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Polyphony and embodiment: a critical approach to the theory of autopoiesis

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Abstract:
The term *autopoiesis* was invented by the neurobiologists Maturana and Varela (1980) as a definition of life. Living systems are autopoietic systems as they produce and reproduce their own constitutive elements including the boundaries that separate them from the environment. Luhmann extends the concept of autopoiesis to social systems, which use communication as their particular mode of autopoietic reproduction. Art is a functional subsystem of the society that operates in the boundary between consciousness and social systems. This article approaches the theory of autopoiesis through the relationship between polyphony and embodiment. It discusses some ideas about sound, aural perception and music in terms of autopoiesis.

1. Simultaneity and polyphony

One of the most fascinating things about listening is our ability to perceive a multitude of sounds occurring at same time in the environment. We will call this ability “simultaneous auditory perception”. How do we explain this ability?

From a musical point of view, the concept of “simultaneity” is related to “polyphony”, a term used to designate different kinds of music and conveying two important notions: *multiplicity*, and *individuality*. Polyphonic music consists of *several* and *independent* parts generally subordinated to a unifying principle of organization but also presenting a diversity of elements which create variety. In Western music the distinctions polyphony/monody and polyphony/melody express the predominance of the notion of “voice” and the generative function of “pitch” in musical organization. The typical architecture

of Western polyphony is built on a system of voices organizing pitch in two compositional space domains: the domain of horizontality – the linear or temporal succession of sounds – and the domain of verticality – the simultaneity of sounds. These domains can be represented as vectors in 3D space: horizontality and verticality are associated respectively with the functional categories of “melody” and “harmony”, which do not represent internal differences in the system, but rather different points of view for observing the temporal and spatial relationships between the pitches.

On the other hand, the idea of individual “voices” has been extended in the music of the 20th century to other kinds of note arrangements. Pierre Boulez, for example, defines a voice as a “constellation of events” sharing common criteria and having variable parameters such as density and timbre (1963: 153). According to this vision, which is inspired by the aesthetics of serial music, polyphony is a combination and arrangement of structures at different levels. A polyphonic structure can be superposed onto another polyphonic structure to build, for instance, a “polyphony of polyphonies, a heterophony of heterophonies, a heterophony of polyphonies and so on” (1963: 133).

Symmetry and *periodicity* are key concepts in observing the evolution of polyphony. Henri Pousseur, in his article “Pour une périodicité generalisée” (1970: 240-290), develops a phenomenology of the periodicity focused on the observation of sound phenomena. According to Pousseur, sound is an oscillatory event, organized as a periodic form. Therefore, the organization of polyphony can be observed as the interaction of wave phenomena in a network of relationships, which constitutes its system of reference. In this system of waves we can distinguish, on the one hand, the form from the individual components – the waves observed in terms of frequency, amplitude, phase, spectrum, etc – and, in the other hand, the form of the modulations which produce interferences between the components[1]These two forms can be reduced to the same principle, for the individual components of the system can be analyzed themselves as modulations. Pousseur argues that there is neither a low nor a high limit for observing polyphony as a system of modulating waves: any single wave phenomenon, even the most elementary and microscopic, can be seen as a modulation of even more reduced waves; and any complex wave phenomenon – i.e. a macroscopic system of modulating waves – can be seen as a more or less organic member of a higher form (1970: 271).

If we disconnect the definition of polyphony from its historical and functional categories in Western music, we can apply the notions of “multiplicity” and “individuality” to systems of musical organization built upon other kinds of distinctions such as rhythm and temporality. But by trying to transpose the

idea of polyphony – a musical unfolding of a multi-part structure – to non-Western music, we face the question, discussed by many ethnomusicologists, of whether a multi-part music is necessarily a polyphonic one. Multi-part procedures such as parallelism, homophony, heterophony, bourdon-based music, etc. are found in Western and non-Western music and don't necessarily build polyphony, claims Simon Arom (1991: 34). However, the investigation of polyphony shouldn't be restricted to the description of an ensemble of compositional techniques, for that musical practice is embedded in systems of differentiations other than the sound. In fact, as ofthe beginning of the 21st century, the idea of polyphony has been extended to other domains of creation: on the one hand, the development of an electric, electro-acoustic and digital music has integrated the "acoustic medium" into the broad realm of classical and popular "technoculture" (Lysloff and Gay 2003) and on the other, we are experiencing the emergence of new forms of "sound art" and "interdisciplinary art", which explore the multiple and polyphonic connections between sound, media, image, body, gesture, space movement, etc. (Chagas 2003a; 2003: 241).

For the moment let us focus on the acoustic domain in order to find in it a physical and sensory ground for defining polyphony. According to Arom, the use of the term "polyphony" should be confined to music in which we can distinguish a system consisting of more than one "voice" and the occurrence of a "predictable regularity" (Arom 1993:188). This notion of predictability, introduced by Arom, implies a self-referential conception of polyphony: the multiples and simultaneous events must be organized in a system of relationships producing a temporal processing of *meaning*. The meaning is constituted by the "distinction between actuality and potentiality" (Luhammn 2000; 107), which is achieved through the selection of connective possibilities of the elements in the system. We can have simultaneous and independent "voices" but they must accomplish a self-referential process of producing and actualizing meaning in order to be considered a polyphonic system. Polyphony is thus the manifestation of simultaneity – a system of multiple and individual events – which is recognized as a meaning-producing system distinguishing itself from the simultaneity of sounds occurring in the environment. We have to selectively recognize some sounds as belonging to the polyphony and ignore others as part of the environment. My hypothesis is that our capacity for building polyphony is closely related to our ability for "simultaneous auditory perception". Distinguishing sounds from the environment and distinguishing polyphony as a form of sound organization are similar cognitive operations; both emphasize our capacity for creating meaning by selecting acoustic distinctions.

Therefore, I propose following definition: *polyphony is the specific mode of*

operation of auditory perception which distinguishes multiple and independent events and creates a musical difference between sound and environment. The environment is the totality of simultaneous acoustic events, and the operation is the distinction which marks a boundary separating some events from others. The boundary is the difference between the “marked” space of the polyphony and the “un-marked” space of the acoustic environment (Spencer-Brown 1969) [2].The form of the marked space is the form of the polyphony, which can consist of anything: single sounds, a combination of sounds, or, borrowing Boulez’s words, any “constellation of events”.

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2. Sound and space

In the beginning of this essay I introduced the concept of “simultaneity,” examined briefly the historical-musical context of polyphony, and introduced an operational definition of polyphony which will be later re-elaborated in the context of autopoietic theory. In this section I will approach polyphony through the bias of the medium of“space” in order to investigate some acoustic, psychoacoustic and philosophic implications of the relation between sound, space and architecture. Sound waves travel through the air, but they can also be conducted by other media including gases, liquids, and solids such as wood, concrete, steel and metal. Sounds require a *medium* in order to be perceived as *form*. Air and space are the primary media of acoustic perception, but other than air, which could so far not be codified for musical purposes, space is the medium that shapes the relation between sounds and bodies. Sound waves produce vibrations which are reflected, absorbed or transmitted by spaces. There are two kinds of vibrations: those that reach the body *directly* and those that reach the body indirectly through the *reverberation* in space. The two kinds of vibrations confront each other and make their respective levels communicate. As soon as a sound is produced in space we are no longer in the domain of simple vibration, but in the domain of *resonance*, where different levels of vibration traverse bodies and create different and simultaneous modes of vibration.

Reverberation is also a crucial aspect of musical listening. No music can be enjoyed in an anechoic chamber, where even a symphonic orchestra would sound thin, flat and weak. Bodies need to get in tune with their spatial environment in order to resonate. To enjoy music is also to enjoy the space in which music is performed or heard. Throughout course of the music history we see a close relationship between the invention of polyphony and reverberation. I believe that the architecture of the Gothic cathedrals, for example, contributed to the “harmonic” perception, for the individual sounds of

melody resonate a long time in large spaces and are perceived simultaneously with the subsequent sounds. The earliest form of simultaneity in Western music is the two-voice parallel *organum* of the 9th Century. The sustained note style of the organum continued to develop into the late 13th Century. Perotin's four-voice organa are considered to be very first four-part pieces in the history of western music. It would be interesting to analyze the relationship between the construction of medieval polyphony and the reverberation provided by the space of medieval cathedrals [3].Of course we can only speculate about this question, since we cannot reconstruct the performance conditions of that time. Nevertheless, I claim that the resonating spaces of the Gothic churches, as they drew the listener's attention to the reverberating sounds performed by the individual voices (and also instruments), was crucial for developing the harmonic dimension of medieval and renaissance music, as a synchronization of individual melodies, and later the syntax of the tonal harmony (Chagas 2003b: 182-206). However, the effect of resonance or reverberation on musical composition has been grasped only intuitively, even with harmony becoming a major issue in music, since the Baroque.

The domain of reverberation received more attention from scientists and musicians when musical polyphony shifted the focus from the *harmonic* to the *colorist*. As pointed out by Pousseur in his emblematic essay *L'Apothéose de Rameau* (1968), the harmonic domain, which is historically attached to the beginning of Western polyphony, is associated with the numeric, quantitative aspect of sound, to its virtual proportionality as vibrational system. Harmony is related to notions such as polarity, attraction, subordination, repulsion, etc. Harmonic complexity is better grasped in terms of "family resemblances" (Wittgenstein 1971: 57), which organize, for example, the notions of *consonance* and *dissonance*. The colorist domain is actually a primary domain of sound perception, as it is associated with the very first impression of sound as a phenomenon: its luminosity, or color, or timbre, or *Klangfarbe*. This function depends both on such experiences as inertia, weight, obscurity, opacity, gravity, etc. and the notion of *periodicity*, which establishes the difference between "sound" (periodic vibrations) and "noise" (non-periodic vibrations). Music has always dealt with colors and differences between sounds, but those differences have been mostly associated with bodies (voices) and objects (instruments) which produce sounds. One of the consequences of polyphony is to increase levels of sound perception, which are perceived as differences in loudness, frequency and color. The development of chamber music and orchestral music in the 18th and 19th centuries reflects the process of differentiation of musical parameters leading in the 20th century to radical approaches like the shift from melody to Klangfarbenmelodie in the music of Anton Webern and the emergence of

electronic and electro-acoustic music [4]. The reverberation time of modern concert halls has been extremely reduced in comparison to that of medieval cathedrals; different spaces are being designed for different kinds of music – chamber music and orchestral music, jazz, pop, etc. Nevertheless, as pointed out by Everest, our present knowledge of reverberation is still very incomplete (2001: 194). We simply know that different kinds of music require different reverberation times, but we don't have enough clues about the impact of resonance on our bodies.

In the age of technical reproduction, the concept of reverberation undergoes a radical change. Reverberation becomes an instrument of the *deconstruction and re-construction* of space. Natural reverberation must be eliminated from recorded sound and reconstructed artificially in the "neutral" listening environment of the control room. Artificial reverberation has been an additional feature in analog recording and is also necessary in digital audio processing. All the music we hear through electronic and digital media such as radio, TV, CD, DVD or i-pods, etc. is being processing by some kind of "signal processing" apparatus, which treats sound as numerical data and simulates reverberation and other effects. According to Flusser, apparatuses are black-boxes that simulate thinking in such a way, that "human beings function as a function of apparatuses" (2000: 24). It doesn't matter what kind of music we are listening to: classical, popular, pop, rock, rap, traditional music of the world, etc. Every single sound has been flavored with some "effect", most of them with a chain of effects rounded at the end by a sort of reverberation "sauce". These effects may or may not add value to the music, but in any case, they represent a function of the apparatus that produces them [5].

Digital reverberation illustrates two fundamental principles of contemporary music: (1) time delay and (2) feedback. Everest describes a simple model of digital reverberation which explains these principles: "a signal is delayed and a portion of the delayed signal is fed back and mixed with the incoming signal, the mixture being delayed, and so on" (2001: 156). This schema not only describes of an electronic signal patch but also reflects the way we deal with recorded music today, particularly the music of the past: we listen to some musical work which has been recorded and manipulated by a "time delay" machine (a recording machine), and our listening experience is fed back in the global media machines that produce and reproduce music in our society [6].Listening to recorded music is a "time delay" experience, which is shaped by "time delay" machines and fed back in the same (non-trivial) machines. The manner in which music is "consumed" in post-industrial capitalist societies reinforces the idea that polyphony is essentially the simultaneity of musical experiences generated by music: both contemporary music and music

composed in the past and re-processed in the present. The musical experience consists not only of musical works but also includes musical discourses and observations that organize music into a social system – a system of production and reproduction of communications based on the observation of musical works (Luhmann 2000). We will discuss this idea later.

Just as we can only intuit the relation of space, natural and artificial reverberation to the body, we lack sufficient knowledge about the effects of different kinds of sound and music on the body. In fact, we ought to consider the musical experience as a resonance coupling at least two bodies: the *performing* body and the *listening* body. (Let's make clear that the concept of body is not necessarily associated with human beings performing or listening to music, but also with the objects, the machines and abstract music systems taking part in the musical process). These two bodies are thus coupled both through the physical *vibrations* and *resonances* produced by the sound waves in the space and also through something less physical and more intuitive that Deleuze calls *sensation*. The concept of *sensation* conveys the phenomenological point of view that subject and object – performing and listening bodies – are indissolubly connected through their *Being-in-the-Word*. Deleuze defines the work of art as a *bloc of sensations*, as something that exists in itself and exceeds any living being. (1994: 164). According to Deleuze, sensation must be understood as a "synthesis of a plurality of levels or constituting domains" (2004: 33).His aesthetic emphasizes the multi-disciplinary character of any artistic object, as the levels of sensation are connected to the different sense organs and also to other levels. In his essay on the painter Francis Bacon, Deleuze draws the phenomenological hypothesis that "between a color, a taste, a touch, a smell, a noise, a weight, there would be an existential communication that would constitute the "pathic" (non representative) moment of *the* sensation" (2004: 37). The sensation is thus a kind of invisible force acting on the body, the experience that creates a unity between the performing and listening bodies: "at one and at the same time I *become* in the sensation and something *happens* through the sensation, one through the other, on in the other" (2004: 31). Following this point of view, we can define polyphony as the sensation that captures simultaneity in the world. The body is not only taken by the vibrations and the resonances – the physical experience of sound and space – but also by polyphonic forces: in the way that painting renders non-visible forces visible, music must "render non-sonorous forces sonorous" (2004: 48) and polyphony renders non-simultaneous forces simultaneous.

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3. The acoustic environment

In the first part of this essay I proposed an operational definition of polyphony – the distinction that introduces the difference between *sound* and *environment* – and in the second part I investigated the first term of this distinction – sound – in relation to space. In this section I will approach the second term of the distinction: the environment.

According to the model of acoustic communication developed by Terhardt (1998), the investigation of simultaneity and polyphony should be undertaken in the realm of three different domains: sound waves, auditory sensations and information. We would than study the correlation between simultaneity in the physical word (the structure of sound waves), simultaneity in the subjective perception (the perception of simultaneous events) and simultaneity as information (the meaning of the simultaneous sounds) [7]. The auditory acquisition of information, following Terhardt's model, is accomplished byauditory systems that work as sensors selecting the information from the acoustic environment and create a subjective *representation* of sound objects. But the auditory systems can only achieve this subjective representation of the acoustic environment by intelligently *interpreting* the sound sources existing in the real world. Auditory representation and interpretation are analytical processes. The representation of multiple sound objects is achieved through a time-based interpretation of spectral-pitch patterns. The auditory system discovers and represents *periodic* sound objects, compensates for different kinds of distortions and discontinuities of sound signals, and also provides complementary information for defining the sensation of pitch. Terhardt's virtual-pitch theory illustrates this representational approach to auditory perception (1998: 358-368).

Nevertheless, instead of focusing on the ability of the "ears" and the "brain to represent and interpret sound objects, I assume an *enactive* approach to auditory perception, according to which, listening can be defined as a "cognitive process involving multiple levels of interconnected, sensori-motor activity" (Varela, Thompson and Rosh 1991: 206). The enactive approach is also an attempt to overcome the dichotomy between object and subject; it proposes a phenomenological synthesis between the traditions of realism, which sees the world as an external reality, and idealism, which claims that the word is an internal construction of ourselves. As the focus shifts away from the process of acquiring information to the way of *being* in the world, listening thus becomes an embodiment process, an interaction of our bodies with the acoustic environment. Sounds affect the whole body, and embodiment is shaped by our aural history and by multiple levels of interaction with the sonic environment.

The ability for simultaneous auditory perception, which seems to be closed related to pitch and frequency (Terhardt 1988), is thus a kind of interaction developed by certain kinds of living system, such as humans and other animals, in their specific interactions with the environment, in both a biological and social sense. We are surrounded by sounds and can distinguish them as time and space events. We are connected to the sonic environment, for instance, when we are driving cars, watching television, or talking with people. And we are also listening to sounds, but in a more unconscious way, in such situations as reading a book, talking with people in a café, sleeping, writing an essay, etc. Of course, turning the radio on, talking to somebody, or sitting in a concert hall are all different kinds of listening. According to Sterner, who developed a study of the aural past (2003a), the word “listening” designates a whole range of heterogeneous activities involving the perception of sound. In his study of the function of music in commercial spaces, Sterner utilizes the ambiguity of the term “listener” to “denote a person perceiving sound in either the active or the passive sense, or both” (2003b: 319). Listening, thus, is an activity that presupposes different kinds of cognitive actions, different kinds of interaction between the body and the environment.

The concept of soundscape, introduced by Murray Schafer (1977), reflects the awareness of the acoustic environment as a natural, cultural and social landscape and provides a foundation for the development of interdisciplinary sound studies, embracing and cross-crossing different traditional areas such as acoustics, psychoacoustics, noise pollution, sound engineering, signal processing, communication, media, language, music, etc. Schafer (1994) defines a soundscape as a sonic environment; his research focuses on the relationship between man and the different kinds of sonic environments such as natural, industrial, electric, etc. Thompson emphasizes listening by defining soundscape as an auditory or aural landscape (2003: 1). A soundscape is “simultaneously a physical environment and a way of perceiving this environment”. In her study of the American soundscape of the beginning of the 20th century Thompson analyses scientific and aesthetic ways of listening and the reformulation of the relation between sound and space. The soundscape of modern societies is shaped not only by sounds associated with the traditional categories of language, music and nature but also with the sounds produced by mechanical, electric and electro-acoustic devices. Audio technology creates not only new sounds, but also new spaces and ways of listening. Technical reproduction disconnects the artwork from its origin and materiality (Benjamin 1977). The recording of an orchestra becomes its own reality, a new way of thinking and listening to symphonic music. Such electric instruments and electroacoustic devices as microphones and loudspeakers affect the cultural practices involving music in the whole word. Digital technology accomplishes a further step:it abolishes the difference between

original and copy, allowing the manipulation of the reproduced material and intensifying the process of recombining media and forms (Chagas 2003a). Digital music and sound art explore new connections between sound, noise and language and shape the physical and cultural spaces of listening. Digital art intensifies the enactive character, the cognitive process, by exploring new ways of combining sound, images, movement, gestures, spaces, etc., on the one hand, and intensifies the experience of virtual acoustic spaces as simulation, on the other. (Baudrillard 1995).

Technology increases the variety of musical forms and performing and listening situations, which convey different cultural and social values. Beyond the traditional dichotomies between classical and popular music, or between art and entertainment, we need to analyze the sonorities generated by music and other practices involving sound as a continuous experience of constructing and deconstructing sonic environments. For instance, how do we find a common ground between the “background” music of commercial spaces (which can be both classical and popular) (Sterne 2003b), and the “foreground” music performed in live concerts? We must also analyze the way in which bodies interact with these different environments. For instance, how the is the body affected by the energy and tensions produced in acoustic immersive spaces (such as malls and concert halls), and by listening to music through mobile devices such as ipods? Viewed from this perspective, the quality which we call “simultaneous auditory perception” is a complex issue involving not only the ability to perceive a multilayered structure of simultaneous sound events but also to manage the variety of acoustic “territories” developing simultaneously in our lives. According to Guattari (1992), such acoustic territories would be better understood as “complexes of subjectivity”, founded upon the multiple exchanges between individuals, groups and machines in the capitalistic society. He argues that this subjectivity is essentially a “polyphonic and hetero-genetic” experience and can only be understood through an ethic-aesthetic approach (1992: 17-20). We will return to these ideas at the end of this essay.

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4. Polyphony and cognition

As I said before, the traditional connotations of the word "polyphony" concern both the domains of "sound" and "composition". In the domain of “sound”, the term polyphony is related to the idea that one can perceive a "multiplicity" of sounds and distinguish "individually" the various processes which generate them. In the domain of “composition” the idea of polyphony is shaped by a similar idea: it presupposes that one can listen to music by distinguishing both

the various sequences of events which are developed simultaneously and the multiple relationships existing between them, which create a sense of global unity. Simultaneity of sound alone is not a sufficient condition for the existence of polyphony. If one listens to a single interval for the duration of a couple of minutes – at least two sounds with recognizable and different pitches produced by two bodies, instruments or electronic devices – one will not have the feeling of a polyphony unless one perceives some changes that can be given individual or structural meaning.

Let us think of somebody who listens for the first time to a four-voice fugue by Bach, or to dense orchestral polyphonic textures such as Schoenberg's *Pélleas et Mélisande* (1903), Stravinsky's *Le Sacre du Printemps* (1913), Ives's *Symphony no. 4* (1925), Stockhausen's *Gruppen* (1958), Ligeti's *Atmosphères* (1961), Boulez's *Pli Selon Pli* (1962), etc. Or maybe she/he simply listens to a four-part motet by Josquin des Prez. Will this listener be able to distinguish the multiple polyphonic layers of these compositions? Can she/he follow the individual sequences of events occurring simultaneously? The answer will be undoubtedly negative, unless we are dealing with an exceptionally talented listener. Certainly, by listening several times to any of these pieces, one will develop the ability to make more distinctions in the musical structure and gradually build an auditory impression of the polyphony. Initially there is something like a scaffold of musical fragments and intuitions that we fill with forms as our "comprehension" grants meaning to our perceptions. With each new instance of listening, we discover new things that have not been detected before and the "perception" reveals new aspects of the polyphony. The impulse to listen, which pushes us to keep discovering the music, will cease only if the music doesn't succeed on holding our attention (or of course because of an external fact which prevents us from listening to it). But even if the music ceases to interest us, we will always have the impression that there is still something to perceive or to understand (to discover) in the polyphony.

This hypothetical description of how we listen to polyphonic music raises the fundamental question: How can we be fascinated by polyphony (and consequently by music) if we are not even able to perceive it?

Polyphony is found in the music of several ethnicities, cultures and geographic regions of the world. Unlike melody, which is considered a universal human phenomenon, the meaning of polyphony is marked by its meaning in the particular music. From a historical prospective, polyphony is a legacy of the Middle Ages (the first theoretical sources of the polyphonic music date from the 10th century), one of the many "inventions" of medieval society that have been incorporated into our social life. One can describe the origin of this

invention in a few words:polyphony is created when people sing plainsong melodies with more than one voice; the voices must sing simultaneously and form intervals which are not unisons or octaves (these intervals being regarded as natural "doublings" that occur when several people - adults and children - sing the same melody together).

The invention of polyphony, as simple as it appears to us today, looks astonishing if analyzed from the perspective of the relationship between an “external” and an “internal” world [8].Let us focus on this very basic musical situation: I sing a melody in duet with somebody; my partner and I sing the same melodic line, but in parallel fifths or fourths. This is the principle of organum, which is considered to be the first form of polyphony and still exists as a compositional technique in many musical languages. In order to classify the music produced by our two voices as "polyphony", it is necessary that I achieve at least two cognitive operations:

1. I must perceive the sounds produced by my own voice and that of my partner as something “exterior”. This is the necessary condition for perceiving the differences (between our voices) as independent, analyzable events.
2. I must perceive the sounds produced by my own voice and that of my partner as something “interior”. - This is the necessary condition for perceiving the differences (between our voices) as a single, synthesizable event.
3. I must be able to communicate the perception of these differences to my partner and possibly to a third person who is listening to us.

How can this happen? Let us examine this question from the point of view of the neurobiological thinking that generated the autopoiesis theory, which defines our sensory nervous apparatus as an operationally closed system, without inputs and outputs towards to the external world (Varela 1979: 145). The organization of the nervous system is defined by the relations occurring in the network of the neurons which interact and generate an image of the world (Maturana 1985: 142). Any neuronal activity causes changes that affect the activity of other or the same neurons: the nervous system operates in an *autonomous* and *circular* way. We hear and see practically nothing from the outside. According to Foerster, "we are primarily listeners of the brain, listeners of the head - and not of listeners of music" (Foerster 2000: 142).

This specific aspect of our perception is explored by the “constructivist” approach to cognition, which claims that we perceive the world as representations of our internal activities. Some tricky mechanisms of our

perception contribute to this point of view. An example is our capacity to compensate for the *blind spot*, a “hole” in our vision caused by the absence of photo receptor cells (rods or cones) in a certain part of the retina (Foerster 1984). Experiments have shown that this visual gap is not itself "visible", because the brain compensates for it, ”inventing" images to fill the blind spot. The remarkable aspect of this blindness is that it “is not perceived at all, neither as something present, nor as something absent.” Foerster seized this constructivist quality of our perception in his emblematic phrase: "We don’t see that we can’t see" (1998: 117). In other words: perception is always related to the action that allows us to see (or to hear) something, even if it is not something “real”.

Audio technology offers many examples of how auditory perception compensates for the limitations of electronic apparatuses. The reproduction of low frequencies is a known case. The frequency response of such audio devices as microphones, recorders and loudspeakers is often limited to the middle range of the listening spectrum because low and high frequencies require expensive technology, which is not necessarily compatible with the commercial interests of the entertainment industry. But this limitation doesn’t prevent people from listening to symphonic music played back poorly from low quality speaker devices such as portable radios, cassette recorders and digital mp3 players. Our auditory perception generates the low and high pitches that make it possible to recreate the harmony and therefore understand the composition. According Terhardt’s theory of virtual pitch, the perception of these missing pitches is accomplished through associations with the spectral characteristics of harmonic sounds, particularly the speech sounds of the listener (1998: 360) [9]. The success of mp3 audio files is an emblematic example. Digital formats such as mp3, which take advantage of the “economic” aspect of data compression, explore psychoacoustic aspects of listening, such as the mask effect, which occurs when some frequencies are not well perceived or perceived at all because they are hidden or covered by others. Data compression concerns also video and image technology. As it becomes an increasingly important issue in digital media and communication, we will need to take its impact on visual and auditory perception much more seriously.

Digital compression is one of the many technologies which are currently shaping what Maturana calls the "space of the perception” of organisms in the environment. He defines perception as the "process of compensation of modifications undergone by the nervous system in relationship with an interaction" (1985: 86). Perception and the space of perception, claims Maturana, do not reflect or represent any quality of the environment, but only “the anatomy and the functional organization of the nervous system in its

interactions” (1985: 86). Therefore, perception is not the mechanism used by the organism in order to collect information from the environment. Maturana carried out experiments showing that the coding of colors results from interactions in the activity of the retina of primates (Maturana 1985: 88-137). He concluded that "the names we give to the colors can be correlated with the states of the neuronal activity, but not with wavelengths" (Maturana and Varela 1994: 8-9).

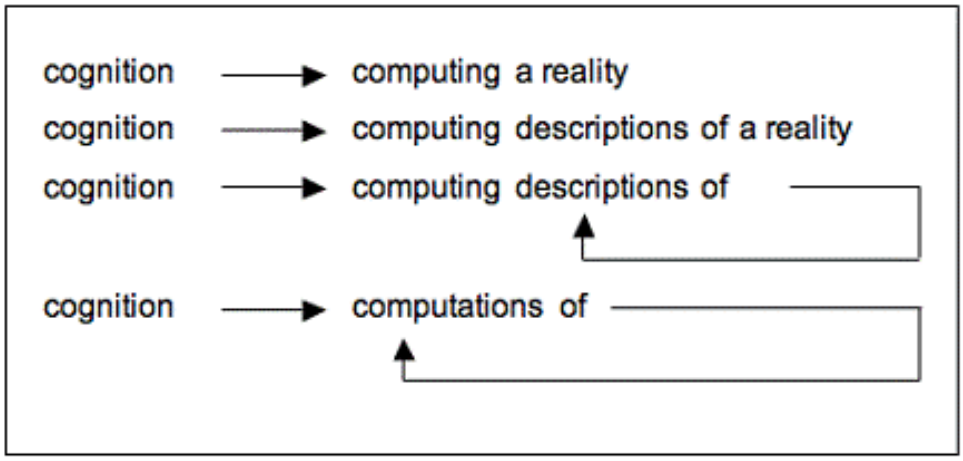
Concerning auditory perception, Foerster (1984) reports an interesting experiment, consisting of implanting micro-electrodes in eight different stations of the auditory pathways in a cat’s brain, from the nervous cells that first perceive the auditory impulses up to the brain. The cat was confined in a cage containing a food box whose lid could be opened by pressing a lever. But the connection between the lever and the lid was only active when a “beep” – a short and repeated sound of a precise pitch (C6 = 1046 Hz) – was presented. The cat had to learn that this beep “meant” food. The analysis of the electroencephalogram shows that no sound was perceived by the cat as long as it did not interpret the sound as connected with obtaining food. Foerster concludes that (1) “nothing is heard “unless coordination of sensation and movement allows us to grasp what appears to be there; and (2) the nerve cell encodes only the quantity of a stimulus, but not the quality. This is what he calls the “Principle of Undifferentiated Encoding” (1984: 291)

The example of the cat shows that we "understand" that there is something "outside" by coordinating the sensation with the "interior" movements of our nervous system. Each sensation causes a change of state in the network of the nerves. In the case of auditory perception, our body produces a correlation between the periodic variations of the pressure of the air and what we describe as "sound" or "music". But this doesn’t explain how our brain discloses the diversity of our experience. , Returning to our starting question, neither does it explain how we distinguish the sound sensations produced by two voices singing simultaneously and seize them as a polyphonic unit. This implies simultaneous operations to distinguish the events at several levels. Polyphony occurs only when consciousness simultaneously distinguishes the individual voices and their multiple relationships. Two voices singing in unison produce sound variations which can be decoded as "perturbations" by the auditory system, but these "perturbations" must trigger structural changes in the cognitive process in order to establish a sensation of polyphony. Therefore, there should be a *structural coupling* between the nervous system and consciousness. We will return later to this concept of structural coupling.

Foerster (1984) proposes to explain cognition as a recursive process of descriptions of descriptions of a reality, as an infinite process based on the

concept of computation. The physical sensations are correlated with a certain experience which we describe as "a reality". In the case of a musical sound, the cognitive process calculates descriptions of this reality which can produce, for example: a certain motor activity, a gesture, an expression, the movements of “following a musical phrase with understanding” (Wittgenstein 1980: 51e). How is that possible, asks Wittgenstein? What is the experience of polyphony? How can someone express the understanding of polyphony? How do I experience polyphony by performing or listening, for example, to a two voice organum or a Bach fugue?

For Foerster (1984), since "a reality" is only the description of a reality, the cognitive operation is reduced to recursive calculations and descriptions of a reality, which are reduced to calculations of descriptions of descriptions, which are reduced to calculations of calculations. Figure 1 shows his successive interpretations of this recursive process, (1984: 294):



According to this conception of cognition, founded on the idea of a recursive process of the "computation" of a reality, the nervous system is capable only of self-observation and establishing a contact with the environment only in the recursive field of its own operations. Thus, the nervous system cannot operate outside its own boundaries, and the totality of its operations produces only *self-reference*. To borrow a statement from Luhmann, the nervous system “cannot establish any contact with the environment from within the recursive realm of its own operations” (2000: 8). Only consciousness can exteriorize the external world, such as it is apprehended by perception, and make it available for communication. Consciousness operates by producing a continuous distinction between *self-reference* (sensations) and *hetero-reference* (sequential and recursive operations), thus accomplishing the emergence of the external world. By creating the distinction between inside (self-reference) and outside (hetero-reference), consciousness corrects the operative closure of the nervous system.

5. The distinction between perception and communication

Luhmann developed a view of modern society as a functionally differentiated system consisting only of communication. Society is akin to living systems; it detaches itself from the environment, which is not only the physical environment but everything which is not-society. Society defines itself by creating the boundaries that reduce the complexity of the environment and develops its own subsystems. Subsystems are functional systems of society based on specific types of communication: law, science, politics, economy, education, love, mass media, art etc. These functional systems are autonomous and distinguish themselves from their environments. Luhmann's theory approaches these functional systems by describing the operations that "actually occur by which the system reproduces itself and its difference to the environment" (2000: 4). These operations constitute the particular mode of autopoietic reproduction of the social system, and their elements are communications, "which are recursively produced by a network of communications and which cannot exist outside such a network (Luhmann 1986: 174).

The operations of social systems produce *meaning* [Sinn], which is operationally a "*re-entry*" of the difference between system and environment into the system itself (Luhmann 1997: 45). The concept of re-entry is borrowed from the calculus of indications developed by the mathematician George Spencer-Brown in *Laws of Forms*. Spencer's logic introduces the idea of form as a performing act: "Draw a distinction" (1969: 3). The distinction creates a form by indicating three values: (1) the marked state of the indication, (2) the unmarked state that excludes the rest of the word and (3) the observer drawing the distinction. The operation of drawing a distinction and observing it gives the observer the possibility of making further distinctions. As pointed by Baecker, it constitutes a perfect example of communication, as it generates three options for handling the distinction: "to call it again, thereby accepting its motives, values and content; to cross it, looking for different motives, values, and contents; or to re-enter it, perhaps in order to examine more closely its motive, value, and content" (Baecker 1999:4). Luhmann developed the analysis of the functional subsystem of art in a series of several articles (Luhmann 1986a; 1986b; 1990; 1994) and in the book *Die Kunst der Gesellschaft* (1995a), which has been translated into English as *Art as Social System* (2000). As in most of his previous books on

other functional systems, Luhmann reviews and reconstructs the framework of his theory by reflecting on the issues of that particular system, so that *Die Kunst der Gesellschaft* represents a later stage of the theory of social systems [10].

In the beginning of his observation of the artistic system Luhamnn draws a distinction between *perception* and *communication*. He qualifies this approach as a “new territory for aesthetics as an academic discipline” (2000: 15), because, as he claims, it eliminates the idea of subject and the distinction between rational and aesthetic cognition. Art operates in the boundaries between social systems (society) and psychic systems (consciousness) and that is why it presupposes different systems of information processing. As a communication system art cannot perceive; there is no way that individuals can communicate through art. Luhmann says: “Communication can no longer be understood as a ‘transmission’ of information from an (operatively closed) living being or conscious system to any other such system” (2000: 9). As we stressed before, communication is the particular way social systems operate in order to produce meaning. In other words: communication is a particular way of constituting *form* in the *medium* of meaning. In the course of his theory, Luhmann develops different ways of articulating the difference between cognitive and social systems, including the distinction between *medium* and *form*, which is developed in *Die Kunst der Gesellschaft* and plays an important role in his later theory (Luhmann 1997) [11].

Like the nervous system, communication is an operatively closed system which can only produce the operational elements of its own system - i.e. its own communications. The closed operational mode dismisses the possibility that communication – i.e. social systems – can perceive. Human beings participate in communication only as "addresses". They do not originate communication, because communication works only with its own operations. In one of his most polemic articles Luhmann launches the provocative thesis: "But humans cannot communicate, not even their brains can communicate, not even consciousness can communicate. Only communication can communicate" (Luhmann 1995c: 111).

In order to reach this conclusion, Luhmann considers that communication systems are autopoietic systems in a strict, biological sense of the term, and not simply metaphorical – i.e. systems with no inputs and outputs and able to produce and reproduce their components in the space of their existence. The autopoietic organization prevents communication from either receivingor producing perceptions. Luhmann rejects the assumption, largely accepted by metaphysics and phenomenology, that communication can express perceptions, thus making them accessible to the others. Consequently, what I

perceive remains operationally inaccessible to communication. This point of view implies the application of the property of *operationalclosure* of nervous systems, conscious systems and social systems:

> Consciousness compensates for the operative closure of the nervous system, just as the social system compensates for the closure of consciousness. The world in which the system's unique reality is reproduced in the form of recursive connections between its operations is a meaning correlate of the system's own operations (Luhmann 2000: 10).

Unlike the nervous system, which operates only by internal references, the mode of operation of consciousness is characterized by continual distinction between self-reference and hetero-reference in all its operations. Consciousness thus corrects the operational closure of the nervous system by making the distinction between inside and outside, between *self-reference* and *hetero-reference*. This distinction is articulated as a semiotic structure producing *meaning*. The communication process is a self-accomplishing, self-defining process in the medium of meaning: everything which is determined by communication is determined by communication itself. This occurs: (1) from the factual point of view by means of the difference between self-reference and hetero-reference;and (2) from the temporal point of view through recursive anticipation and feedback.

Let us return to the musical situation described earlier: I am singing a duet with somebody else. What kind of cognitive process is going on when the music sung by these two voices – the combination of the sounds produced simultaneously by me and my partner – is defined as polyphony? According to the cybernetic conception of cognition, what happens is a recursive process of "calculation of a reality" (Foerster 1984, see above); I can say that I am exteriorizing the construction of an external world. I am calculating – analyzing and synthesizing – the sounds of the world on the basis of the perceptions of my own body. Polyphony constitutes the limit of my comprehension and reflects my incapacity to grasp the world as a unity. There is an abundance of information, and at every moment, I have to choose some aspects of it to exteriorize in terms of self-reference. It is my whole body – not merely the nervous system – which is presented to my consciousness in the form of "polyphony". At every moment my body vibrates, attuned to the diversity of sounds and resonances, to the simultaneous and independent voices, to the successive and simultaneous events occurring and changing over time.

These perceptions are processed by my consciousness only as *immediate* impressions, while my brain carries out quantitative computing operations, which are highly selective and operationally recursive. These operations are

mediate in nature. My perception cannot distinguish the multitude of sound sensations as a unit. But polyphony can organize simultaneous auditory perceptions, by providing the forms which show the possibility of creating order in the process of "externalizing" the world by means of consciousness. Polyphony is the possibility of combining the external world (hetero-reference) and the interior world (self-reference) by distinguishing the sound world that I perceive as a unit, within which I can still make more distinctions. In other words, by observing polyphony in the world, I grant the world the possibility of being polyphonic, of being analyzed and synthesized by new polyphonic distinctions. I can reintroduce the distinction of the polyphony in the polyphony, the distinction in the distinction or, borrowing the words of Spencer-Brown (1969), the "re-entry" of the form in the form.

Polyphonic music intensifies spatial and temporal experiences of simultaneity because it provides the forms which show this possibility. This formalization is precisely the function of art: art enables communication through avoiding language, language as a structural coupling of consciousness and communication. Art is produced exclusively for the sake of communication, and it achieves this goal by using perception for purposes other than its primary goals. Art seeks a different relationship between perception and communication, a relationship that *surprises* and defies normality; and this is exactly what is communicated.

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6. The autopoietic machines

The cybernetic discourse emphasizes the flow of information between machines and living systems, focusing on such issues as control and optimal information exchange. Norbert Wiener expresses this idea in radical terms: “Information is information, not matter or energy. No materialism which does not admit this can survive at the present day” (1948: 132) [12]. The characteristics of living systems, according to Wiener, are “the power to learn and the power to reproduce themselves”(1948: 169). Machines and living systems share the ability to process information, so the computing machine provides an analogy for understanding how the brain and nervous system work. The theory of autopoiesis, which emerges from the heritage of cybernetic thinking, shifts the focus of investigation from information flow to *circularity* and *self-organization*, providing the biological basis for a new cybernetic metaphor of machines as living systems [13]. The term *autopoiesis*, invented by the neurobiologists Maturana and Varela (1980) as a definition of life, generates a broad epistemological discourse linking the molecular level of the production of cells to the activity of the nervous system and to the

cognitive domain. Against the primacy of information over materiality, a basic tenet of first-wave cybernetics, the autopoiesis theory defines living systems in terms of their interactions with the *environment*. According to Maturana, there are “different domains of interactions” which are independent but can be related through the *descriptions* made by the *observer*.” In autopoiesis theory there is no information circulating between those different domains and no genetic code providing the key to living. The observer is the link that accounts for the self-referring circular organization of the living system: “the observer generates relations between different domains (or between different *descriptions*), as states of neuronal activity that in him lead to definite modes of conduct (*descriptions*) that represent these conjoined interactions as singular independent entities” (Maturana 1980: 55). In describing living systems, cognition and linguistic activity constitute a domain of interactions, a domain with which the observer interacts as a thinking system. Therefore, the physical and the cognitive domains are different descriptions of autopoiesis. According to Maturana: “the observer is a living system and any understanding of cognition as a biological phenomenon must account for the observer and his role in it” (1980: 48).

The word autopoiesis is a construct conveying two ideas: “auto” refers to “self” and “autonomy”; “poiesis” refers to “creation” and “production”. Autopoietic systems are defined as unities, as networks of productions of components that recursively, through their interactions, continuously regenerate and realize the network of processes that produced them and constitute, in the space in which they exist, the boundaries of the network as components that participate in the realization of the network (See Maturana and Varela 1980: 78-79). Maturana and Varela describe living systems as machines and explain their autopoietic nature as thought and the duality between organization and structure. What characterizes the machine, as a unit, is its *organization*, which is defined by the totality of relations existing between its components. The actual relations that maintain the components of a particular machine and concretize its organization in a given space constitute its *structure* (Maturana and Varela 1980: 77; Varela 1979: 9). In other words: the organization of a machine is independent of the properties of its components; the same organization can be carried out by different kinds of components, therefore by different structures. Since the autopoietic machine is defined by the relations observed between its components, the organization of autopoietic systems is not primarily a matter of materiality and exists only as descriptions made by the observer. This is one of the most important consequences of the reconstruction of cybernetics operated by the theory of *autopoiesis*.

The difference between organization and structure is illustrated by following example from Maturana and Varela (1980: 42-43): There are all kinds of

chairs: chairs made out of wood, plastic, metal, collapsible chairs, wheelchairs, etc. But they must divide a certain organization to be recognized as chairs: they must be at least used for sitting. In the same way, the composition of a fugue presupposes a certain organization that defines the melodic and harmonic relations between the constitutive voices, but the structure of a fugue can be achieved through different kinds of musical elements (and through various methods of composition). The distinction between organization and structure allows us to compare polyphonic systems functioning in different domains. For example, by excluding the "material embodiment" of music, it is possible to establish similarities between the organization of polyphony in different historical periods, such as the counterpoint of the medieval polyphony and an electro-acoustic composition. Obviously, the recognition of a system – whether a chair, a fugue or an electro-acoustic musical composition – is a matter of cognition. The observer must define the domain of descriptions; he must be able to distinguish: (1) "the relations which define a system as a unit"; (2) "the boundaries which delimit its unit in the space in which it is realized" (Maturana and Varela 1980: 109).

Despite its epistemological vocation, the theory of *autopoiesis*, as formulated by Maturana and Varela, can be better understood as a metaphor for the cellular processes of living systems. Autopoietic machines are primarily biological machines, which can create and specify their own organization. The cell metabolism produces components "which make up the network of transformations that produced them. Some of these components form a boundary that functions as the limit to this network of transformations" (Maturana and Varela 1987: 44). The "metabolism" remains as the metaphor for the "dynamic" of the system – "the network of relations between the processes of production of components" – and the "membrane" persists as the metaphor for the "boundary" of the system – "the topological domain of its realization as such a network" (Maturana and Varela 1980: 79). The characteristics of the autopoietic machines can be summarized as following:

1. The autopoietic machine is *autonomous*. All changes are subordinated to the maintenance of the organization, independently of the transformations they can undergo.
2. The autopoietic machine is *individual*. It maintains its identity independently of interactions with the observer.
3. The autopoietic machine is a *unity*. Its operations specify the boundaries of the process of self-production.
4. The autopoietic machine has no *inputs* or *outputs*. Nevertheless it can undergo the perturbations caused by the environment, for which it tries to compensate by structural changes.

This definition of autopoietic machines has two important implications: (1) the distinction between *system* and *environment*, made by the observer, and (2) the concept of *structural coupling*. An autopoietic machine is an operationally closed system that communicates with the environment only through perturbations. In order to compensate for these perturbations, the autopoietic machine undergoes internal transformations. This relation between perturbations and transformations is a process of structural coupling through which the recurrent perturbations of the environment produce a continual selection of the system's structure (Varela 1979: 33). However, the distinction between the system and the environment belongs only to the domain in which the machine is observed. It is thus the observer that distinguishes and indicates the autopoietic network as a difference between the system and the environment (Luhmann 1997: 66). The concept of structural coupling, according to Foerster, is a natural expansion of the concept of autopoiesis:

> In order to maintain its self-(re)production, an organism A needs an organism B, which similarly requires an organism A for the same purpose. In this way, structural couplings are established between A and B. Each sustains its individual autopoiesis, constituting a beautiful logical idea (Foerster 2002: 166-167).

The concept of structural coupling also accounts for the application of the theory of *autopoiesis* to other phenomenological domains which can be described by the observer, such as the cognitive domain. In *The Tree of Knowledge* (1987) Maturana and Varela trace the circular process of the structural coupling of autopoietic systems from unicellular organisms (first-order autopoietic systems), to multi cellular organisms with nervous systems (second-order autopoietic systems) and to cognitive organisms (third-order autopoietic systems) living in societies and communicating through language. They define language as the domain of consensual interactions emerging from the structural coupling of the ontogenesis of autopoietic systems. This domain of interactions characterizes what they call the linguistic domain. It is composed of the totality of descriptions that can be formulated by observation. The form of these descriptions depends on the particular mode of the autopoiesis. No cognitive knowledge is possible outside the process of transformation that maintains the system. The linguistic interactions thus concern communication, which is the consensual domain that guides the structural coupling, between organisms.

The radical link connecting the linguistic domain to social systems has been established by Luhmann [14]. But the ground for considering societies as self-reproducing systems had already been created in the autopoietic discourse of Maturana and Varela, since the circular and self-referential organization of the

living system emphasizes the “networks of productions of components” rather than the components themselves. In an earlier text, Luhmann proposes a general theory of self-referential autopoietic systems based on a multilevel approach. He distinguishes three levels: (1) living systems (cells, brains, organisms, etc.), (2) psychic systems (consciousness) and (3) social systems (societies, organizations, interactions). These levels are “different types of systems, or different kinds of modes of realization of autopoiesis” (Luhmann 1990: 2). Luhmann’s extension of the theory of autopoiesis keeps the ideas of “production” and “reproduction” but disconnects *autopoiesis* from its biochemical origin. The reproductive dynamic of social systems is driven by the operation of “communication”, which is a synthesis of three selections, namely *information*, *utterance*, and *understanding* (including misunderstanding). This synthesis is accomplished by the network of communication which characterizes the social system. The selection that produces a unity is produced in the system itself. However, Luhmann rejects the idea that communication can produce some element – some “Gestalt”. Communication produces a difference between *system* and *environment* (1997: 66-67), a state of indeterminacy which is internal to the system and can be reduced solely through the system. Therefore, *autopoiesis* should be understood as the indeterminacy internal to the system and reducible only through the operations that produce determination in the system.

Luhmann’s theory of autopoietic social systems is more than a transposition of concepts from biology. One of his most important innovations is the introduction of *temporality*. Events produce the autopoiesis of consciousness and social systems.. Biological autopoiesis presupposes the reproduction of elements, the replacement of cells within the organism. But the basic element of consciousness and social systems – respectively thoughts and communications – are short-term *events*, which necessarily vanish as soon as they appear. Events cannot be accumulated without producing chaos in the system. Consciousness systems and social systems must renounce all stability at the operative level. “The instability of its elements is the condition that assures its duration” (Luhmann 1990: 9). In other words: the stability of social systems is based on instability. Memory is not a question of preserving elements, but of the power of generating structures. Temporality accounts for the *structural coupling* of consciousness and communication systems. Both systems produce sequences of events at different speeds (rhythms), and these temporal differences require synchronization. According to Luhmann, this process of synchronization explains the emergence of a word independent of cognition: “the system calculates time relations as reality without foreseeing specific meaningful forms” (1997: 116).

The concept of structural coupling explains how a social system shapes its

relation to the environment, since social systems maintain no contact with the environment and can refer only to themselves. Borrowing a concept from information technology, Luhmann argues that structural coupling is a process of *digitalization* of *analogue* relations (1997: 101). The relations between system and environment, as seen by an observer, are primarily relations of an analogue nature as they occur in parallel and continuously. But when the environment impacts a system the analogue relations require reshaping as digital relations. Consciousness cannot communicate, communication cannot perceive, claims Luhammn. They are “operatively closed systems that do not interfere with each other” (2000: 48). The interaction between these domains is accomplished primarily by language, which has the ability to transform simultaneity and continuity into a discontinuous sequence of events. Language is the fundamental medium of communication that assures the autopoiesis of society. Autopoiesis as communication system presupposes the possibility of further communication which cannot be accomplished without language, although language accepts other kinds of communication without language (Luhmann 1997: 205-206).

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7. Autopoiesis of sound and music

The distinction between perception and communication, as we have seen, is the starting point of Luhmann’s autopoietic theory of art. Art makes perception available for communication and accomplishes this function outside the standardized forms of language. Art operates simultaneously in both domains; it “integrates perception and communication without merging or confusing their respective operations” (Luhmann 2000: 48). In other words, art provides the experience of the synchronization of perception with communication and, at the same time, lets both domains operate independently. Perception and communication remain incommunicable in communication through art. However, in order to be autopoietic, communication through art “must present sensuously perceptible objects, without being able to reproduce itself within individually encapsulated psychic systems” (Luhmann 2000: 48). The solution to this problem lies in the concept of *form*, which is for Luhmann something completely different from a *Gestalt* – or from a unity. As we have previously seen, form may be defined as an operational concept, a distinction between two sides, an operation of actualization that indicates one side and excludes the other. Form is the structural coupling that “specifies and determines a work of art at the boundary between psychic (consciousness) and social systems” (2000: 48). The forms of the autopoietic system of art are located in works of art, or objects, which are presented to perception and communication. The fixation of form in a work of art is the necessary condition

for further indications and distinctions. Luhmann refers to works of art as "*condensations of the communication system of art*" (2000: 51), and he makes it clear that artistic communication is only possible within social systems, consciousness, life and materiality. An isolated work of art is not a element of the system; it comes into being only through recursive networking with other works of art, with verbal and writing communication about art, with electronic and digital reproduction and with such entities as museums, concerts, theaters, buildings, and so forth. According to Luhmann, we can bi-directionally observe the autopoiesis of art through the communication with works of art. On the one hand, artistic forms propose suggestions, ideas, variants, etc. that can be accomplished by other works of art. On the other hand, artistic forms generate conversations, writings and other communications through the medium of language. But in order to be autopoietic, the system of art must be operationally closed: it communicates solely by means of distinctions (forms) located within the work itself (Luhmann 2000: 52).

At this point, we have developed some insights into reviewing the concepts of polyphony and embodiment from the prospective of the theory of autopoiesis. At the beginning of this essay, I defined polyphony as the operation through which the observer "distinguishes multiple and independent events and creates a musical difference between sound and environment" [15]. If we take into account the concept of structural coupling, we can also define polyphony as *the interaction between the system and the environment that makes simultaneous auditory perception available for communication*. The psychic system might generate experiences of simultaneity that remain incommunicable but are structurally coupled to the polyphonic forms. There is no connection between polyphony and the acoustic environment, except for a process of selection in the surplus of possibilities available in the system. According to the digital/analogue dichotomy, the structural coupling of polyphony digitalizes such relations as pitch, duration, timbre, and other observable distinctions present in the analogue medium of the (acoustic) environment. This structural coupling is accomplished in the medium of "sound", the primary medium of acoustic communication, including music. Sound is an ephemeral medium – sound waves strike the air and vanish. As pointed by Sterner, "sound is a very particular perception of vibrations" (2003a: 11), namely those vibrations that are intended to be heard specifically by humans (but not by dogs, for example). Vibrations travel through different media, including human bodies, but only the vibrations situated within a particular range are perceived by the auditory systems of humans [16]. Sound is an operation made by an observer, that creates a distinction in the vibrating world and makes sound available for communication. Sound is the being-in-the-word of the system of acoustic communication, the unity that emerges

from the continual coupling of self-reference and hetero-reference that generates communication through audible vibrations. According to Luhmann's distinction between perception and communication, consciousness (sound) compensates for the operative closure of the nervous system (hearing), and the social system (acoustic communication) compensates for the operative closure of consciousness. Communication through sound accomplishes this combination by continually reproducing the distinction between utterance (self-reference) –vibrations – and information (hetero-reference) – sounds – under conditions that generate the possibility of understanding (Luhmann 2000: 10-11). The unity called "sound" contains the distinction of the "unmarked" space of the vibrations that create the form of sound. The form itself is the boundary that discriminates and indicates "sound" in the unmarked space of the world and, in this sense, regenerates the unmarked space of the world in the distinction of sound itself, making possible further operative possibilities of discriminating sound. In this sense, sound is a self-determining process, an autopoietic system of communication.

Sound vibrations themselves should not be understood as physical elements, but as units distinguished in an observed system. The structural coupling of vibrations with media such as space, bodies, buildings and other objects in the physical world – including electronic and virtual objects – is the being-in-the-word of sound. The definition of sound is thus the distinction of a particular *embodiment* based on the "understood possibilities of the faculty of hearing" (Sterne 2003a: 12). This distinction is the boundary of a two-sided form that distinguishes the marked space of the vibrations considered as sound from the unmarked space of the vibrations that are considered as no-sound. Let us analyze the case of the sound produced by my voice. As soon as this sound is articulated and resonates in the medium of the air it unfolds into a two-sided form. If the observer exercises the option to remain in marked space – the space of the sound – I, she or he can make other distinctions which will be always distinctions inside sound domain. For example: I can decide to increase the pressure of the vocal emission in order to raise the audible volume, or to modify the form of the vocal apparatus in order to transform the resonance and consequently the timbre, or to modify the character of the vocal emission in such a way that it becomes a scream [17]. But the observer can also decide to remain in unmarked space. For instance: the voice can talk and articulate using language, or remain silent. Each operation that distinguishes a sound and generates a two-sided form creates an *asymmetry* in the world, and it is up to the observer to decide on which side she/he continues to make further distinctions. What distinguishes a work of music from another sound object – or another work of music – is the use of internal forms, which are always distinctions operating in the recursive domain of the work itself. As soon as an observer produces operations of distinction he or

she is confronted with the question of the musical form and, consequently, with the fundamental question of the distinction between the musical work and other sound objects [18].

Polyphony emerges in the Western world with the distinction of the individual voice. Everyone who has had the experience of singing a melody in unison in a group knows that it is impossible and even undesirable to sing perfectly together. There are always differences between the individual voices, such as variations of time, pitch, timbre, or articulation. However these differences occur within a certain time and (tonal) space threshold, so that the melody is perceived as a single event. Polyphony begins when these differences start to make a difference, i.e., when they are perceived as disparate elements of the system. The individual voice becomes a medium for organizing polyphony as a recursive network of “voices” interacting in the successive and simultaneous domains of sound. The concept of “voice” points also to the relation between “music” and “language”. Both are communication media in social systems. Voice is the fundamental medium of the Western polyphony; language is the fundamental medium of social systems. The analogies between music and language have driven the investigation of musical meaning with concepts borrowed from linguistics and – in a certain sense – from semiotics [19]. Nevertheless, as Ruwet argues, “musical semantics” doesn’t win so much when it is inspired by linguistics. He claims that,

> the only voice leading to the study of the meaning goes through the formal study of the musical ‘syntax’ and through the description of the material aspect of the music on all the levels where it has a reality (production, acoustic transmission, perception, physiological implications such as the modifications of the rhythm of heartbeat, etc.) (1972: 12).

By contrast, the operational theory of autopoiesis treats form as a self-reference, a distinction made by an observer that separates into two sides. Form is essentially a boundary which opens the possibility of seeing the “work of music” as both a marked and an unmarked space. The marked space is the internal side and the unmarked space the external side of the “work of music”. The internal side unfolds a network of recursive distinctions of two-sided forms, which are actualized by the observer. This actualization is a temporal sequence of events (distinctions) which can be processed both in the “real” time – the time in which the music is performed and listened – and in the “historical” time – the successive performances that a work of music may undergo in the course of history, and also all kinds of communication generated by the works of music. The process of *differentiation* of forms, which characterizes the evolution of music, unfolds a continuous “re-entry of the form into the form, of the distinction into what it distinguishes’ (Luhmann

2000: 301). Let us look at an example: if we observe the system of the vocal polyphony of the motets of Josquin des Prez (c. 1450-15210), we distinguish formal choices based in the use of plainchant melodies, contrapuntal techniques, the treatment of consonance and dissonance, modal cadences and other typical features of Renaissance style. The setting of texts in Josquin's motets, which are borrowed from the Old Testament and other biblical sources, has an important influence on the construction of forms. Josquin's musical compositions explore and delineate elements of the text, such as the structure of the verses, rhetorical effects and symbolic meanings (Sherr 2000) [20]. However, contrapuntal architecture dominates polyphonic composition in such a way that the text remains "invisible" as an unmarked space of the music.

The relation between music and text undergoes a change when the contrapuntal system reaches the boundaries of the modal system and exhausts its supply of formal possibilities. Composers of the time crossed this boundary, searching for forms in the unmarked space of the text. In the later motets of Josquin of Prez, for instance, we observe how the musical form changes for the purposes of clarifying phonetic articulation and textual understanding. The rhythmic complexity of the counterpoint is reduced and a texture of motivic construction emerges within the counterpoint in order to emphasize some words. The dramatic form of the madrigal in the 16th-century Italian music, which led to development of the opera in the beginning of the 17th Century, marks the reintroduction of the unmarked space of text into the form of vocal polyphony. This re-entry of text occurs simultaneously with the re-entry of harmony. The decrease in countrapuntal invention, joined with the increase of homophony, cadential progressions and the outstanding role of the voices of extreme registers (the bass and the soprano), contributes to the development of forms based not on the sequential organization of consonant and dissonant intervals, but on the functionality of pitches and its relationship to a tonal center. Formal arrangements such as "chord" and "tonality" belong to the harmonic system which characterized the music of the Baroque and Classical periods, although the self-description of the harmonic system will be undertaken only in the 19th Century (Dahlhaus 1968) [21]. The development of concert music and the rise of the opera with its internal differentiations between arias, recitatives, duos, soloists, choruses, etc. characterize the increasing *autonomy* of music from religion and scientific rationalism (Luhmann 2000: 267). We observe a correlation between the "enlightenment" and the re-entry of the melody into polyphony. In a time "when individuals were no longer disciplined by class hierarchy, but instead by the supposition that they act rationally" (Luhmann 2000: 268) melody emerges as the space of individuality. By contrast with the polyphony of the Renaissance motet, which is an arrangement of a fixed number of voices progressing simultaneously and

submitted to the laws of counterpoint, this later polyphony is formed by themes, subjects, motives, arpeggios, harmonic progressions, rhythmic patterns and other elements which could be combined in many new and different ways.

The binary opposition between counterpoint and harmony is a construct, a device for describing the *dynamic stability* of polyphonic systems according to the predominance of certain formal arrangements. Stability is a necessary condition for distinctions occurring between *variation* and *selection*, and it is the foundation of the evolution of systems. (Luhmann 2000: 223-225). Luhmann developed the distinction between variation and selection in the realm of his evolutionary approach to artistic systems. According to Luhmann, "a system must already be stabilized if it is to offer possibilities of variation. Stability is the beginning and the end of evolution, a mode of structural change that simultaneously generates instability" (200: 224). Variation is the operation and selection the structure. Variation occurs through unexpected (new) operations and selection "concerns the structural value of an innovation: the innovation is either accepted as something worth repeating, or it is isolated as a singular occurrence and rejected" (2000: 225). The re-entry of counterpoint into harmony is a singular innovation in the vocal and instrumental music of Johann Sebastian Bach, one rejected by other composers of the time. The reintroduction of counterpoint also generates dramatic structures in the music of Mozart and expands thematic development in the late music of Beethoven. There are many other examples of the re-entry of counterpoint into the music of such Romantic composers as Chopin, Mendelssohn and Brahms as well as into the music of many 20th- century composers. Rosen, who considers Chopin "the greatest master of counterpoint since Mozart" (Rosen 1995: 285), shows how Chopin re-elaborated Bach's counterpoint in a very paradoxical way. For example, the technique of constructing counterpoint from a single line, typical of Bach's works for such solo instruments as flute and strings, is found in the finale of the Chopin's Sonata in B flat Minor, op. 58. Chopin composed a monophonic *perpetuum mobile* whose parallelism of two hands implies three- and four-part polyphony (Rosen 1995: 285-302). Rosen argues that Chopin took over from Bach the craft of creating polyphony from scale passages; and that he achieved an even greater richness with the chromatic development of his harmony. In some respects he went further than his master in giving polyphonic life to the arppeggio (Rosen 1995: 301). Webern claims that his music and Schoenberg's music are rebirths of polyphonic thinking. The twelve-tone technique is a synthesis of all the former techniques of polyphony, including the music of the Franco-Flemish composers of the Renaissance. The style of Schoenberg and his school, according to Webern, seeks "a new inter-penetration of music's material in the horizontal and the vertical

[polyphony]" (1963: 35).

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8. Conclusion and further developments

Polyphony, embodiment and autopoiesis are the three key concepts of this essay. In this section, I will present a brief conclusion, highlight some thoughts and point to some directions for further development both in theory and artistic practice.

The theory of autopoiesis, invented by Maturana and Varela, accounts for the limitations of the biological observer and develops generative mechanisms for describing living systems. Structural coupling is the mechanism through which autopoietic organisms communicate with their medium. It accounts for the emergence of new domains of experience. According to Maturana and Varela, language is the consensual domain of descriptions and self-descriptions through which the observer explains the theory itself. In this sense, the theory of autopoiesis accounts for the circularity of biological existence.

Luhmann extends the theory of autopoiesis to the social domain by characterizing social systems as autopoietic. The autopoiesis of social systems is based on communication: social systems produce and reproduce processes of communication which define the boundaries between system and environment. Luhmann's theory of social systems remains highly controversial but provides a very stimulating and fruitful approach for investigating communication systems such as art and music. Luhmann developed also a theory of form/medium, based on the concept of form proposed by Spencer-Brown in his *Laws of Forms*, which integrates the mechanism of observation in the form itself. Form becomes the distinction, a condition of possibility for observation, and consequently a epistemological principle.

Based on Luhmann's distinction between perception and communication, I define polyphony as the mode of operation of consciousness that gives form to simultaneous perception of the acoustic environment. This form of this operation is defined as *sound*, which is the difference between *self-reference* (internal world) and *hetero-reference* (external world) in acoustic perception. This definition of sound implies also that consciousness must establish a differential relationship to the environment in order to delimit the boundaries of sound itself. These boundaries are represented through distinctions such as between *sound* and *not-sound*, or between *sound* and *silence*, or between *sound* and *noise*. However, those boundaries are not derived from any quality

of the sonic vibrations in themselves, but remain internal operations of the system. They are based both “on the understood possibilities of the faculty of hearing” (Sterne 2003a: 12) and on the structures of the social system that creates meaning through sounds. Sound is also the basic distinctive element of the medium of language, and language is the main medium of communication, which is the basis of the autopoiesis of social systems. The definition of sound is thus the particular embodiment based on our possibilities of perceiving acoustic vibrations as meaningful elements. Our sonic experience is shaped by the definition of sound in the social system.

Sound is the virtual form of polyphony as it presents itself as a complex *texture* that cannot be reduced to a single phenomenon. Music articulates sound complexity as an experience of temporality. A musical sound, for example a tone sung by a voice or played by an instrument, is a temporal object possessing a specific duration. Music articulates sound objects as a sequence of events and also has the ability to create multi-layered sequences of sequences of events. In Western music a single sequence of events is associated with the notion of “voice” or “part”, and the sequence of simultaneous sequences of events – voices and parts – is associated with the notion of polyphony. However, a phenomenological analysis can reduce these differences to levels of *temporality* that create time-consciousness. According to Varela’s enactive point of view, “any mental act is characterized by the concurrent participation of several functionally distinct and topographically distributed regions of the brain and their sensorimotor embodiment” (1999: 272). Temporality is the complex task of relating and integrating these different components that require a “*frame or window of simultaneity that corresponds to the duration of lived present*.” [in italics in the original text]. Varela argues that temporality is not a stream based on sequences of elements, but that it should be explained as a recursive structure of temporal scales composing a unified whole. His idea of three scales of duration for understanding temporality, introduced in this article (1999: 273), is a promising approach to the investigation of polyphony as a dynamic, recursive cognitive process. Undertaken here, such an investigation, however, would exceed the scope of this essay.

The definition of sound as a mark of the boundary between vibrations that are considered sound and the vibrations that are considered not-sound (or silence, noise, etc.) implies the synchronous coupling of vibrations with other media, such as bodies and spaces. Bodies produce, transmit, reverberate and absorb sounds, and in doing so they account for the primary embodiment of polyphony as a medium of communication. But the notion of embodiment cannot be reduced to the physical reality of human and non-human bodies. Hayles (1999) criticizes the contemporary belief that the body is primarily a

discursive and linguistic construction. She blames post-modern theory for concentrating on discourse rather than on embodiment and, doing so, replicating once again the Cartesian mind/body duality, wherein philosophy cannot conceptualize itself as having a body. Hayles draws an interesting distinction between "body" and "embodiment": on the one hand, body is an abstract idealized form, a discursive universal construct, and embodiment, on the other, is an enactment related to the specifics of contexts, place, time, etc (1999: 196). Experiences of embodiment are always implicated within a culture, never coinciding fully with a purely abstract idea of the body.

In this essay I have limited my investigation of polyphonic embodiment to the realm of sound phenomena. However, the idea of polyphony also accounts for the plural subjectivity suggested by the constructivist and psychoanalytic philosophy of Deleuze and Guattari [22]. Polyphonic subjectivity, which transverses the material and virtual universes of capitalistic society, operates by means of “technological machines of information and communication” which address not only memory and intelligence, but affect also sensibility and emotion – our “unconscious ghosts” (Guattari 1992: 15). The notion of *polyphony* is closed related to *heterogeneity*. Guattari proposes a polyphonic and heterogenetic movement of comprehension leading to the constitution of new complexes of “subjectivation”, founded on multiple exchanges between individuals, groups and machines. Polyphonic subjectivity is embodied in the “complex refrains” [*ritournelles complexes*] assembling fragments of different domains such as biological, ethnological, socio-cultural, “machinic” and cosmic [23].

As an alternative to the scientific and philosophical models, Guattari proposes a polyphonic analysis of subjectivity based on the “ethic-aesthetic paradigm” which defines the polyphonic and heterogenic complexes of subjectivity as “machinic” assemblages. The notion of “machinic” embraces both technological and abstract machines, such as social bodies, scientific discourses, cultural formations, desires, collective behaviors, etc. It extends the concept of autopoiesis but through a different prospective from Luhmann’s theory of social systems. Instead of focusing on operationally closed systems, the notion of “machinic” emphasizes the relations of *alterity* between collective entities. The machinic assemblage brings the idea of autopoietic “machines of subjectivity”, which implies that subjectivity is not restricted to human consciousness but is extended to the autopoietic dimension that characterizes the integration of human beings with machines (Guattari 1992: 62).

The aesthetic paradigm must be understood as a critique against the homogeneity imposed by capitalistic values. Polyphony becomes the expression of the heterogeneity of artistic creation, which consists of

combined “chaos and complexity”. The concept of “chaosmose”, introduced by Guattari, (1992) expresses the necessity to create a synthesis between the formal complexity and the creative domain of chaos, which includes different kinds of elements such as discourses, references, affects, etc. Hayles (1999) proposes a similar approach stressing the distinction between pattern and randomness, which accounts for the contingency and unpredictability of systems and the interpenetration of rational and irrational forces in the same organization. The emergence of chaos in systems can also be seen as the re-entry of unmarked space into form (Spencer-Brown 1969). An example of the re-entry of chaos into musical systems is the introduction of “noise” – as sonic quality or random process – into the acoustic and electroacoustic music of the 20th Century.

The aesthetics of the “machinic” raises the question of the subjectivity in our relationship with technological machines. The idea of polyphony refers not only to a multiplicity of elements, layers or contexts, but also to a multiplicity of beings through the integration of human life with machines. The autopoietic dimension of the machinic became the experimental field of the arts dealing with the technological apparatus. The aesthetics of the “machinic” explores parameters and functions of the machines, such as interactivity, automation, interface, and control of processes that can be connected with or independent from the human body (Broeckmann 1997). The creative process involving the interaction between human and technological processes brings awareness of the changing “relation of human subjectivity to its environment” (Hayles 1999: 290). Art must develop forms that account for the transformation of human existence in a heterogeneous environment. Polyphony becomes the possibility of articulating the autopoietic dimension of this process.

Notes

1. Pousseur’s analysis of periodicity in music is influenced by his experience of analogue electronic music, particularly the technique of voltage control, which has been used by composers since the 1950s and implemented in the commercial analogue synthesizers of the 1960s and 1970s (for example the Moog synthesizers). The fundamental of analogue synthesis is the transformation of time-varying electric signals in sound waves. Electric signals such as those oscillator-generated are in principle “simple” sounds, but they can undergo different kinds of modulation – such as amplitude or frequency modulation – for generating complex sounds. The electric, formal properties of the single signals involved in the modulation process are reflected as interferences in the resulting sound wave (For a comparative analysis of analogue and digital electronic music see Chagas 2002). In opposition to

analogue signals, autopoietic systems do not have inputs or outputs, but they can be perturbed by “independent events and undergo internal structural changes which compensate for these perturbations” (Maturana and Varela 1980: 81).[§]

2. Spencer-Brown’s logic of distinction developed in *Laws of Form* (1969) had a significant impact on Luhman’s concept of form. Spencer-Brown defines form as an imperative demand: “draw a distinction” (Spencer-Brown 1969: 3). Spencer-Brown’s concept of form has been commented on and developed by many authors, including Luhamnn. See the collective book *Problems of Form* (Baecker 1999). See particularly in this collection Luhmann’s article “The Paradox of Form” (Luhmann 1999).[§]
3. For an investigation on Perotin and Leonin, the two major composers of the ParisNotre-DameSchool, see respectively Flotzinger 2000 and 2003.[§]
4. The electronic music composers of the “German school” emphasize the impact of serial thinking on early electronic compositions. See Eimert 1965.[§]
5. Flusser developed a phenomenology of the technical image and the camera as an embryonic form of all apparatuses in the book *Für eine Philosophie der Fotografie* (1983). English translation: Flusser (2000). Later he extended his investigation to a critique of the telematic society (Flusser 1985).[§]
6. Following the ideas of Foerster, the machines that reproduce music in society can be analyzed as “non-trivial machines”. He defines machine as a set of rules and laws through which a certain state is transformed into a different state (Foerster 1993a: 135). In his analysis of the complexity of cognitive behavior he differentiates between trivial and non-trivial machines. A trivial machine is an analytically determinable and predictable machine whose operations are not influenced by previous operations. For non-trivial machines, however, an observed reaction to a certain stimulus might not occur later when the same stimulus recurs. A non-trivial machine is analytically indeterminable and unpredictable. See Foerster 1993b.[§]
7. Terhardt applies the cosmology of Popper (1971) to the study of acoustic communication. Popperian cosmology splits the universe into three interacting sub-universes: (1) the world of physical objects, events and direct experience (sound), (2) the world of mind, mental objects and events (perception) and (3) the world of human knowledge and all the products of the human mind (information). For a different approach to acoustic communication, see Truax 2001.[§]
8. The concepts of “internal” and “external” have different interpretations in cognitive studies. See the interviews with Heinz von Foerster, Ernst von Glasersfeld, Humberto R. Maturana, Gerhard Roth, Siegfried J. Schmidt, Helm Stierlin, Francisco J. Varela and Paul Watzlawick in Pörksen 2002.[§]
9. Terhardt divides the perception of pitches into two categories: spectral pitches and virtual pitches. Spectral pitch is the pitch we hear when the fundamental is strong enough; virtual pitch, however, is extracted by the auditory system from a range of the spectrum above the fundamental. Virtual pitch doesn’t depend on the fundamental being audible. See Terhardt 1998: 307-368.[§]
10. Niklas Luhmann (1927-1998) worked on his theory of society (or theory of social

systems) for nearly 30 years (1968-1998). He proposed the first version of the theory in the book *Soziale Systeme. Grundriß einer allgemeinen Theorie*, published in 1984 [English translation *Social Systems* (Luhmann 1995b)], and the latest version in the book *Die Gesellschaft der Gesellschaft* [*The Society of the Society*], published in 1997, which represents to some extent the conclusion of his theory. In addition, Luhmann has published hundreds of articles on individual aspects of the theory and some books on the functional systems of society. In each of these books, written successively between the two general theories, Luhmann re-elaborates the framework and the concepts. They are thus intermediary stages in the theory of social systems: *Die Wirtschaft der Gesellschaft* (1988) [*The Economy of Society*], *Die Wissenschaft der Gesellschaft* (1990) [*The Science of Society*], *Das Recht der Gesellschaft* (1993) [*The Law of Society*] and *Die Kunst der Gesellschaft* (1995) [English translation: *Art as Social System* (Luhamann 2000)]. Other books on functional systems were published after Luhmann's death: *Die Politik der Gesellschaft* (2000) [*The Politics of the Society*], *Die Religion der Gesellschaft* (2000) [*The Religion of the Society*] and *Das Erziehungssystem der Gesellschaft* (2002) [*The Educational System of the Society*]. A certain number of books containing analyses and interpretations of Luhmann's thinking published in the last ten years can be useful for approaching his complex universe; for example: the glossary of by Baraldi, Corsi, and Esposito (1997); the lexicon of by Krause (1999); the monograph of by Reese-Schäfer (1999); and the introduction to Luhmann's system by Jahraus (2001).[§]

11. The distinction between medium and form is discussed in Luhmann (1986b, 1997: 190-205; 2000: 102-132). For an application to the musical domain, see Chagas 2003b.[§]
12. For a mathematical theorization of information see also Shannon (1948).[§]
13. For an analysis of the theory of autopoiesis in the historical context of cybernetics see chapter six of Hayles: "The second wave of cybernetics: from reflexivity of self-organization" (Hayles1999: 131-159). For a critical approach to the theory of autopoiesis and its developments in different fields see Mingers 1995. For a general overview, glossary, bibliography and other information on autopoiesis and enaction see Whitaker 2001.[§]
14. Both Maturna and Varela are opposed to the application of the notion of autopoiesis to social systems. Varela affirms that "this term should be restricted to systems, whether natural or artificial, that are characterized by a network that is, or resembles very closely, a chemical network" (1979: 15). Maturana radically criticizes Luhmann's theory. He argues that Luhmann, by using the autopoiesis for explaining the social, "does not illuminate the social phenomena and processes but rather hides them" (2002: 106). Maturana is a humanist. He believes that Luhmann "excludes" human beings from society and, worst than that, reduces them to merely their function. According to Maturana, humans assume the status of "slaves" in Luhman's social system, which cannot be a social system at all, but a "tyranny" (2002: 107).[§]
15. See in this essay: "1. Simultaneity and polyphony".[§]
16. The human ear has a theoretical frequency range of about 10 octaves (between

20-20,000 Hz), which is significantly reduced by age and other factors, such as physical damage caused by noise and the environment. The frequency range depends also on sound dynamics. Low sounds need to have a greater dynamic in order to be perceived. Music has a dynamic range of about 75 dB and a frequency range of about 50-8,500 Hz. Speech has a dynamic range of about 42 dB and a frequency range of about 170-4,000 Hz. See Everest (2001: 89-108).[§]

17. Deleuze (2004) analyzes the scream in the paintings of Francis Bacon as the operation through which the entire body escapes through the mouth. According to Deleuze, Bacon's paintings establish a relationship between the forces that sustain the scream and the visible scream (the mouth that screams). In the same way, music is not concerned with rendering the scream harmonious, but to "establish a relationship between the sound of the screen" and these forces (Deleuze 2004: 51)[§]
18. However, we have to consider that music cannot be reduced to sound. Wittgenstein says that music has an infinite complexity which is kept in the silence [*Die Musik verschweigt*] (1980: 8e-9e). The English translation ("music conceals") doesn't convey Wittgenstein's idea that sound is in a certain way only the surface of music. Wittgenstein insinuates, for example, the role of *gesture* on musical understanding (1980: 51e). Inspired by Wittgenstein and Flusser, I developed a phenomenological approach of vocal, instrumental and electroacoustic gestures (Chagas 2003d).[§]
19. For a semiotic approach to music see, for example: Nattiez, Jean-Jacques. 1975. *Fondements d'une sémiologie de la musique*. Paris: Union Générale d'Editions; and Nattiez, Jean-Jacques. 1987. *Musicologie générale et sémiologie*. Paris: Christian Bourgois. For semiotical approaches of music see for example: Tarasti, Eero. 1994. *A theory of musical semiotics*. Bloomington: IndianaUniversity Press; Hatten, Robert. 1994. *Musical Meaning in Beethoven: Markedness, Correlation and Interpretation*. Bloomington: IndianaUniversity Press; Monelle, Raymond. 2000. *The sense of music*. New Jersey: PrincetonUniversity Press; Campbell, Naomi. 2000. *The Sonic Self. Musical Subjectivity and Signification*. Bloomington: IndianaUniversity Press. For a historical and critical review of musical semiotics see: Tarasti, Eero. 2002. *Signs of Music. A Guide to Musical Semiotics*. Berlin: Mouton de Gruyter.[§]
20. See in this collection: Elders. Willem. 2000. "Symbolism in the Sacred Music of Josquin". In *The Josquin Companion*, ed. Richard Sherr, 531-568. New York: OxfordUniversity Press; Finscher, Ludwig. 2000. "Four-Voice Motets". In *The Josquin Companion*, ed. Richard Sherr, 247-279 New York: OxfordUniversity Press; Macey, Patrick. 2000. "Josquin and Musical Rhetoric: Miserere mei, Deus and Other Motets". In *The Josquin Companion*, ed. Richard Sherr, 485-530. New York: OxfordUniversity Press.[§]
21. Dalhaus questions the role usually attributed to Rameau as founder of modern harmony. According to Dalhaus, the main characteristic of Rameau's theory is not the concepts of degree (Fétis) of function (Riemann), but the idea of chord as a entity defined through the opposition between consonance and dissonance. Rameau's theory didn't account for the formal logic of harmony (Dalhaus 1968:

22).[§]

22. The ideas of Deleuze and Guattari concerning music are exposed by Deleuze and Guattari 1997. See chapter 11 “1837: Of the Refrain (pp. 310-350). For a synthesis of Deleuze and Guattari’s ideas on art see Deleuze and Guattari (1994). For an introduction and overview of Deleuze on the arts see: Bogue, Ronald. (2003). *Deleuze on Music, Painting, and the Arts*. New York: Routledge. For an application of Deleuze and Bergson’s ideas on the study of new media see: Hansen, Mark B. N. 2004. *New Philosophy for New Media*. Cambridge, MA: The MIT Press.[§]
23. The machinic phylum concept has been explored by Manuel de Landa, who reinterprets and develops the philosophy of Deleuze and Guattary, as an overall set of self-organizing processes. In Landa’s materialistic philosophy, the notion of a machinic phylum blurs the distinction between organic and non-organic life. See: De Landa, Manuel. 1991. *War in the Age of Intelligent Machines*. Cambridge, MA: The MIT Press; De Landa, Manuel. 2000. *A Thousand Years of Nonlinear History*. Cambridge, MA: The MIT Press.[§]

References

- AROM, Shimha. 1991. *African polyphony and polyrhythm : musical structure and methodology*. Translated by Martin Thom, Barbara Tuckett, and Raymond Boyd. Cambridge; New York: CambridgeUniversity Press.
- _____1993. “Une voix multiple. Entretien avec Simha Arom”. In: *Polyphonies. Cahier de Musiques Traditionnelles* 6: 185-199. Genève: Ateliers d’ethnomusicologie.
- BAECKER, Dirk (ed.). 1999. *Problems of Form*. Translated by Michael Irmscher with Leah Edwards. Stanford, CA: Stanford University Press.
- BARALDI, Claudio; Corsi G. and Esposito E. 1997. *Glossar zu Niklas Luhmanns Theorie sozialer Systeme*. Frankfurt am Main: Suhrkamp.
- BAUDRILLARD, Jean. 1995. Simulacra and Simulation. Translated by Sheila Maria Glaser. Ann Arbor: University of Michigan Press.
- BENJAMIN, Walter. 1977. “Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit”. In *Illuminationen*, ed. S. Unseld, 136-169. Frankfurt am Main: Suhrkamp.
- BOULEZ, Pierre. 1963. *Penser la musique aujourd’hui.* Paris: Éditions Gonthier.
- CHAGAS, Paulo C. 2002. Spiel und Dialog: das Komponieren mit Apparaten. In *Elektroakustische Musik. Handbuch der Musik im 20. Jahrhundert Band 5*, ed. Elena Ungeheuer, 182-196. Laaber: Laaber-Verlag.
- _____2003a.”Virtuality and Metadesign. The Sound Art in the Age of Connectivity“. In *Proceedings of The Ninth Biennial Symposium on Arts and Technology*, 24-35. New London CT: ConnecticutCollege.
- _____2003b. *Polyphony, form, art sonore*. Ph.D. Dissertation, Université de Liège [not published].
- _____2003c ”La distinction entre médium et forme: une nouvelle approche de la

sémiotique musicale“. In *Proceedings of The Tenth Journées d'Informatique Musicale*. Montbéliard: École Nationale de Musique.

- _____2003d ”Gesture in electroacoustic music: vocal, instrumental and technological”. International Conference ‘Music and Gesture’. University of East Anglia, Norwich, U.K [not published].
- DALHAUS, Carl. 1968. *Untersuchungen über die Entstehung der harmonischen Tonalität*. Kassel: Bärenreiter.
- DELEUZE, Gilles, Guattari, Félix. 1997. *A Thousand Plateaus: Capitalism and Schizophrenia*. Translated by Brian Massumi. Minneapolis: University of Minnesota Press.
- _____1994. *What is Philosophy?* Translated by Hugh Tomlinson and Graham Burchell. New York: ColumbiaUniversity Press.
- DELEUZE, Gilles. 2004. *Francis Bacon. The Logic of Sensation*. Translated by Daniel W. Smith. Minneapolis: University of Minnesota Press.
- EIMERT, Herbert. 1965. “What is electronic music?” In: *Die Reihe 1*, 1-10. Bryn Mawr, PA: Theodore Presser Co.
- EVEREST, Alton F. 2001. *The Master Handbook of Acoustics* [4th ed]. New York: McGraw-Hill.
- FLOTZINGER, Rudolf. 2000.*Perotinus musicus. Wegbereiter abendländischen Komponierens*. Mainz: Schott.
- _____2003.*Leoninus musicus und der Magnus liber organi*. Kassel: Bärenreiter
- FLUSSER, Vilém. 1983. *Für eine Philosophie der Photographie*. Göttingen: European Photography.
- _____1985. *Ins Universum der technischen Bilder*. Göttingen: European Photography.
- _____2000. *Towards a Philosophy of Photography*. Translated by Anthony Mathews. London: Reaktion Books.
- FOERSTER, Heinz von. 1984. “On Constructing a Reality”. In *Observing systems* (2nd ed.), ed. Heinz von Foerster, 288-309. Seaside: Intersystems Publications.
- _____1993a. *KybernEthik*. Berlin: Merve.
- _____1993b. Prinzipien der Selbstorganisation im sozialen und betriebswirtschaftlichen Bereich. In Heinz v. Foerster *Wissen und Gewissen: Versuch einer Brücke*, ed. Siegfried J. Schmidt, 233-268. Frankfurt am Main: Suhrkamp.
- _____1998. *Wahrheit ist die Erfindung eines Lügners: Gespräche für Skeptiker*. Bernhard Pörksen (ed.). Heidelberg: Carl-Auer-Systeme.
- _____2002. *Der Anfang von Himmel und Erde hat keinen Namen: eine Selbsterschaffung in 7 Tagen*. K. H. Müller and A. Müller (ed.).Berlin: Kadmos.
- GUATTARI, Félix. 1992. *Chaosmose*. Paris: Galilée.
- HAYLES , N. Katherine. 1999. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: The University of Chicago Press.
- JAHRAUS, Oliver. 2001. “Zur Systemtheorie Niklas Luhmann”. In *Niklas Luhmann. Aufsätze und Reden* (2001), ed. Oliver Jahraus, 299-333. Stuttgart: Reclam.
- KRAUSE, Detlef. 1999. *Luhmann-Lexikon* (2nd ed). Stuttgart: Ferdinand Enke.

- LUHMANN, Niklas. 1984. *Soziale Systeme. Grundriß einer allgemeinen Theorie*. Frankfurt am Main: Suhrkamp.
- _____1986a. “Das Kunstwerk und die Selbstreproduktion der Kunst”. In *Stil. Geschichten und Funktionen eines kulturwissenschaftlichen Diskurselements*, ed. Hans Ulrich Gumbrecht and K. Ludwig Pfeiffer, 620-672. Frankfurt am Main: Suhrkamp.
- _____1986b. “Das Medium der Kunst”. In *Niklas LuhmannAufsätze und Reden* (2001), ed. Oliver Jahraus, 198-217. Stuttgart: Reclam.
- _____1990. “The Autopoiesis of Social Systems”. In *Essays on Self-Reference*, 1-20. New York: Columbia University Press.
- _____1994. *Die Ausdifferenzierung des Kunstsystems*. Bern: Benteli.
- _____1995a. *Die Kunst der Gesellschaft*. Frankfurt am Main: Suhrkamp.
- _____1995b. *Social Systems*. Translated by John Bednarz, Jr. with Dirk Baeker. Stanford, CA: University of Stanford Press.
- _____1995c. “Wie ist Bewusstsein an Kommunikation betteiligt?” In *Niklas Luhmann Aufsätze und Reden* (2001), ed. Oliver Jahraus. 111-136. Stuttgart: Reklam.
- _____1997. *Die Gesellschaft der Gesellschaft*. Frankfurt am Main: Suhrkamp.
- _____1999. “The Paradox of Form”. In *Problems of Form*, ed. Dirk Baecker, 15-26. Translated by Michael Irmscher with Leah Edwards. Stanford, CA: StanfordUniversity Press.
- _____2000. *Art as Social System*. Translated by Eva M. Knodt. Stanford, CA: University of Stanford Press.
- LYSLOFF, René; Gay, Jr. Leslie C. (eds.) 2003. *Music and technoculture*. Middletown, CT: WesleyanUniversity Press.
- MATURANA, Humberto R. 1985. [Humberto R. and Köck, W. K. (ed.)]. *Erkennen: Die Organisation und Verkörperung von Wirklichkeit. Ausgewählte Arbeiten zur biologischen Epistemologie* (2nd ed.). Braunschweig: Vieweg.
- _____2002. “Das Erkennen des Erkennens verpflichtet”.In *Die Gewissheit der Ungewissheit. Gespräche zum Konstruktivismus*, ed. Bernhard Pörksen, 70-111. Heidelberg: Carl-Auer.
- MATURANA, Humberto R., VARELA, Francisco J. 1980. Autopoiesis: The Realization of Living. In *Autopoiesis and Cognition: The Realization of Living* [1980]. Boston Studies in the Philosophy of Science, vol. 42. Boston: D. Reidel.
- _____1987. *The tree of knowledge: the biological roots of human understanding*. Boston: Shambhala.
- MINGERS, John. 1995. *Self-Producing Systems. Implications and Applications of Autopoiesis*. New York; London: Plenum Press.
- POPPER, Karl R. 1971. *Objective Knowledge. An Evolutionary Approach.*London: OxfordUniversity Press.
- PÖRKSEN, Bernhard. 2002. *Die Gewissheit der Ungewissheit. Gespräche zum Konstruktivismus*. Heidelberg: Carl-Auer.
- POUSSEUR, Henri. 1968. “L’Apothéose de Rameau”. In *Musiques Nouvelles*. *Revue d’Esthétique*, 105-172. Paris: Klincksieck.
- _____1970. *Fragments théoriques sur la musique expérimentale*. Bruxelles: Université Libre de Bruxelles.
- REESE-SCHÄFER, Walter. 2001. *Niklas Luhmann zur Einführung* (4th

ed).Hamburg: Junius.
- ROSEN, Charles, 1995. *The Romantic Generation*. Cambridge, MA: HarvardUniversity Press.
- RUWET, Nicolas. 1972. *Langage, musique, poésie*. Paris: Éditions du Seuil.
- SCHAFER, R. Murray. 1994. *The Soundscape: Our Sonic Environment and the Tuning of the World*. Rochester, VT: Destiny Books. Previously published as *The Tuning of the World*, New York: Knopf (1977).
- SHANNON, Claude E. 1948. “A Mathematical Theory of Communication”. The Bell System Technical Journal 27: 379-423, 623-656. <http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf>[Consultation: October 20, 2005].
- SHERR, Richard (ed.). 2000. *The Josquin Companion*. New York: OxfordUniversity Press.
- SPENCER-BROWN. 1969. *Laws of Form*. London: George Allen and Unwin.
- STERNER, Jonathan. 2003a. *The Audible Past*. Durham; London: Duke University Press.
- _____2003b. “Sounds Like the Mall of America. Programmed Music and the Architectonics of Commercial Space. In *Music and technoculture*, ed. R. Lysloff and L. C. Gay Jr., 316-345.Middletown, CT: WesleyanUniversity Press.
- TERHARDT, Ernst. 1998. *Akustische Kommunikation. Grundlagen mit Hörbeispielen*. Berlin; Heidelberg: Springer.
- THOMPSON, Emily. 2002. *The Soundscape of Modernity. Architectural Acoustics and the Culture of Listening in America*, 1900-1933. Cambridge, MA: The MIT Press.
- TRUAX, Barry. 2001. *Acoustic Communication* [2nd ed.]. Westport, CT: Ablex Publishing.
- VARELA, Francisco J. 1979. *Principles of biological autonomy*. New York: North Holland.
- _____1999. “The Specious Present: A Neurophenomenology of Time Consciousness". In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, ed. J. Petitot, F. J. Varela, G. Pachoud and J.-M. Roy, 265-314.Stanford, CA: StanfordUniversity Press.
- VARELA, Francisco J.; Thompson, Evan and Rosch, Eleanor. 1991. *The Embodied Mind*. Cambridge, MA: The MIT Press.
- WEBERN, Anton. 1963. *The Patch to the New Music*. Ed. Willi Reich. Translated by Leo Black. Bryn Mawr, PA: Theodore Presser Company.
- WHITAKER, Randall. 2001. *The Observer Web: Autopoiesis and Enaction*. <http://www.enolagaia.com/AT.html> [Consultation: November 15, 2005].
- WIENER, Norbert. 1961. *Cybernetics: or Control and Communication in the Animal and the Machine*. Cambridge, MA: The MIT Press.
- WITTGENSTEIN, Ludwig.1971. *Philosophische Untersuchungen*. Frankfurt am Main: Suhrkamp.
- _____1980. *Culture and Value*. Translated by Peter Winch. Chicago: The University of Chicago Press.

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