we can see the object in blue (*ambmonitor*) which shows the projection location in the spatialization field of the six different signals encoded for the ambisonics system at a given moment in the piece.

Figure 5 – Projection and sound diffusion module of *Interstício de tempo* patch

The blue cable carries the seven audio signals from two granular synthesis processes in ambisonics: 1. from the acoustic sound of the flute; and 2. from the granular synthesis of the flute's infinite reverb. Based on this choice of procedure, the grains produced by the synthesis processes are neither directional nor located at one point in space. They end up filling the entire sound projection space, creating a diffused field where grains of different sizes and morphologies spread out.

Next, the third-order ambisonics system is decoded into an eight-channel 2D projection, followed by slight compression and a simulation of the eight-channel projection on two virtual channels. This was the configuration used by Carrascoza in a concert held in Berlin on April 2, 2024. Next, the direct sound captured from the flute is mixed with the sound of the electronics, a reverb is applied to this mix and, finally, the final result in two channels is projected in the concert hall.

3.3 VIDEO

The video is produced within the same patch in Max, using mainly Jitter objects. The images are abstract constructions based on dots and lines with different densities and sizes.

The manipulation of the position of the lines and dots in the image (closer or distant from the viewers) and their rotation in three planes (x, y, z) is defined by an analysis of the amplitude and frequency of the sound captured from the flute in real time by objects in the Max program

that perform these functions. This creates a direct identification between sound and image, with a causal interaction between these two elements, searching for performance with more immersive conditions. Figures 6 and 7 show images captured during the performance.

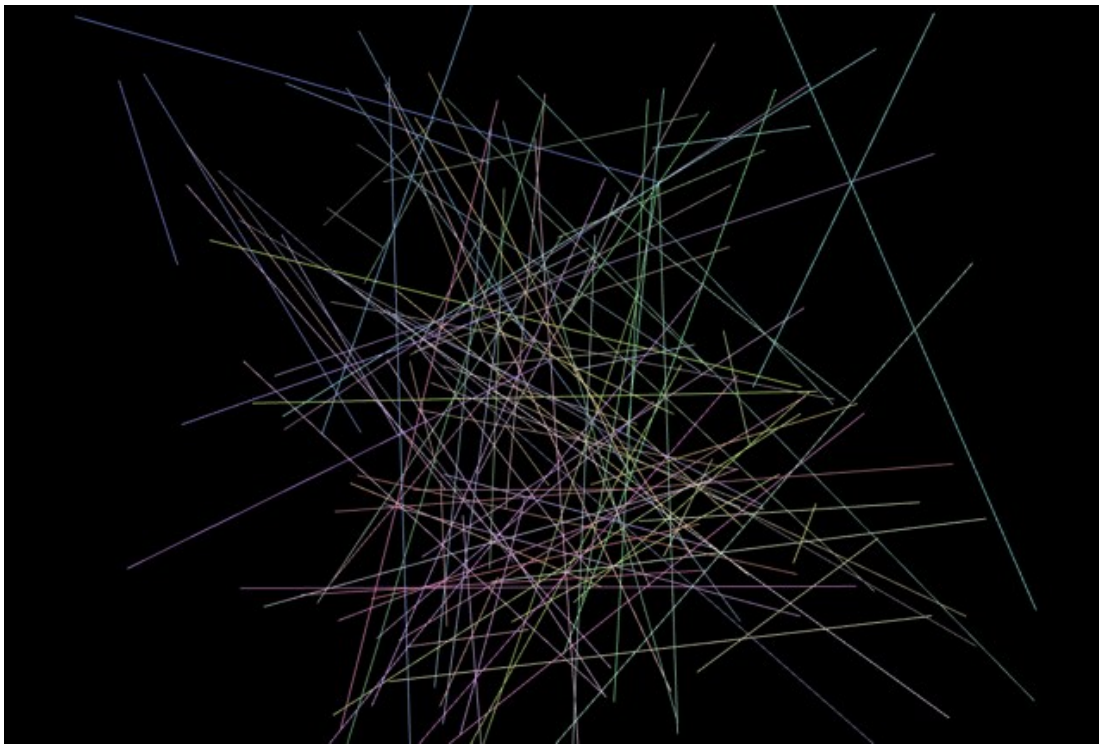

Figure 6 – Line-based frame from *Interstício de tempo* video

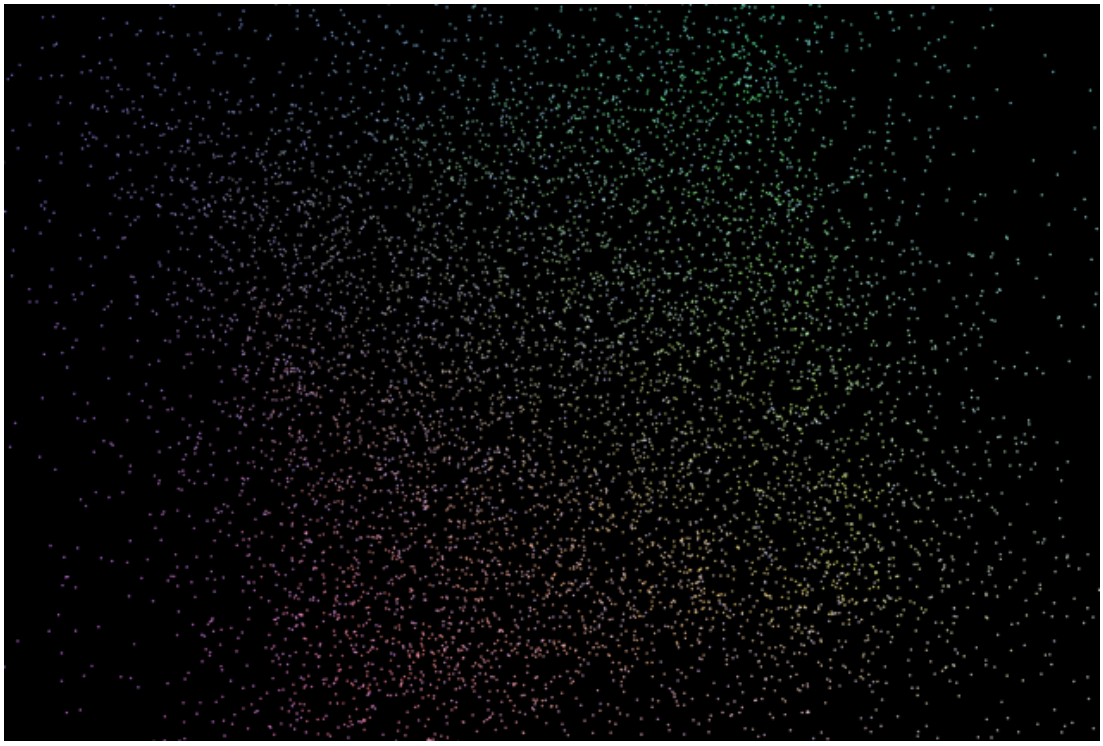

Figure 7 – Point-based frame from *Interstício de tempo* video

5 Final Considerations

In form of conclusion, the synthesis processes, performed in real time from the input of the sound of the flute, combined with a spatialization in ambisonics in the case of this brief analysis, or even in relation to any works that present live interactions between sound and image, can be deepened from an approach that emphasizes the technical and listening biases. The malleability of performance and the technical implementation of synthesis and spatialization processes open the possibility of producing a range of emergent sonorities resulting from the interrelationships between individuals and technical objects and the different transductive and modulating processes involved. Moreover, telematic and in-sight performances enhance the idea of the multiplicity of listening due to the influence of the medium on this process.

In previous texts we have utilized many of Simondon's concepts and studies in computer-aided music and in its processes for the generation of new forms (principle of individuation), as well as transduction and modulation operations, and his studies on perception, invention and technical objects. In all these readings, what stands out is a continuity between universes that are apparently separate, such as nature and technique. In this article, specifically, what we tried to explicit is a possible continuity built between listening and technique as processes that are part of the same phenomenon or system and are interconnected in the creative processes of composition and performance (and also analysis). A technical choice or a technical medium influences sound production, which consequently influences characteristics and listening or leads to certain emergent processes that arise in listening. At the same time, analytical listening can produce certain actions, choices, and technical adaptations, which create a system that feeds back between these two poles. Therefore, music and technology can conceive their own practices based on technical processes, aesthetic and listening choices.

The richness of these practices would not lie in a technical or automation standard, or even in a single possible listening without varieties or differences, but precisely in a technical plurality and a plurality of listening. To the extent that the notion of culture used here comprise technique and that musical richness is mainly based on a variety of cultures resulting in a multiplicity of styles, genres and expressions, technical diversity would be represented in cultural diversity and in musical practices that make use of technology in different creative ways. Different technical configurations can lead to different treatments and materials, different sound results and different ways of listening.

This continuous thread connecting technical mentality, its constructions, creative processes, and perception with the study of the multiple characteristics of listening could lead to more dynamic understandings of the processes and environments of live electronic music. An understanding of sound as energy that is transformed and modulated by the agents who make music and construct its form would contribute to improving the construction of compositions,

sound processing systems and their performances, or even to pedagogical processes and performance practices in live electronic music, including works of different levels of difficulty, with the aim of familiarizing performers with this musical practice that is fundamentally based on sound. Below, in figure 8, we present a table that intends to synthesize Simondon's concepts and their use in describing the processes of creation and performance.

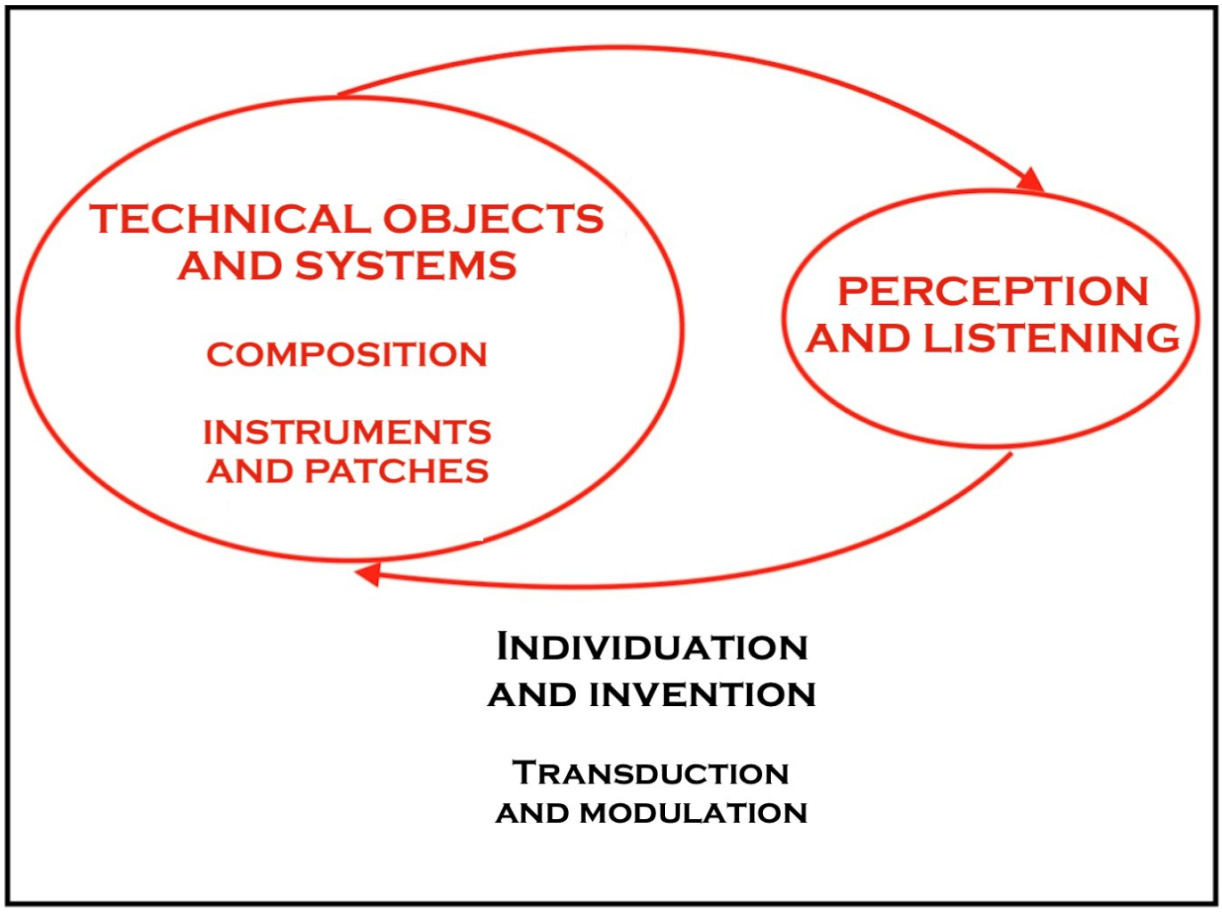

Figure 8 – Individuation and invention as principles for organizing systems based on technical objects, perception, and listening processes

The creation of computer-aided compositions, as well as the construction of systems involving patches and digital instruments constitutes acts of individuation and invention, just as musical perception and listening are also acts of the same nature. Thus, individuation and the invention of new forms, whether technical or perceptive, are based on operations of transduction and modulation, and both can be conceived by analogy, whether by an organism that perceives through its sense organs, or by an individual who creates technical systems for making music. We can therefore see evidence that technique enters the cultural dimension through this continuous relationship with listening and perception in music. Technical or perceptive individuations, among other things, are engines of creativity that give impetus to new works or to new systems of creation, performance, analysis, or musical pedagogy.

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