A Typo-morphological Approach to Human–Machine Interaction Analysis in Music

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Abstract

This article proposes an analytical perspective on the aural analysis of human-machine interaction. Starting from Pierre Schaeffer's musical thinking, it focuses on the perception of sound morphologies that generate from human machine interaction. This interaction, usually interpreted under the perspective of the devices and technological innovation, will be interpreted through the perspective of musical perception and semantics. In the article, the author applies the criterion of 'allure', that permits to analyse the sound objects sustain and to indicate the sound agent as mechanical, living or natural. 'Allure' is used as a theoretical framework for the analysis of human-computer interaction in music. Inspired by a hypothetical perceptive Turing's test, the author employs the 'allure' criterion as a conceptual tool for an aural analysis of human-machine interaction: aural analysis can indeed reveal the interaction of sound agents through the cognitive mechanism of motor imagery. This approach can be extended and developed in music information retrieval. The author will develop this reflection showing the actuality of Schaeffer's perspective in HCI analysis. Finally, to highlight the interaction between human and electronic sound sources, the author will consider a case study: the first movement of *Traiettoria* for piano and electronics by Marco Stroppa.

POST- AND TRANS-HUMAN SOUNDS

The debates in ethics and Art on the transition to a post- or trans- human anthropology are today largely discussed and are frequently related to topics such as the impact of technology, the economic processes in human life, health and care systems. In this epoch, artificial intelligence and nanotechnologies are about a form of humanity that is characterized by new types of bodies (Barad 2003). According Rosi Braidotti (Braidotti 2013: 49), "contemporary bio-genetic capitalism generates a global form of reactive mutual inter-dependence of all living organisms, including non-humans".

Symptomatically, the century that saw the rise of the problematics of listening as a way for theorists and composers to analyse and create musical forms in accordance with the electroacoustic means, has also contributed to the development of the reflection on the relationship between humans and machines. This relationship has been thoroughly investigated in philosophy (Benjamin 1936), psychoacoustics and informatics (Risset 2014) and literature (Valéry 1931), which have made music a crucial interdisciplinary field providing cases and examples leading to new musical graphemologies as well (Lévy 2013). In the 20th century music, the human-machine interaction had its principal impact in musical practice, in studio and in concert, through the development of electronic, mixed, interactive and *live* musical forms (Holland, Wilkie, Mulholland and Seago 2013). This relationship, that marked avant-garde movements, has progressively become a central aspect of musical practice in general, from popular to contemporary music (Born 2005).

Music is one of the artistic frontiers in the debate on human-machine interaction, and probably the most developed. The technical revolutions of the century are reflected in the

increasing role of devices and of the modification of performative actions of the human body in concert and its role as the main source of sound production. In electronic musical practice, musicians are experiencing the transition to a new form of acoustic production, where the performer is differed, evoked and/or used as controller (Tanaka 2006). This transition is characterized by a transformation of the gestures, movements and manners to interact with sound.

This phenomenon has been largely studied by philosophers, neuroscientists and anthropologists (Rose 2017). However, the analysis of musical forms based on the integration of human and machine sound features is still relatively underdeveloped in musicology. Indeed, as claimed by Dufourt (1991a), the use of technologies requires a consistent musical thinking apt to the morphological aspects of sound. The anthropological changes prompted by economic development are accompanied by aesthetic shifts too. We are increasingly becoming accustomed to sonorities produced by machines or by the human-machine interaction, which change the habitual relationship between an agent and a perceived sound. This experience modifies the expectation of the sound agent, creating the conditions for a post-human agency, a hybrid of human and machine. What was traditionally understood as sound and defined by an inherent morphology (Wishart 1996: 109), is today based on a broader proprioceptive experience where sound perception and body action are brought into question. For example, consider the massive and pervasive sound amplification and sound transformations, or the public getting used to physically participate in musical events and concerts with virtual performers, e.g. the Japanese virtual singer Hatsune Miku.

Starting from this ecological perspective, I argue that music constitutes an aesthetical familiarization that cognitively contributes to the biological evolution of humankind. I thus propose to analyse the interaction of human and non-human sonorities and to consider the non-human sounds as comprising embodied sound morphologies, linked to the usual experience of, for instance, real sounds coming from the acoustic everyday perception (Norman 1996), instruments and voices. This approach considers perception as an adaptive strategy characterized by the decontextualisation of the usual experience and aiming to progressively construct a coherent conditioning based on the recognition of sound sources. Indeed, listeners are getting used to recognise synthesisers and sound transformations, also thanks to handy musical devices in smartphones. The perception of the subsistence of the human body in musical experience remains central but is steadily extended and transformed. The interrelation, expansion and even conflict between the perception of a human agent and/or its absence, highlights the importance of a comparison between human and non-human sound agents, defining hybrid morphologies consisting of gesture-led movements and abstracted textures. This interaction provides a hybrid sound territory in which humans and machines define specific sound morphologies and musical meanings, i.e. the interaction of hypothetical hybrid sound-agents.

The mutation of the relationship between humans and devices was examined by Pierre Schaeffer (1966). From a holistic point of view, he maintained that the relationship between sound production and sound perception should be considered together, paving the way for the ecological debate. Indeed, Schaeffer (ibid.) connected instrument making and sound morphology: i.e. the first two chapters of the *Traité* are "*faire de la musique*" – i.e. doing music – and "*entendre*" – i.e. listening, whereby the latter is seen as a consequence of the former, in which the notion of musical instrument is discussed through the lens of new electric devices. Schaeffer claimed that passing from music making to music listening renewed listening through the act of making ("On passe ainsi du 'faire' à l''entendre' par une renouvellement de l''entendre' par le

'faire'. C'est en quoi le livre suivant pourra confronter à son tour aussi bien les plus anciennes définitions de l'entendre que les plus nouvelles façons de faire entendre") (Schaeffer ibid.: 99). Through this analysis, Schaeffer (ibid.: 145) aimed to identify the correlation between the physical object and the sound object.

We suggest that, in Pierre Schaeffer's musical thinking, the distinction between the 'ancestral' instrumental body driven sonority and the new electroacoustic one, is fundamental. This distinction allowed to develop, from an updated interpretation of his theoretical framework, a possible coherent approach for the aural analysis of human-machine interaction as well.

In the *Traité*, the notions of 'sound body' and 'sound object' are defined as problematizing the relationship between the physical presence of the musician as sound agent and its displacement in time and space due to recording techniques and electronic devices in general: electronic instruments cancel, *de facto*, the necessary presence of the human in music. Indeed, Schaeffer claimed that in electronic sounds, the human material is absent, in the same way as the biological or the mineral texture do not exist in the plastic material, even if it imitates their grain (Schaeffer 1966, 64). However, the human reference remains and it is evoked by the sound morphologies. The relationship between production and perception emerges when he considered instrument making. In order to define the notion of instrument, he introduced the principles of permanence and variation: the usual instrument produces sounds that have a balanced equilibrium between the recognition of usual features and their development in other forms. His aim was to indicate, through a specific *solfège*, the relationship of the instrument and of the sound: however, this relationship was complex and his project finally failed. In the *Traité*, both the displacement and the transformation of the human presence by electronic means are considered in relation to usual sound perception and causal induction. We think that the rule of permanence and variation is also valuable for the agent recognition. Acousmatic music, which avoids the reference to sound agent at a perceptive and semantic level – i.e. the reference with a visible and touchable sound agent, allows to understand the perceptive constraints that emerge from the interaction between the traditional sound proprioceptive experience and the disembodied one (Schaeffer 1966, 93). The complex processes of listening, that Schaeffer defined in four modalities (cf. *écouter*, *ouïr*, *entendre* and *comprendre*), indicates the delicate interaction between the semiotic and the acoustic level. Indeed, the suggested process of disembodiment or decontextualisation ("déconditionnement"), can be seen as constitutive of the most complex bio-technological evolution of the integration of electroacoustic sounds in a proprioceptive, embodied and accessible experience for the humans, who become progressively active in the sound generation process.

HYBRID SOUND OBJECTS: SCHAEFFER'S LEGACY

Music interaction does not necessarily imply new musical forms. For example, Joseph Schillinger's Theremin concerto, *First Airphonic Suite* (1929), is a classical tonal concerto. At the same time, music interaction can be seen as producing new musical forms. Indeed, the use of new instruments can lead to the creation of new musical genres, e.g. rock, experimental music, "musique concrète", electronic, dance, techno, multimedia arts. All these electronic musical genres have a specific relationship with the traditional proto-electronic musical practice.

The emergence of new musical forms constitutes a complex output that concerns listening and sound production together. On the one hand, the human-machine interaction in music is characterized by the comparison of sound morphologies and devices creating super-human sonic forms. On the other hand, this interaction engenders musical theories that frame the sonic

appearance of those new morphologies within the utilisation of electronic devices. Pierre Schaeffer is therefore still crucial for this reflection.

To compare sounds and devices from the traditional and the electronic musical experiences is a well-established practice. Indeed, in the fifties, Karlheinz Stockhausen defined this contact between instrumental and electronic sounds with the notions of known and unknown sound morphologies[1]. To refer to a cognitive dimension of knowledge about sound points to the inherent possibility of humans to recognized an experienced sound and to reproduce it thanks to the embodied perceptive experience, whereby unknown sounds are understood as not produced by humans and not belonging to the usual experience. This contrast participates in the definition of super-human sound entities, characterized by the contact of expanded human sonorities until their farther surrogates. The referential perceptive aspect is therefore crucial in that our perceptive system possesses an automatic "search engine" (Emmerson 2007: 5) of the causal origin of sounds. The relationship between sounds produced by instruments and those generated by machines is recognizable thanks to the identification of the agent incorporated in the perceived source. Generally, musical practice necessitates the development of specific concepts and an intellectual discourse (Duchez 1989): the intertwining of instrumental and perceptive constraints shapes the emergence of musical forms generating hybrid arts forms (Levinson 1984) that are at the core of Schaeffer's theoretical analysis.

In the wake of these considerations, the questions tackled in this article concern the analysis of hybrid post-human sonorities and their role in musical experience and practice. To put forward the analytical approach here proposed, we will identify in Pierre Schaeffer's theoretical discourse the fundamentals for the development of specific tools that can guide a musical analysis of the interaction of humans and electric devices from an aural perspective. Indeed, sound morphologies are very specific and necessitate clear analytical paradigms. This approach permits us to determine the relationship between the sound and the agent. The purpose is to examine human-machine interaction in music and toward music, conceiving hybrid sonorities as the perceptive result of the complex interrelation of humans and non-humans.

For Schaeffer, musical objects can be categorized according to three binary categories: mass/facture, duration/variation, balanced/unbalanced. These categories are based on the sonic complexity of sound object according to the notions of pitch, the quantity of perceptive information and the form. For Schaeffer, those distinctions uniquely concern the 'sound object', conceived as the correlate of reduced listening (Chion 1983). The *Traité* advances a listening methodology, which aims to encourage a musical awareness of sound phenomena emerging from electronic music. Schaeffer aimed to define a *solfège* for electronic equipment, in order to determine the relationship between sound and 'facture', as in instrumental music, in which the *solfège* allows to represent the musical procedures with the sound result as well. The project of this new *solfège* of the musical objects" ought to:

> dégager […] une certaine musique d'une certaine lutherie, […] de lier une théorie des structures musicales à une pratique des timbres et des registres. […] ; il s'agit de faire correspondre à telle sorte de moyens instrumentaux (tablature) telle sorte de musique, basée chacune sur une relation fondamentale.

[1] Stockhausen, Karlheinz, *Kontakte* (1959 – 60). On *Etude, Studie I & II, Gesang der Jünglinge, Kontakte*. Kürten: Stockhausen Edition CD3.

[free a certain music from instrument making, […], to link a theory of music structures to a practice of timbres and registers. […] It is all about associating specific instrumental means (tablature) to a music type, based on a fundamental relationship] (Schaeffer 1966: 498).

In order to trace the lines of this *solfège*, listeners are asked, phenomenologically, to picture an acoustic image of sound objects, without any references to the causality of the musical act. As a result, this radical process can unleash perceived sounds from their instrumental or physical cause and encompass their perceptual aspect. Schaeffer's typology allows us to identify sound objects following the criterion of 'stress-articulation':

[...] l'univers sonore parait [...] obéir aux mêmes lois d'articulation et d'appui, à condition d'en rester aux généralités et de donner un sens très large à ces deux critères. [...] les factures d'une typologie gestuelle peuvent constituer, pour l'ensemble des objets sonores, un premier critère d'identification, donc aussi de classification.

[sound universe appears to follow to the same laws as stress-articulation, if we understand these laws and two criteria broadly. […] the execution of a gestural typology can constitute, for the ensemble of sound objects, a first criterion of identification, thus of classification too] (Schaeffer 1966: 365)

In the *Traité*, electronic sounds are "detached from the ancestral contingencies" (Schaeffer 1966: 239). The interaction between sounds that are detached from usual mechanical sound production and instrumental or vocal ones, implies a particular perceptive form, which is for Schaeffer defined by a specific sustain. For him, typo-morphology allows to compare the natural with the artificial through the perception of a *vibrato* that indicates the persistence of a human action in the sound production. The perception of this element, that signals the agent is defined as 'allure':

une interrogation très générale de l'homme devant tout objet, qu'il soit musical ou non: "naturel ou artificiel? artisan ou machine? bois ou plastique?" Pour l'objet musical, c'est l'allure qui permet de répondre. Dans l'allure, la perception s'attache à tout qui ce peut révéler la présence du différencié, du vivant.

[a general interrogation of the individual in front of an object, being it musical or not: 'natural or artificial?' craftsman or machine? Wood or plastic?" For the musical object, it's the *allure* that allows us to answer to these questions. In *allure*, perception relates to all that can reveal the presence of the differentiated, of the living] (Shaeffer 1966: 556)

The 'allure' criterion is based on the perception of the dynamism of the agent, observed towards its kinaesthetic aspects. It

révèle la façon d'être de l'agent énergétique et, d'une façon très générale, si cet agent est vivant ou non: la vie se manifeste en effet par une fluctuation typique.

[reveals the shape of the energetic agent and, generally, if this agent is living or not: life manifests itself through a typical fluctuation] (Schaeffer 1966: 550).

'Allure' is defined by a typo-morphological diagram characterized by a typical movement of sustain. In Figure 1, the agent of the sustain is characterized by three aspects: the *mechanical*, the

living and the *natural*. The sustain form is characterized by three types of movements: *order*, *fluctuation* and *disorder* (Schaeffer 1966: 557).

At the base of this Schaefferian problematics lies that of the human-machine interaction: listening and producing sounds are two sides of the same coin.

Sustain's Form

Morphological Criterion / ***Typological Criterion***	Order	Fluctuation	Disorder
Mechanical	**1**	2	3
Living	4	**5**	6
Natural	7	8	**9**

Sustain's Agent

Figure 1 : 'Allure"s Typology and Morphology

Schaeffer's approach put forward a framework for the study of the interaction of the perceived sound sources. While he applied the concept of allure to the analysis of the sound object, i.e. a disembodied listening, we will try to show that the analysis of the 'allure' perception allows to understand the interaction of instruments and electronic sounds.

RECODING REDUCED LISTENING: A COGNITIVE BASIS

For Rolf-Inge Godøy (2006), typo-morphology is based on the cognitive basis of motor perception. Godøy (2006: 152) claims that the criterion of 'stress-articulation' is grounded in the ecological principle of "chunking of the sensory stream". While he agrees that reduced listening extracts sound experience from causality and from anecdotic signification, he maintains that it continues to be based on perceptive schemata as energy and discontinuity (ibid. 2006). Godøy hypothesises a process of musical imagery tracing the sound in music perception: a recoding of musical sound into "multimodal gestural-sonorous images based on biomechanical constraints (what we imagine our body can do)" (ibid.: 149). Sound perception and motor imagery share similar cognitive schemata. These aspects have been recently the object of research in cognitive sciences, which show that typo-morphology is linked to the perception of gestural movements, characterizing the perception of the sound agent in the sound objet through kinaesthetic features.

Motor imagery shows the motoric representations of human beings, focusing on the multimodal projection enhanced by perception (ibid.). Indeed, listeners envisage the action that causes the sound. Two cognitive principles characterize the motor imagery: first, the 'agency detection' (Launay 2015) and, second, the 'constructive imagery' (Schaefer 2014). 'Agency detection', or 'implied agency', indicates the musical perception of agent's actions. Implied agency means the human strategy to identify the sound source or the agent. Indeed, when listening to non-musical sounds, the sound source is prioritized by the listener (Gaver 1993a). Launay (2015: 32) claims that:

> It is now commonly accepted that there is a continuum between perception and action, so that the perception of sound can be a motor process for a listener. […] there is now much empirical support to demonstrate that if people have clearly learnt associations between a sound and their own movement, regions of the brain involved in making that movement are active during the perception of that sound.

Electronic sounds and the acousmatic experience could be used to analyse the listening strategies related to sound perception. Indeed, Launay claims that (Launay 2015: 33):

> In the twentieth century acousmatics have been revived as a musical movement, in which everyday sounds (e.g. footsteps) are decontextualized and emphasis is placed on their acoustic properties rather than the source of sound. Within this music, and other forms of electronic music that remove visible agents from sound production, there is much recognition of the role that recognizing agency and movement in sound can play in the listeners' experience. Empirical evidence has shown that in electroacoustic music the presence of animate sounds can have a significant effect on the way that music is perceived. Given that identifiable agency could be entirely removed from music of this kind, it is important to note that researchers and musicians have repeatedly returned to the potential importance of agency detection.

Rebecca Schaefer (ibid. 2014) insists as well on a similar idea, i.e. the 'constructive imagery'. For Schaefer the auditory imagery preserves the features of the imagined stimulus, semantically investing the perceived information. The constructive imagery permits to organize the perceptions in a coherent cognition, based on a prediction of sound events (ibid., 163). Those cognitive mechanisms influence standard perception. In a similar manner, acousmatic music exalts the presence of sound agency, thanks to its absence: for Emmerson (2007), electronics 'sublimates' and 'celebrates' the human body.

This cognitive science debate shows how acousmatic music repertoire can raise questions on the human and non-human relationship and representation in music. The typo-morphological approach inspired different analytical perspectives at the end of the 20th century as well. Spectromorphology (Smalley 1997) considers the perception of gestural sound elements as fundamental. This tendency is based on the definition of sound categories coming from the aural distinction of gesture and texture, which defines a continuum based on the capability of the listener to identify a human agent articulating the sound. If this agent not recognizable, the textural aspect would predominate. Smalley (1997: 111) claimed that:

> A human *agent* produces spectromorphologies via the motion of gesture, using the sense of touch or an implement to apply *energy* to a *sounding body*. A gesture [...] is proprioceptive: that is, it is concerned with the tension and relaxation of muscles, with effort and resistance. In this way sound-making is linked to more comprehensive sensorimotor and psychological experience.

The synesthetic approach – typical of ecological theories – is present in Smalley's reflection. Notions of gesture and texture are linked to the notion of 'source bonding', which defines a kind of implied agency. At the same time, Smalley's notion of gesture surrogates is similar to the concept of 'constructive imagery', as Schaeffer's holistic perspective continues to stimulate musicological research. His legacy is demonstrated by the genetic and aural methodologies that still mark electroacoustic music analysis (Dias de Sousa and Couprie 2015) and by the application of this methodology in the analysis of improvisation.

Research in cognitive sciences and analytical perspectives on electroacoustic music analysis are therefore closely related. It is indeed possible to find in the typo-morphological approach a way to define the constructive imagery of the human-machine interaction. Humans and machines constitute a specific sound dichotomy that replicates the one proposed by Smalley of gesture and texture. This perspective expands the standard typo-morphology and allows us to study this interaction not only from a point of view of devices but from that of reception too. Furthermore, it offers the possibility to link the aural analysis to most recent debates concerning

embodied cognition. The connection of sound morphologies and agents allows for a possible inductive esthesic analysis (Nattiez 1987) based on source recognition. Indeed, electronic music broadens the range of sonic archetypes of vocal and percussive sounds (Laliberté 2004). As revealed by cognitive sciences, humans perceive the relationship between sound agents aurally (Launay 2015), sound morphologies being strictly related to sound causality and gestures.

To show the advantages of this approach, we will use the 'allure' criterion in the analysis of the first movement of *Traiettoria*, for piano and electronics by Marco Stroppa: *Traiettoria…deviata* (1982).

LIVING, MECHANICAL AND NATURAL: A CASE STUDY

Currently, there are no means of music information retrieval analysis or machine learning that can analyse the perception of the interaction of humans and machines, as the agent perception is strictly related to the perception of intentionality. This is a task which, while it involves perception and comprehension, entails the interrelation of the four forms of listening proposed by Schaeffer. This perception is a complex cognitive activity and it is inherently human: the recognition of an agent, related to the recognition of a possible danger, is biologically linked to the way humans perceive the environment (Castellengo 2015). In this context, the utilisation of the analytical framework based on the concept of allure offers an original perspective.

In mixed music, the understanding of the relationship between sound sources is of primary importance. Indeed, the listening of mixed musical works under acousmatic conditions implies an appreciation of the difference between musical sources and, in concerts, also entails the possibility to distinguish between visual and acoustical cues and to appreciate the interrelation of instrumental and the electronic elements. This points to what Schaeffer defines 'characterology', namely, 'return to the objet' that produces the sound (Dack 2008). Mixed music listening cannot be utterly reduced to a Schaefferian sound objet. Nonetheless, the Schaefferian notion of 'sound object' is not completely detached from a causal anchorage either.

For all these reasons, and because mixed music is a clear case of human-machine interaction in studio and in concert, we will analyse *Traiettoria* through the concept of allure, in order to highlight the sonic transformation of electronic and the instrumental means in a post-human sonic morphology. *Traiettoria* is a work for piano and electronics composed by Marco Stroppa (an Italian composer born in 1959) between 1982 and 1984 in the studio of Padua's CSC Centre and Ircam. It is today considered a classic example of mixed music repertoire. In this piece, the electronics consists of synthetic sounds elaborated by the computer. Thus, the relationship between the instrumental part and synthetic sounds creates effective contact points characterised by the perceivable differences between the two sound sources: the perception of the human agent, on the one hand, and the non-human generator, on the other. This piece comprises a large range of synthetic sounds (additive, FM, FOF), which are used to create a contact evoking living, mechanical and natural sound sources. At the same time, this difference provides a clear perceptive discrimination that helps the appreciation of the formal articulation of the work. The piano and the synthetic sounds define two clearly opposite sound dimensions that possess a specific sound identity. In this case, the compositional practice entails a mimetic interrelation between the mechanical source and the human one. Overall, the relationship between the instrumental and the electronic part is characterized by two approaches. The first one relates to the symbiotic interaction between the two dimensions, for instance at the end of the instrumental introduction (3min08s), when the electronic part emerges from the piano resonance. The resonance of the piano seems to transform into a non-human sound as the listener attends to the

mimetic metamorphosis of the chord of the piano into a developed electronic sound. The second pertains the dialectical interchange of the instrument and the electronics, characterized by the alternate succession of the instrumental and the electronic part, as expressed in the title of the following sections of the piece, i.e. *Dialoghi* (Dialogues) and *Contrasti* (Contrasts). The way the sustain of the sound event is composed highlights the interrelation of human and non-human sound components. As already suggested by Schaeffer, the interaction of 'balanced' and 'unbalanced' sounds accompanies that of human and non-human (electronic or natural) sounds. In order to analyse *Traiettoria…deviata*, it is crucial to perceptively differentiate the sound sources and to apply a strategy of segmentation of the sensory stream that allows for an analysis of the 'allure' [2] of the sustain.

Figure 1 describes the typological and morphological elements of the 'allure'. The relationship between sound agents and the form of the sustain of the amplitude envelop are characterized by a standard perceptive association, defined by the numbers 1, 5 and 9. Schaeffer proposed to associate the mechanical agent with an ordered form of 'allure', the living with a fluctuation of the sustain, and the natural agent with a disordered sustain. He therefore creates a categorisation based on the perception of three levels of organisation: the ordered, the fluctuation and the disordered. It would be interesting to apply this perspective to a lager repertoire and to instrumental, natural or synthetic samples, to define the sonic features of each sound event and to provide data for a possible application to machine learning. The notion of 'allure' allows to identify the typology of *vibrato* and the semantic paradoxes of the sound interaction perception, i.e. the mimetic transformation of the instrumental into the natural and/or the mechanical sound provoked by the electronics. The problem of the semantic recognition at the core of this approach can open up new avenues of research in music information retrieval.

The spectromorphologial approach and the typo-morphological one analyse the formal behaviour of the piece in order to identify its constitutive sound events, through the perception of the stress-articulation elements. In spectromorphology, the structural functions are defined by three moments: attack, sustain and release. Through a spectromorphological analysis based on the perception of gestural articulations, the segmentation process can determine the gestural/textural relationship, clarifying which is perceptively prevailing between the internal, characterized by the texture, and the external, characterized by the gesture. The perspective proposed by the criterion of the 'allure' complements this analytical approach and encompass the perceptive analysis of human-machine interaction in music. *Traiettoria…deviata* is defined by 16 events. Figure 2 indicates the spectromorphological structural functions and the allure typology and morphology, highlighting the predominance of the mechanical, living or natural agent during the events.

Event	**Structural Functions**	**Allure's Tipology**	**Allure's Morphology**
I: 3min 08s	Emergence-Transition-Plane	Living (3'08''-3'20'') ➔ Mechanic – living (3'20'' - 3'30') ➔ Mechanic	Order Fluctuation Disorder Fluctuation Disorder

[2] Stroppa, M. 1992. *Traiettoria* (1982/84). On *Computer Music Currents 10*. Wergo – WER 2030 – 2.

		(3’30’’ - 3’58’’) ➔ Mechanic (3’58’’ - 4’8’’) ➔ Mechanic (4’8’’ - 4’11’’)	
II: 4min 15s	Attack-Maintenance-Plane	Mechanic Living	Order Order
III: 4min 22s	Attack-Maintenance-Arrival	Mechanic	Order
IV: 4min 26s	Attack-Maintenance-Closure	Mechanic	Fluctuation
V: 4min37s	Attack-Maintenance-Disappearance	Mechanic	Fluctuation
VI: 4min43s	Anacrusis-Maintenance-Plane	Mechanic Living	Fluctuation Order
VII: 5min	Attack-Prolongation-Disappearance	Living	Order
VIII: 5min01s	Emergence-Sustain-Closure	Living (5’1’’ - 5’8’’) ➔ Mechanic (5’8’’ - 5’12’’) ➔ Mechanic (5’12’’ - 5’20’’) ➔ Mechanic (5’20’’ - 5’29’’)	Disorder Fluctuation – Disorder Fluctuation - Order Order
IX: 5min29s	Attack-Prolongation-Disappearance	Mechanic Living	Order Disorder
X: 5min43s	Attack-Prolongation-Disappearance	Mechanic-living	Order
XI: 5min55s	Attack-Sustain-Plane	Mechanic-living	Order
XII: 6min12s	Attack-Sustain-Disappearance	Mechanic-living	Order
XIII: 6min24s	Emergence-Sustain-Disappearance	Mechanic-living	Order

XIV: 6min36s	Attack-Sustain-Plane	Mechanic-living	Disorder
XV: 6min42s	Attack-Sustain-Plane	Mechanic	Order
XVI: 6min53s	Attack-Sustain-Plane	Mechanic-Natural	Disorder

Table 1

Table 1 shows the evolution of the agent component: the human/living sound aspect is dialectically related to the mechanical one. It defines an element of the formal dynamic of the piece based on the recognition of an agent. Moreover, the piece is characterized by the interchange of living and non-living sonorities, creating a morphology based on the alternate predominance of human and machine sound sources. In this way, the piece proposes a representation of agent interaction and a semantical interpretation of this comparison. Indeed, the electronic sounds encompass the instrumental ones, which become part of a larger sonic morphology. In general, the main perceived agent is the mechanical one. Yet, this agent is characterized by a disordered vibrato that is similar to living and natural agents. Indeed, the electronic part evokes the vestiges of a possible living or natural sound source.

At the beginning, the living typology is associated with a morphological movement characterized by an ordered sustain (3min08s - 3min20s), where the living envelop is compared to the mechanical resonance of the electronics emerging from the piano chord at 3min08s. The sound transition is defined by a mechanical/living typology that evolves in a mechanical/fluctuation between 3min20s and 3min30s. Between 3min30s and 3min58s, the mechanic/fluctuation of 'allure' increases intensity and vibration. This vibration raises with the volume between 3min58s and 4min08s, until the sound becomes complex, inharmonic and then, between 4min08s and 4min11s, mechanical and disordered. These transitions in the first event highlight the mimetic character of electronic sound, that assumes the forms of living and natural allures, compared with the usual behaviour proposed by Schaeffer. Through the comparison of the analyses with the central axe characterized by the numbers 1, 5 and 9 of Schaeffer's table, it is possible to observe this specific transformation. At the beginning of the event, the electronics starts from the living ordered 'allure', characterized by the sound of the piano; progressively the electronics assumes the shapes of a natural sounds with a morphology characterized by the disorder. This aspect does not change even if we consider the variables of the table as discrete ones. A synchronic representation of the discrete variables of the analysis represents the predominance of the mechanical typology (Figure 2) and, from the point of view of morphology (Figure 3), the prevalence of the ordered vibrato and the relative balance between fluctuation and disorder.

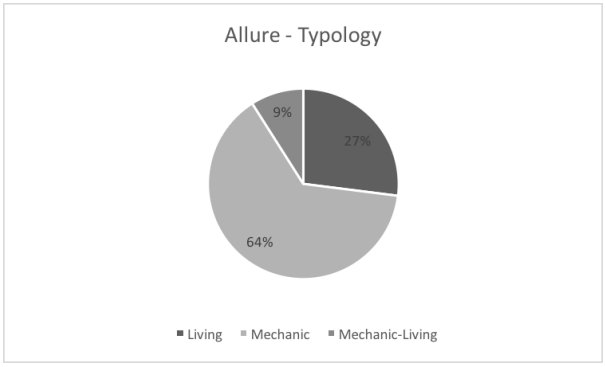

Figure 2 Traiettoria...deviata allure's typology

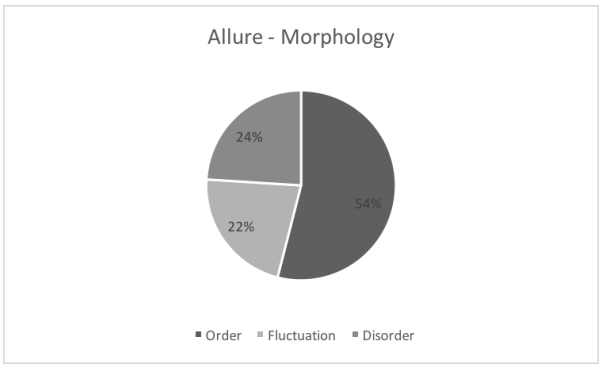

Figure 3 Traiettoria...deviata allure's morphpology

Figure 2 and 3 illustrate the mimetic role of the electronic sound source, in-between the human and the machine. Indeed, the interaction of the instrumental and the electronic parts is characterized by a predominant mechanical and ordered typo-morphology. The human-machine interaction is therefore orientated towards an electronic model: the piano is directed to a specific model, characterized by an electronic source. The analysis of the 'allure' allows to understand, in the specific case of a mixed music work, the interaction of two different kinds of agents (the living and the mechanical) and to present the interaction of the agent through the mimetic transformation of the morphology. It also allows to interpret the interaction starting from the perception of the living content of the sonic experience. In contrast, for instance, in *Pluton* by Philippe Manoury (1988-92), a piece written in the same years of *Traiettoria*, we can observe an opposite approach, based on the utilisation of iterative morphologies and balanced sound typologies that are strictly linked to the human agent. These observations can be interpreted under a technical perspective as well. The development of the techniques in interactive music are linked to specific sound morphologies related to gestures and the control of the traditional musical parameter, highlighting a connection between the perception of the gestures and the pitch. The concept of allure seems then particularly helpful in analysing the human-machine interaction in music, and could help develop a more formalised model of analysis.

CONCLUSION

In this paper, I have advanced a method for the aural analysis of the human-machine interaction in music and problematized the relevance of an esthesic approach that studies this interaction from an aural point of view. This method aims to fill the gap left by the lack of analytical approaches in the MIR community concerning the analysis of sound agents and their semantical implications and also attempts to open new avenues for further developments in musical analysis and machine learning. The goal of this paper is to balance the standard perspective on the study of human-machine interaction, that is characterized by analytical approaches based on the study of devices: most of the debates concerning the human-machine interaction are indeed related to technological innovation. However, the improvement of the technological environment is not sufficient to explain the emergence of new coherent musical forms. Indeed, this complex reality is characterized by specific forms of the sensible (Dufourt 1991). It is therefore important to investigate the new morphologies emerging from the human-machine interaction in order to interrogate and understand the becoming of music in the context of the current bio-technological environment. As Schaeffer noted, the irruption of the electric means of sound production in the musical practice led to a specific sound experience that modifies but does not erase the proprioceptive perception. In the contemporary moment of rapid transition to a post-human environment, the semantic aspect of this interaction influences the implementation of the cognitive schemata of sound perception through musical practice. It is therefore crucial to develop analytical models through which we can understand the perceptive output of this transition, in order to identify the elements of the interaction of humans and machines during this transitional process. As suggested by Jerrold Levinson (1984), hybrid art forms are characterized by the possibility to recognise the interaction of their intrinsic elements. I suggest that, from the point of view of the agent and from that of the sound morphology, the elements of this interaction are still recognisable. It is then necessary to explore this process of recognition.

This analytical perspective, based on the aural utilisation of the notion of 'allure' proposed by Schaeffer, could be applied to a large corpus of musical works characterized by the interaction in studio, in concert, or both, between humans and machines. The first effect of this perspective is the investigation of the perceptive result of the human-machine interaction. The relationship between instruments and sound results could be then analysed from the point of view of the listener, focusing on the perceived interaction rather than on the producer's sensation. This problem, highlighted by Atau Tanaka (2006), is a crucial one for research on new musical interfaces for musical expression. The second effect consists in the development of an interdisciplinary research focused on listening and of an aural methodology for the analysis of human-machine interaction in music. In this sense, Schaeffer's typo-morphological remains crucial as it is coherent with the present need for a methodological discussion on aural analysis and could be expanded to the domain of human-machine interaction. Schaeffer's notion of 'allure' could potentially lead to the development of machine learning techniques.

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