

LUCA COSSETINI – ANGELO ORCALLI

ON THE CRITICAL EDITING OF ELECTRONIC AND MIXED MUSIC. HISTORICAL MATTERS AND NEW PERSPECTIVES

ABSTRACT

I testimoni delle opere elettroniche e miste prodotte nel secolo scorso con mezzi analogici sono entrati ormai nel dominio documentale digitale e la riflessione teorica sull'etica della preservazione, del restauro e della riedizione di questi documenti non può prescindere dai modelli della communication engineering: il processo di codifica e di decodifica, di trattamento del segnale delle registrazioni audio, oggi anche nel Web, sono della più grande importanza. Nata nel contesto dei sistemi di comunicazione elettroacustici ed elettronici, la ricerca musicale del secolo scorso ha trovato nella Teoria dell'informazione un motivo conduttore privilegiato. Nel mondo della musica elettronica e mista, il sistema tecnologico diviene parte integrante del progetto compositivo e le tracce audiovisive rappresentano una 'proiezione' del progetto di produzione. Queste fonti audio consegnano all'editore testimonianze essenziali per ricostruire l'universo teorico e tecnologico del compositore, vale a dire la sua pre-post-storia. In questo saggio il ruolo meta-concettuale della Teoria dell'informazione e della comunicazione viene quindi storicizzato per diventare parte integrante di una metodologia sistemica di restituzione dell'opera musicale elettronica. Attraverso numerosi esempi (opere di Edgard Varèse, Luigi Nono, Bruno Maderna, Gérard Grisey) mostriamo peculiarità e problematiche inerenti l'edizione critica di questo repertorio.

PAROLE CHIAVE Opere di musica elettronica e mista, restauro audio ed edizione critica, teoria dell'informazione, Edgard Varèse, Luigi Nono, Bruno Maderna, Gérard Grisey

SUMMARY

Today, the sources of electronic and mixed music produced in the XXth century by analog means have entered the digital documentary domain. Therefore, the theoretical reflection on the ethics of preservation, restoration and re-issue of audiovisual documents cannot ignore the models of communication engineering: encoding and decoding, audio signal processing – also implemented in the World Wide Web today – are of paramount importance. After World War II, a new musical research was born within the context of acoustical and electro-acoustical communication systems and it found a privileged thread in the Theory of Information. In the world of electronic and mixed music the technological system is an integral part of the compositional project, and the audio tracks represent a 'projection' of the production project. Audio recordings deliver to the editor an essential evidence for reconstructing the technical and theoretical world of the composers, which is to say their pre-post-history. In this paper, the meta-conceptual role of Information and Communication Theory is historized and it becomes an integral part of a systemic

method for the restitution of the electronic musical work. With a wide range of examples (including works by Edgard Varèse, Luigi Nono, Bruno Maderna, Gérard Grisey) we show peculiarities and issues of the critical editing of this repertoire.

KEYWORDS Electronic and mixed music, audio restoration and critical editing, Information Theory, Edgard Varèse, Luigi Nono, Bruno Maderna, Gérard Grisey



Introduction

During the XXth century, new means for sound recording and production radically changed compositional thoughts and musical practices. Such a revolution opened a wide-ranging discussion on a number of issues, including philosophical, technological, practical, historical, and critical questions: after a ‘technological reporting’ phase, scholars have recently shown a strong interest in the impact of audio technologies in the field of historical and social sciences.¹ Audio technology was born within the context of Communication Theory; and, as a matter of fact, the latter, in its multiple variants, was a common thread in the composers’ reflection: from Karlheinz Stockhausen’s ‘stated’ communication, to Pierre Schaeffer’s analysis of communication within a production system, to Grisey’s aesthetic and perception perspective derived from Abraham Moles’ theories, just to name a few examples. Today, the sources of electronic and mixed music² have entered the digital domain. Therefore, the theoretical reflection on the ethics of preservation, restoration and re-issue of these audiovisual documents cannot ignore the models of Information and Communication Theories. We believe that the paradigms of those theories have a considerable historical value, because of their pervasiveness in the field of Humanities as well. Due the major media changes that editorial criticism and music publishing are today subjected to, we contend that Information paradigms have to be taken into account for approaching the study and the critical editing of electronic music. In this paper, the meta-conceptual role of Information and Communication Theory is historized and it becomes an integral part of a systemic method for the restitution of the electronic musical work. We then reconstruct a brief history of audio restoration; with a wide range of examples (including works by Edgard Varèse, Luigi Nono, Bruno Maderna, Gérard Grisey) we show peculiarities and issues of the critical editing of electronic and mixed music.

¹ There is a broad literature in this field. The reader can refer to: ARBO – LEPHAY, *Quand l'enregistrement*; BAYLEY, *Recorded Music*; BONNET, *Les mots*; FRANGE – LACOMBE, *Musique et enregistrement*; GAYOU, *Musique et Technologie*; LYSLOFF – GAY, *Music and Technoculture*; STERNE, *The Audible Past*; STERNE, *MP3*.

² With ‘mixed music’ we refer here to music involving both an electronic and an instrumental part. For a discussion on the history of the term please refer to ORCALLI, *Analyser la musique mixte*.

From notation to sound recording

From the moment that music, in the course of its development, decided to opt for the support of writing, it also implicitly accepted to share Faust's ideal of technical knowledge, manufacturing of tools, mechanical work and measurement of time. Nevertheless, until the new audio recording and electronic processing methods came along, music as an art form always regarded notation as the preferred way of representing sound and composition ideas. The abrupt extension of organology from its acoustic dimension to new forms of sound production then projected writing beyond its flat graphical dimension, and the advent of new digital media led to a restyling of relationship systems throughout all sectors of art and knowledge. Today's composers are, as a matter of fact, able to work with a variety of writing methods, moving with extreme ease between traditional notation systems and a synthesis of sound in real time as in live electronics. The balance has shifted from music written using notes to a systemic concept of writing/sound production, moving in the direction of greater attention to the performance dynamics of musical processes. Deep changes have followed as regards the definition of writing music. There has been a movement from essentially notational systems to continuous sound representation systems, where the border between sketches and score remains fuzzy. As Goodman already noted, on the one hand «an extreme spirit of *laissez faire* has led some composers to use systems that restrict only slightly the performer's freedom to play what and as he pleases», but

such latitude is not incompatible with notationality [...]. At the opposite extreme, some composers of electronic music, with continuous sound-sources and means of activation, and with the human performer dispensable in favor of mechanical devices, seek to eliminate all latitude in performance and achieve "exact" control.³

Electronic writing would thus be considered autographic: «we have no notation or score, and ironically the demand for absolute and inflexible control results in purely autographic works».⁴ Even though the electronic music composer intends to 'autographically' fix the first 'instance' of the work on an audio record, the work itself soon loses its autographic character because its fruition is inextricably linked with reproduction systems, therefore to their technological development over time, and to the transfer of audio tracks onto other supports in different technological and cultural settings.

Already in the Sixties and Seventies, one of the great forerunners of electronic music, Pierre Schaeffer, highlighted the two levels in the communication process, which assertively came to the fore during the years of World War II: the scientific exploration of communication systems and the social contextualization of the various artistic and scientific factors implicit in the new means available.

³ GOODMAN, *The Languages of Art*, pp. 190-191.

⁴ *Ibid.*, p. 191.

C'est que la *diffusion* (qui s'impose, dès le départ, comme la mission même de radiotélévision, dont elle justifie l'existence) ne devient que progressivement une tout autre réalité : un *phénomène social*, désormais susceptible d'exercer sur le message une *action en retour*.⁵

This feedback action seems to be the result of a transformation process, where Schaeffer points out the aspects related to their interaction with technical and artistic developments. Schaeffer analyzed some elements constituting the media in order to outline a global – and not only sociological – theory: for this purpose his analysis no longer revolves around the two traditional poles sender-receiver; in Schaeffer's view there are actually four poles: two of them are the famous poles of production and diffusion; if we just considered the latter, though, we would fail to understand the significance of communication technologies in terms of culture and power transformations. This is why Schaeffer added two more poles: expression and impact (Figure 1); the combination of these four poles – production, expression, diffusion and impact – results in the set of changes and in the form of communication which has now become widespread.

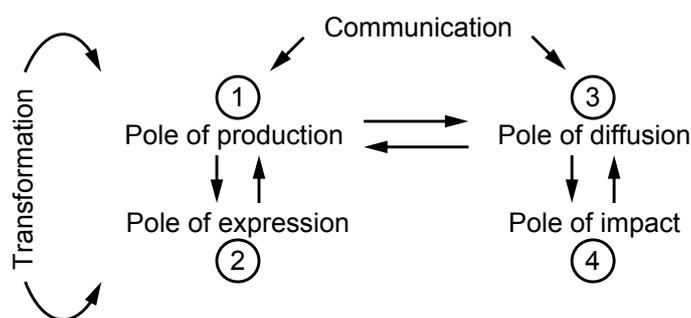


Figure 1. Schaeffer's Communication Model

Schaeffer thus posed the semantic issue of communication at a systemic level, as opposed to a semiological approach, with three underlying elements: composer, performer and audience. The system through its historically given context transforms the meaning of communication, in the sense that it transforms the very concept of sound and music production.⁶

During the 1960's the development of audiovisual systems changed the forms and proportions of communication: through the transistor technology new ways of accessing sound paved the way for groundbreaking musical experimentations;

⁵ SCHAEFFER, *Machines à communiquer 1*, p. 27.

⁶ This phenomenology approach seems consistent with the mathematical formulation of the information theory according to Shannon, which rejected a discussion of the semantic aspects of communication, moving away from the mere sender-receiver relationship perspective to a global overview of communication processes. Taking into account all possible messages and encrypting keys in any given system, Shannon placed his analysis outside the system, trying to expressly define the conditions making it possible to describe not the individual process but the whole communication sets.

this led to production systems overturning the order of competences, which until then had been measured based on the composer's ability to adjust to the rules of music notation. The result was an extension of *horizontal* musical culture, which led to areas typically belonging to *vertical* transmission, associated with schools and academic institutions, starting to follow market concepts. The statement of a new paradigm was already announced in the 1950s in papers regarding the use of the communication and information theory for a number of disciplines and scientific areas, including what were known as exact sciences, as well as human sciences and biology. Post-structuralist approaches then confined writing to the fate of endlessly recomposing, in the name of the impossibility of fixing meaning, of enclosing it within final representations. In this way, plagiarism was implicitly rejected; it was not recognizable because each repetition is at the same time a shift, a reinvention of semantic contents. Each production which can be easily communicated moves through a network of signs, a multiplicity of voices proliferating through inter-subjective experiences. The idea of copyright is thus jeopardized from its very basis because any kind of originality and authenticity is denied. In separating history from textuality, one of the tenets of post-structuralism was that work is testimony to nothing else but its own existence, it refers to nothing else but itself. Attention is thereby fully focused on the linear process of transmission, to making the system accountable. James Grier commented that:

long before the post-structuralists, editing, whether of literature or music, assumed many of the attributes of deconstruction. [...] Editors have always shaped the texts of their editions to conform to their personal interpretative conception of the work.⁷

He also highlighted the impact of the publishing industry on musical text traditions:

since the first inscription of Western art music in Carolingian Europe through Petrucci and Artaria to the most recent scholarly editions, music editors, scribes and publishers had acted as mediators between composer and audience. They standardize notation, adapt work for current performing or institutional needs, correct errors that are obvious to them, introduce corruptions of their own, and generally influence the musical text in any conceivable way.⁸

Based on this perspective centered around production systems, according to Grier, publishing and sound recording are on the same level;⁹ in fact he states that: «the work exists in a potentially infinite number of states, whether in writings (the score) or in sound (performance); the text is one of those states».¹⁰

Generalizing, each individual signal set by a recording system should be regarded as a possible implementation of a system generating aleatory signals. Musical work itself is a process whose witnesses (recordings) are its 'states', defined

⁷ GRIER, *The Critical Editing of Music*, p. 6.

⁸ *Ibid.*, p. 4.

⁹ *Ibid.*, pp. 6-7.

¹⁰ *Ibid.*, p. 23.

by the constraints of the technology of the time and by the models of sound. The implications of the stochastic paradigm in the documentary and specifically philological-musical setting are relevant and inevitable for any musicologist who needs to be equipped accordingly: in order to adjust the source criticism to the characteristics of the medium it is necessary to forfeit seeing authenticity as a quality of the document *per se*, viewing it rather as a property of its production or re-mediation process. The historical survey on audio production system thus becomes a fundamental support because knowledge from outside the signal provides valuable information. As regards audiovisual sources, the success of editorial criticism is bounded to the fact that the ‘observation’ of sound recordings requires operational knowledge of the technical means for audio reproduction and analysis. On the other hand, the editorial criticism of audiovisual recordings cannot be reduced to a mere preservation process, entrusted – in the best of cases – to a skilled IT engineer.

The need for an extension of our critical perspective cannot be felt, unless the media framework created by the new possibility of accessing sound is taken into account. In his masterful review of mass media, carried out on the basis of the polarity *trace/aura*, Walter Benjamin provided a clear analysis of the sensorial and experiential forms of expression deriving from the complex of technical-theoretical conditions created by audiovisual production in its infancy. According to Benjamin, the experience of proximity and shock caused by the direct stress to which humans are subjected by technical apparatus was the root cause of the elements which make the reproducible artwork less authentic and unique, preventing it from creating its own tradition. At that time, it would have been impossible to predict to what extent the technological acceleration produced by World War II would pave the way for the possibility of a further change of perspective. Walter Benjamin could certainly not have imagined that, from the moment a distance, or a gap, was created – but most significantly a kind of discontinuity – in the media sphere (between the analog and digital world), a time would come when the forms of artistic production of his time would be reaffirmed through an act of recognition. From the moment that the new media system started to administer to the whole analog experience the narcotic of faithful rendering of the signal (active preservation), through digital encoding, the meeting of the two systems necessary for the analog and digital conversion started to produce an *aura* which had been unknown until then, which is a result of the technical-theoretical distance which separates them. The transfer operations have led to that degree of dia-systemic tension which has caused the issue of authenticity and value in art music resulting from the reproducibility of analog technologies; the trend today seems to be towards a criticism of these sources, with the aim of counteracting the often a-critical and sometimes fraudulent replacement which the new media system often involves.

From the ethics of preservation to the critical editing of electronic and mixed music

Almost thirty years have passed since UNESCO promoted the publishing of a guide for the preservation of audiovisual documents with a view to establishing a code of professional standards which could serve as international reference framework to regulate all activities aimed at preserving, restoring and re-publishing analog audio and video recordings.¹¹ This started a trend towards the ethics of preservation of audiovisual records. More specifically, the criteria in the audio section of the *Guide* aimed at counteracting the obsolescence of large-scale archive sources: collections of audio recordings, recordings on tape of popular tradition events, radio and television broadcasts, theatre and festival performances. The actions for active preservation could be summed up with the instruction: «the function of the archivist is to save, not to rewrite, history». Preservation work thus needed to: (a) ensure the recovery of the recorded signal, according to the characteristics of the original format; (b) make sure that the signal was accurately transferred onto digital supports; (c) prevent any exposure of the materials to arbitrary modernization treatments of the audio content.

The authors did not go into detail as to the intrinsic value of individual recordings: they were mainly concerned with defining a basic level for preservation, regardless of the distinguishing features of the recorded contents. It is worth noting that the *Guide* does not include specific instructions regarding preservation and reproduction of music composed by the author on an audio support. The guidelines provided were related, on the one hand, to the need for safeguarding an extraordinary heritage consisting of countless hours of recording, and on the other to the awareness that the resources made available by institutions for this purpose would be limited.

Today the pressing need felt at the time by the editors of the *Guide* has been partly superseded, and the procedures to transfer audio materials from the analog to the digital domain have been to a large extent established. The positive effect of new forms of access as regards preservation are clear, nevertheless they have not been methodically analyzed yet: the accelerated rhythm of digital communication tends to instantaneously combine something that used to exist with the here and now. Users of specific audiovisual records seem inclined to use current data, without worrying too much about their origin or authenticity; what they are actually interested in is finding new relationships between what has been produced and what can be reproduced through the immediate manipulation made possible using digital means.

This media change has led also critics to reconsider the concept of source, the author's role and the historicity of music in relation to the non-homogeneous plurality of composition instruments which is now gaining ground. In the case of recordings referring to art music, the goal of enhancement still remains extremely problematic. The uniqueness of the recording of an event mainly consists in the

¹¹ BOSTON, ed., *Guide to the basic technical equipment required by audio, film and television archives*.

event itself being unrepeatable, therefore it is intertwined with its content. On the other hand, the uniqueness of a pure electronic music *master* copy, produced for example in a radio studio in the 1950s, mainly resides in the editing work which is performed by the composer directly on the support: sometimes the recording standards of the time are voluntarily violated, revealing significant moments within the creative process of the music. Moreover, the dissemination of recorded art music has been completed through copies, performance editions, re-issues, etc.; it is possible, therefore, that there might be variants, versions and preparatory materials of the musical work. The whole set of these records referring to a piece of music has a value in itself, regardless of the audio quality of the recording. For these recordings, the use of automated and selective transfer procedures should of course be counteracted. By releasing us from a repetitive process, automatism also end up by dispensing us from actual learning, an essential element for a recognition of the value of individual recordings. Ethics is associated with the discovery of the value of our actions, therefore it is necessary to separate between what can be left to automation and what – due to its uniqueness – constitutes a challenge to understanding what is new. The tension between technocratic and anthropocentric automation is not a merely theoretical concern; indeed, it involves the practice of studio technicians, who are increasingly led to making repetitive choices which diminish the value of their work on a daily basis. As a consequence, less and less attention is paid to issues associated with recognizing the value of the individual recording and, as a consequence, reproduction strategies specifically designed for art music are not implemented. In conclusion, long-standing issues, related to the ethics of the preservation of sound recordings and to the critical editing of audiovisual and mixed music, are now starting to emerge again in new and complex forms: (a) authenticity of the documents, (b) the concept of noise, (c) audio access forms, (d) training to a listening practice historically aware of the technological and composition levels achieved in the development of audio products. These issues concern – although to a different extent – both analog and digital music recordings, as well as those derived from analog records.

Three operating and conceptual levels can be defined today: (1) the faithful transfer of the recorded signal applies to all documents. Generally speaking, as part of these process, two systems inevitably come into contact: the historical and remediation approach. The basic principle of this first level can be defined as dia-systemic; (2) the second level requires awareness of the relativity of our knowledge. Technological advancement and the progress of our knowledge as regards documents, may assign important operational significance to data which in the past were not considered essential. Noise can become a signal, something which used to be regarded as a useful signal could then be read from another cultural perspective as noise. This level can be reached through the exchange of information at international level between archives and studios, active in the field of audio but not only: experiences and practices from other domains in respect of preservation and restoration may become a source of useful input. The basic principle at this level is feedback. (3) In the case of recorded art music it is

essential to add a third level. Sound recordings, in this instance, are a projection of the technical-theoretical choices made by the composer. The components of a piece of music recorded onto an audiovisual support are a sort of holographic image showing multiple diffractions of the composer's ideas. Enhancing these documents in order to preserve them implies achieving a new level: live performance of the music in a concert. The ethics of respect for the author and for music with an artistic value, is sustained in this case by a principle which could be defined as holographic.¹²

The preservation and restoration of audio documents and the reproduction/regeneration of audiovisual works (electronic and mixed) cover a conceptual extent which is located at a crossroads between hard sciences and technologies (theory of signals, audio technologies, chemistry-physics of supports, etc.) and human sciences (ethics, ontology, aesthetics and interpretation, in the two senses associated with music: critical editing and live performance). The act of acknowledging the value of a recording normally results from selecting properties which have the power to produce relevant cultural effects in the world. These properties emerge in a specific historical or technological setting, although they can all be associated with the properties of the document as a data transmission channel.

Audiovisual documents in the Theory of Communication

Within the media domain, and most notably of audio recording systems, the recording of sound is considered an application of time in respect of the space which separates a sound from its source and alters its nature, giving it objective traits and an independent existence which it did not have before. The process of objectifying sound through audiovisual recording makes it possible to separate source and receiver in terms of time: the support thus acts as a channel and makes it possible to decode the message later in time. This assimilation of the recording and reading process to a transmission channel has led to assuming that the benchmarks of the theory of information could be applied to the preservation of sound records. If communication is replaced by recording, then the channel is no longer the origin of propagation events, but rather a long-lasting support which preserves the writing of the signal over time in the form of a track. From this perspective, the following question arises: can Shannon's model (or its variants) be regarded as equally relevant when source and receiver are separated not only through space but also across time? In communication through space there is often a feedback information line available, and many basic and effective communication processes are based on the latter. On the other hand, in communication through time it is impossible to communicate between future and past; no feedback information pathways are available, hence no communication process of this nature is possible.

¹² The foregoing principles can be operationally turned into several approaches to audio records; please refer to ORCALLI, *Orientamenti ai documenti sonori* and ORCALLI, *Tracce sonore*.

According to Robert Escarpit, from the point of view of Shannon's theory, the idea of fixing information in terms of time might seem paradoxical because – by definition – information is associated with the degree of uncertainty of an event, namely something which occurs at the juncture in time within which an attempt is made to build a stable identity and information setting. Does turning an event into a record possibly mean depriving it of its unpredictability? An event occurs, a document is produced, it exists, therefore it is clearly defined, fully intelligible and predictable.¹³ Nevertheless, in discussing this topic, Escarpit also comments that time, the effect of which is neutralized by the creation of the document, should be reintroduced in the form of motion to make sure that information can be reproduced: such scanning enables a linear and diachronic sequence; even though a single recording and reproduction device does not produce any information, the scanning operations (when the document is produced and in the moment the event is 'reproduced') need to be perfectly symmetrical; this of course implies strict synchronicity of movements when scanning; any variation in the scanning process leads to noise, therefore to a disturbance factor. To conclude, fixing is not a regression, it reduces the effect of time, although it does not totally delete it: stability in a recording is nothing but the persistence of a configuration acquired by the support at the exact time the data are stored; considering the time distance and the transmission process effect, by altering these configurations, 'noise' is introduced, therefore the information content provided by reproducing the acoustic image of the event cannot be regarded as separate from the time distance from its occurrence, in the sense that the audio signal may be perceived at a later date and within a different setting. Therefore it does not seem possible to reduce time difference to distance in space because the latter becomes a kind of historical distance subsequent to a change in the 'technological' setting.

Shannon's encrypting theory, however, includes a whole set of elements which are nothing but trivial for the purposes of our study. First of all, Shannon associates the issue of encrypting with that of the presence of noise within the channel.¹⁴ Second of all, even though his point of view is always based on the perspective of transmission through space, by underscoring the issue of the enunciation site, he indirectly also raises the question of selecting the message in a given context, which leads to the degree of *a priori* knowledge of the possibilities involved, and thus of knowledge on the part of the receiver and of the recipient.¹⁵

From our point of view, the actions aimed at acknowledging the value of a recording, at restoring and reproducing electronic music are clearly conditioned by the knowledge and interpretation methods available at any given historical time or within a specific context. Recognizing the role of knowledge external to the document to be restored, or limiting oneself to analyzing information which can be derived from the support, regardless of the content of the document, or of its establishing and historical origin, has been the greatest watershed which

¹³ ESCARPIT, *Théorie générale de l'information*.

¹⁴ SHANNON, *Communication Theory*, p. 685.

¹⁵ *Ibid.*, p. 664

divided the theory of restoration according to Schüller from what could be defined as Bayesian approach.¹⁶ The possibility of decrypting the format of a record and the types of noise found on the audio track becomes an inevitable passage as part of a process aimed at going beyond the mere preservation ethics phase. This is due both to the uniqueness of the document, which means that it is impossible to define its properties on a strictly statistical basis, and to the need of considering the reproduction of music first and foremost as the collation of documents, then as content analysis process. The possibilities of restoring electronic or mixed music for reproduction purposes are essential based on individual documental evidence, as well as on a subjective assignment of conditional probabilities.

Integrity vs authenticity

There is no doubt that the purpose of Shannon's model regarding the theory of information is first of all to ensure integrity of a message: the message represents the sender to the receiver (the preservation of movement, or of the message, is part of Cartesian concept of duplicating movement); integrity, however, does not mean authenticity. As Benjamin said, authenticity is not an intrinsic property of the product of technical reproducibility. Nevertheless, it is fair to say that it could be, although not immediately. Authenticity is achieved when a gap and an act of recognition are produced at a distance, in other words the same possibility conditions for a critical editing of audiovisual sources.¹⁷ On the other hand, if we opt for Shannon's representation model, the conclusion is that 'historical distance' equals 'noise', because it prevents the exact acquisition of the original configuration of the recorded signal, thus leading to a loss, on the receiver's part, of some information which is being sent.

All audiovisual documents have a dual historical matrix, one 'internal' and the other 'external'; the former regards the set of transformations which the recording undergoes during the production and transmission process of the audio material, the latter is associated with the characteristics of the materials, of the technological systems which have led to its production and usability. As a consequence, any critical editing of audiovisual sources requires a study not only of the records, but also of the processes which have led to their production, both from an aesthetic-composition perspective and from the technical/technological side. The importance of this approach become clear when audiovisual documents are recordings of electronic or mixed music, that is to say the result of a complex

¹⁶ According to Bayes' approach, all unknown parameters are treated as aleatory variables, to which it is possible to assign an *a priori* probability density function. This probability function is ideally expressed on the basis of some *a priori* knowledge before any data are observed. Bayes' technique differs from traditional methods in the sense that it introduces subjective information factors as estimation parameters (GODSILL – RAYNER, *Digital Audio Restoration*). Bayes' approach has yielded significant results in the field of audio restoration; nevertheless in the case of electronic music restoration, the use of restoration algorithms which take into account knowledge external to the signal is still problematic due to the noise which is intentionally used by composers as musical material.

¹⁷ CANOSA, *Per una storia del restauro cinematografico*, p. 1086.

process involving an audio signal originating from different sources: live, from other supports or produced by synthesis. They are, therefore, not mere recordings of events, because there is a wide range of overlapping issues involved which are typical of analog audio. A critical approach to electronic music production, as a consequence, should start from the hermeneutic assumption of *understanding* the system from which it originated. This includes not only technological equipment, but also a set consisting:

- (a) on the synchronic axis, of the interrelation between subsystems: model devised by the composer, performers, studio technicians, audio recording and acquisition equipment available when the work is produced, storage carriers, formats of the support chosen on the basis of its destination (concert tape, disc, radio recording, etc.);
- (b) on the diachronic axis, of the transmission process which has led to the document reaching us (copies, variants, etc.): this is not only a system of signs designed for communication, but rather a production and transmission system of the music over time. As a consequence, it is fundamental to preserve any historical equipment thanks to which it becomes possible to reconstruct the *world* of electronic music based on its 'writing foundations'.

Installing the dia-system

Transcribing electronic music originally intended for recording on an analog magnetic tape onto another support creates a connection between two systems: the historical, analog, and the re-mediation system, consisting of new technologies, of the set of knowledge and means available in a given period and in the place where the re-transcription onto a new *medium* occurs. The concept of dia-system suggested by Cesare Segre for literary criticism, can also be applied to re-mediation processes involving audiovisual documents: each copyist follows a personal language system, which comes into contact with that of the text during the transcription process. The more attentive copyists will try to leave the text system intact, but it is impossible for the copyist's system not to prevail in some respect; given that competing systems imply historical involvement, it is as impossible to renounce one's own system as it would be to deny one's historicity.¹⁸

In line with this concept, we consider recognition in the domain of audio documents as the intentional act which leads us to discover and identify an item coming from a transmission process over time and to include it as *memory* and evidence of the complex of technical and theoretical conditions created during specific phases of the audiovisual writing development. As products of reproduction techniques, the surviving documental evidence found today is the result of projects related to editing, composing, public or private archiving. In the case of audiovisual recording, they are not evidence of information in themselves. In order to be valid as *memories* they need to be reproduced using instruments consistent

¹⁸ SEGRE, *Testo*.

with the original format, restored and re-reproduced using signal and data processing techniques. Recognition is thus not a continuous process where the past illuminates the present, but rather it is the present which has to deal with the original production conditions. Recognition, in order to be implemented and developed, needs to meet the possibility requirements for its realization: it is in itself an editing and/or archiving project, and in the case of audiovisual records it is the act of devising a *re-mediation* through a device consisting of a *technical-theoretical dia-system* which should allow us to reproduce, re-phenomenalize and represent the source received.

Identity and re-mediation process

Audio documents call for temporal and dynamic restitution forms. Bruno Bachimont assumes that:

Contrairement au document papier, il ne peut pas y avoir identité ente le support d'enregistrement et le support de restitution, la forme d'enregistrement et la forme sémiotique d'appropriation pour le document temporel. Par conséquent, il ne peut y avoir de document temporel qu'à partir du moment où l'on dispose d'un procédé permettant, à partir de l'enregistrement, de reproduire une forme temporelle.¹⁹

An audio document is therefore inseparable from the process that reconstructs it and from the information that parameterizes and controls the reconstruction. A document is no longer a single object, but a 'documentary complex', consisting of a resource, a tool, metadata or parameters of the resource itself, and the reconstructed and perceptible views.

The Theory of Information, in its traditional form of transmitted information theory, can be applied to the re-mediation dia-system, taking into account that there is a transmission of information between the dia-system and the observer; as part of this transmission we need to consider each element as being ordered or organized as the output of a communication channel. It is thus necessary to abandon the model sender/channel/receiver, and to observe from the outside, from angles which allow for a recognition of the documentary value of the sound document and for an understanding of the process which has led to the document being established and transmitted over time.

From a global perspective, the re-mediation process can be seen of consisting of two (but their number could be N) sub-structures:

- (a) the analog document with its reading system;
- (b) the digital conversion and writing system with the new document.

In the unlikely event of being able to produce a perfect copy of the data, the system as a whole contains – in the eyes of an external observer – the same information presented in the original document; this means that the links between the two sub-structures are comprehensive. If, on the contrary, there were no links between the two sub-structures, the result would be the sum of the information

¹⁹ BACHIMONT, *Patrimoine et numérique*, p. 45.

they contain, but in actual fact the re-mediation system would not exist: the sub-structures do not communicate, therefore the internal organization of the system is non-existent. On the other hand, there is increased information in the system when – although some links exist – there remains a certain degree of equivocation; in this way, the information contained respectively in the first sub-structure and in the second includes additional items due to transmission ‘errors’ caused by ‘noise’; if the two substructures, in some way, keep communicating thanks to the recognition and re-mediation of the document, the historical distance – on the part of the external observer – becomes a source of increased information. The idea that ‘noise’ could be a source of information is only apparently paradoxical: there is a knowledge increase when there is transmission between one document and another; the establishing of tradition in itself is fundamental in terms of cultural identity, but there is no development if tradition remains a mere exact duplication of a single ‘book’; on the other hand, the total lack of transmission between components of a cultural unit leads to the system collapsing. Concepts such as ‘recognition’ and ‘historical distance’ are difficult to fit within the traditional theory of information model, they seem to be more suitable as paradigms in the theory of complex systems.²⁰

The dangers of failed recognition

Ethics in the restoration process

In the field of audio, the concepts of preservation and restoration originally appeared in an intuitive way, often based on aesthetic reasons, in relation to the quality of sound or to the admirable intent of enhancing the outcome of a live performance before archiving its recording. Only later on was this naive and subjective form of restoration replaced by the idea of basing the work on the technical-scientific substratum of the audio records. The trend towards the improvement of intuitive understanding of issues based on historical-critical foundations, on the one hand, and technology on the other, has focused first of all on mainly technical aspects which have led to an ethical approach to restoration. Nevertheless, after the micro-temporal levels of A/D conversion had been highlighted in order to reproduce the record in a way which was as faithful as possible to the original, it became clear that the technical evidence of the deep structures of information could not be considered separately from an interpretation in the development of technology and recording practice. A case in point is the instance of mixed equalization at the RAI Studio di Fonologia in Milan.

²⁰ See ATLAN, *L'organisation biologique* and FOERSTER, *On self-organizing systems*.

'Mixed' equalization at the RAI Studio di Fonologia in Milan

Up until the year 1972, when AEG-Telefunken M15 tape recorders were bought, the Music Phonology Studio in Milan recorded on 1/4" (mono and stereo) tapes using Ampex 350 recorders, with NAB equalization. The system was calibrated using CCIR sample tapes (the standard equalization procedure in RAI laboratories); the result was a sort of mixed equalization: the NAB standard to underscore low frequencies during recording and the CCIR standard for the modelling of high frequencies. There are two possible solutions for the correct transfer of the recorded signal onto these tapes: one consists in the correction (in the digital domain) of the equalization curve through filters, the other is the choice of using hardware equipment which can be calibrated in order to allow for a reading of mixed equalization.

The incorrect identification of equalization affected the commercial edition of electronic music by Bruno Maderna now available also on Youtube. The high levels of noise, also caused by incorrect compensation of the equalization, led the person in charge of restoration to select particularly aggressive deletion parameters. This is, for example the case of *Continuo* (1958): during the first few seconds it is possible to hear a sibilant sound which produces a sidereal aura at the beginning of the piece, after restoration this sound fabric is altered to the extent of being made discontinuous (Figure 2).

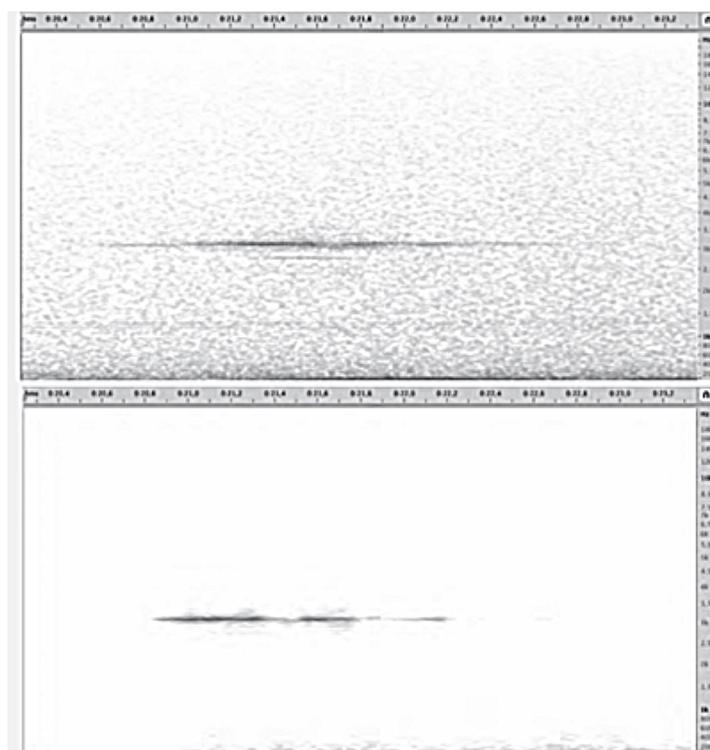


Figure 2. A short excerpt from *Continuo* (Blackmann-Harris window, 2048 points). Above, tape RAI E003 (digitized in 2000 at RAI Audio Lab – Milan, 48 kHz - 24bit); below, <<https://www.youtube.com/watch?v=NkjaBbJSaWQ>>

The problem of equalization has directly involved the act of transferring the tapes containing the electronic music by Bruno Maderna. At first, they were digitalized by RAI (in the year 2000) using CCIR equalization; they were then re-equalized in the digital domain, as a consequence of progress in research work as regards the history of technology conducted in partnership with the Audio MIRAGE Laboratory.

Therefore, even a merely preservative approach implies a recognition process in respect of the record. This is a clear instance of work which would hopefully be completed in a mechanical and automated way, but actually shows a need for multi-discipline collaboration with sound engineers, reproduction technology historians and musicologists.

Electronic counterpoints? Recognizing the synchronization of tracks in electronic music compositions

The issues associated with the acknowledging correct synchronization of the tracks in multi-channel electronic music are clearly exemplified by the electronic music by Edgard Varèse. When the author composed *Déserts* (1954) and *Poème électronique* (1958), he decided to work with separate monophonic tapes; only later (and possibly for reasons associated with publishing or performance reasons) were the latter put together to produce stereophonic copies (in the case of *Déserts*), three tracks recordings (for *Poème électronique*) or quadriphonic versions (also for *Poème électronique*).

In the tradition of *Déserts* the issues related to synchronizing two tapes, caused by the tolerance of the running speed of tape recorders on the one hand and, on the other side, by the objective difficulty – in the absence of automated *sync* systems – involved in perfectly aligning both tapes on the reading head then reproducing them simultaneously, have caused misalignments in nearly all stereo evidence; these variants are not due to the numerous revisions of the electronic part intentionally completed by Varèse.²¹ A case in point becomes clearly apparent analyzing the recording of the concert held in Stratford (Canada), on the 18th of August 1960, on the occasion of the Conference of Composers (directed by Frederik Prausnitz) where *Déserts* was performed, with a new version of the interpolations created at the Columbia-Princeton Electronic Music Center. The Canada Library and Archives in Ottawa have a recording of this concert (WO

²¹ Much has been written about the different versions of the *Déserts* interpolations, regrettably though the sole certainty is that today no agreement has been found even as regards their number (see, for example, OUELLETTE, *Edgard Varèse*; MACDONALD, *Varèse*; GERTICH, *Zur Betrachtung* or CLAYSON, *Edgard Varèse*). Today, more than thirty audio documents of electronic interpolations have been found, scattered across innumerable European and American archives. The most important institutions where these documents are kept are the following: INA in Paris, Norddeutscher Rundfunk in Hamburg, Paul Sacher Stiftung in Basel, Casa Ricordi and RAI in Milan, Institute of Sonology of the Royal Conservatory in The Hague, British Library in London, Columbia University in New York, Library of Congress in Washington D.C., Library and Archives Canada in Ottawa, Stanford University. For a recent *recentio* see COSSETTINI, *Opere chiuse* and COSSETTINI, *Tracks in the deserts*.

43856), but a comparison with other sources of this version, notably the two separate tapes preserved at the Library of Congress in Washington D.C. (RXB 2330 and RXB 2331), is difficult due to the substantial misalignment between the two interpolation channels, which occurred during the performance and then flattened out in the monophonic version. It is therefore safe to assume that use was made of two monophonic tapes, reproduced 'out of sync'.²²

Also Kees Tazelaar, when he 'reconstructed' the 3-track 'master' *Poème électronique* from the separate monophonic preliminary tapes was faced with synchronization problems typical of montage operations with analog magnetic tapes, which had a substantial impact on the structure of the work. «When using the clicks to align the tracks», says Tazelaar, «one immediately notices that the original machines were not completely identical in their tape speeds (a known problem of the so-called Viennese machines) and that the durations of the single tracks were different (through alignment using the sync part)». ²³ To reinterpret the correct alignment of the sound events it was thus necessary to use other multi-track sources: the 35 mm magnetic perforated master used in the Philips pavilion in 1958, the mono soundtrack of the video copy of the lm supplied by the Philips Company Archives, and the Columbia Gramophone record.²⁴

A comment and a few specifically critical-philological questions arise at this point: is it likely that synchronization issues might have occurred also during the production phase of these sources; which ones should thus be considered more authoritative? In a scenario characterized by such indeterminate elements is it even possible to talk about a correct version?

The feedback principle: criticism of criticism

Music, as we stated at the beginning, is also a technological phenomenon, born from the interdependence between material instruments and musical gesture. Music evolution is characterized by important feedback and feedforward mechanisms that link social actors to their cultural and technological context. The

²² The issue of synchronizing Varèse's monophonic tapes has been discussed for a long time: Pril Smiley (Associate Director of the Electronic Music Center at Columbia University) wrote the following note dated 15 September 1992 with regard to the digitalization of the *Déserts* tapes stored at Columbia University: «tape #3 = an attempt to synchronize the two (separate reels) original master (one channel on each reel)» (note kept in the archives of the Computer Music Center at Columbia University in New York). The question thus arises: what is the exact overlapping of the sound events between the two tracks?

²³ DOBSON *et al.*, *Varèse's «Poème Electronique» regained*, p. 39.

²⁴ See TAZELAAR, *On the Threshold of Beauty* The complexity of the reconstruction completed by Tazelaar, and the thorny issue of the synchronization in particular, seem not to be taken in account by Leo Izzo when he states that the monophonic tapes of *Poème électronique* «scorrevano in modo sincronizzato su altrettanti magnetofoni, operando a tutti gli effetti come un unico magnetofono a tre piste» (IZZO, *La genesi compositiva del Poème électronique*, p. 78).

scientific contribution from the source criticism consists in having highlighted that current data and data transmission process are part of an inseparable unit and that between the two there is a non-linear dependency relation because – as part of the performance act – a recursive action is produced between process and analysis of current recorded traces. From the moment that surviving data become the subject of recognition, their knowledge takes place through analysis as regards survival of the work and its success. Considering that observation systems themselves are enhanced by the process which transformed the ‘originals’ into current data, it is fair to conclude that we are faced with a retroaction.

Audio documents are memories, physical systems built to transfer information in time and space. The information they contain concerns events external to the system itself. Information depends on the number of microstates that our observation devices can distinguish in the track, on our conceptual categories (concepts of sound) and on the signal processing systems on which in turn depends the observation scale we adopt to interact with the tracks. There are degrees of freedom that are under our control and easily measurable and degrees of freedom that are beyond our control and are not easily measurable. This distinction changes with the evolution of the technical and cultural environment. Since we deal with signals containing noise, we can only calculate its spectral density. Information is therefore statistical and the recorded signals are finite time series, i.e. single realizations of stochastic processes. In the impossibility to perfectly determine the entire space of manifestations/expressions, we can only obtain a singular mixture of historical analysis of the ramifications of the information contained in the documents.

This is a fundamental aspect in terms of the establishment of audiovisual source criticism because only if a multi-disciplinary team equipped with an audiovisual laboratory is in charge, will it be possible to recognize and thus identify any record. Each form of recognition of evidence requires responsibility and a statement of recognition ability. Therefore, essential for the purpose of recognition is the awareness of the technical-theoretical capacities of the laboratory which, at a given time, is put in charge of interpreting the relevant audiovisual traces. It should also be noted that the level achieved at a certain stage by a laboratory is in itself subject to transformation: progress and scientific updates, ability to understand, involutions and crises characterize the history of every research institute, and in this case are responsible for the ability itself to recognize documents and process the relevant information. The *a priori* knowledge available at any given time affects the whole recognition process. To conclude, we should bear in mind that recognition is always also a process of self-recognition.

Al gran sole carico d'amore by Luigi Nono

Al gran sole carico d'amore is a typical example of Nono's theatre productions in the 1970s. Its staging includes a set of electronic parts overlapping – at different moments during the performance – with the instrumental part and with acting. The reconstruction work, preliminary to the staging of this ‘opera’ at the Salzburg

Festival²⁵ in August 2009 – commissioned by Casa Ricordi to the MIRAGE Laboratory – raised crucial issues regarding the possibility itself of staging the work, in the absence of the composer and within a radically changed media and social framework.²⁶

The authorial sources for *Al gran sole carico d'amore* are as follows: four 1' four-track magnetic tapes, kept in the archives of RAI in Milan (Q31 and Q32) and of Casa Ricordi (RIC212 and RIC213), plus two scores printed by Ricordi.

Issues:

- In all of the records there are macroscopic variants, both as regards the musical text and the sound fabric;
- there are two authorial versions of this work. In the materials accompanying the tapes it is not stated with which version the electronic components should be associated;
- the instructions in the score as regards the electronic components to be used are totally insufficient, without any instruction in terms of sound direction.

In literature a distinction is made between two versions of *Al gran sole carico d'amore*: one dated 1975 and the other 1978, corresponding to two different productions at La Scala in Milan, with the composer himself in charge of supervision and sound direction. The study of the composition process shows a painstaking review of both audio materials and manuscript or printed musical texts: the tapes have been copied several times and their content 're-composed', also through physical interventions directly on the carrier; the score thus becomes full of notes, corrections, deletions and replacements. A large amount of variants in the text and sound fabric leads us today to noticing a continuous process of source adjustment which, almost uninterruptedly, joins the two versions: the 1975 one now needs to be extracted from under the stratifications leading to the 1978 edition, and assigning the various electronic surviving parts to one version or the other is extremely uncertain.²⁷

Analog supports include traces (graphic signs, physical manipulations, corruptions) which risk disappearing while the audio signal is being transferred onto the new medium. In order to preserve them it is necessary to have video footage of the tape running while the signal is being read. With audio synchronization, a video provides a large amount of information about physical manipulations of the carriers or alternations of the signal, which can be useful to interpret the corruptions and guide any restoration procedures. By the same token, notes written on the back of the tape can prove essential for the synchronization between the electronic part and the live instrumental/vocal component. For example, in the *leader* tape segment which comes before the second electronic part (source Q31),

²⁵ The work was performed from 2 to 14 August 2009 at the Salzburger Festspiele after a critical editing of the sources and audio restoration completed on behalf of Casa Ricordi by Luca Cossettini and by the MIRAGE Laboratory team. Conductor: Ingo Metzmacher, Director: Katie Mitchell, Sound Director: André Richard.

²⁶ See COSSETTINI, *Tracce di un contrappunto* and COSSETTINI – ORCALLI, *Témoignages sonores*.

²⁷ See COSSETTINI, *Al gran sole carico d'amore*.

there is an instruction for synchronization with the orchestra, originally intended on measure 35 of the score which was then moved by Nono to measure 42 (Figure 3).

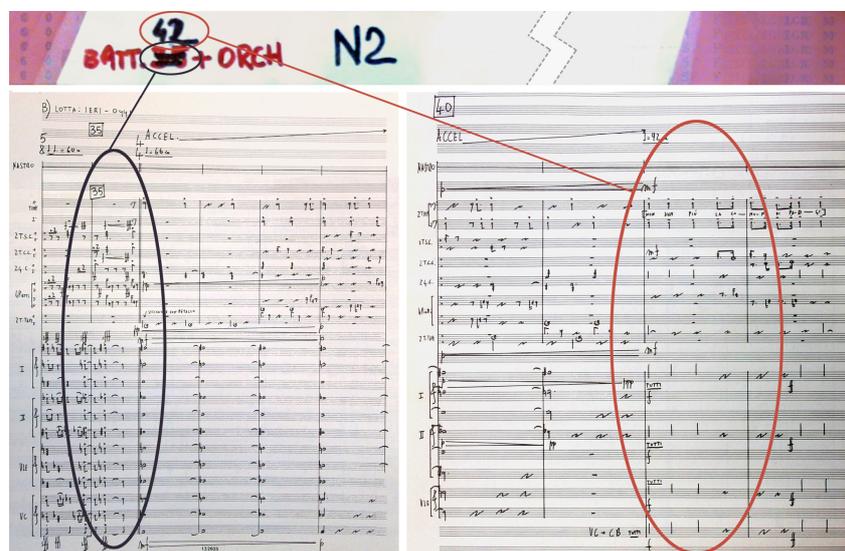


Figure 3. L. NONO, *Al gran sole carico d'amore* (1978). Sources: magnetic tape Q31, Studio di Fonologia Musicale RAI – Milan; two consecutive pages from the published score – Ricordi, Milan, measures 34-42. Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy. Circles and lines have been added by the authors to highlight the synchronization with the tape

In the published scores Nono simply records the presence of the magnetic tape, but does not give precise instructions as to how the dialogue between the two components should be interpreted. The relationships between tape and orchestral element and their variants become clear only by referring to the performance scores kept in the Nono Archives in Venice. The analysis of concordances between the notes found in the drafts used for the staging in 1978, the writings on the tapes and the calculation of the duration of the various instrumental and electronic parts has actually made it possible to find the correct tape sections to be played, as well as all synchronization points. The video of 1978, which is a secondary source because it is a recording of a radically manipulated performance following a montage, then confirmed the working assumptions and clarified the reasons for some of the macro-variants on the different tapes which can be attributed to staging requirements.

Encodings

The model is a message

The plurality of musical writing forms has strengthened the relationship between the level of composition and that of theoretical reflection: many composers have

chosen to formalize their own theories, thus providing a basis for the uniqueness of their languages.²⁸ In the case of mixed music, the presence of a composition model provides an abstract point of reference, sometimes numerical or in any case symbolic, preliminarily designed to produce writing with musical notation and an audio signal. For the purposes of our study regarding critical editing methods, the existence of a composition model even if in the form of sketches is an extraordinary opportunity for any reproduction project: a shift from the ethics of preservation to the theoretical moment of understanding the music. There are many cases where the composition model appears in symbolic form, but without one of the properties which Goodman defines as fundamental in a notation system, i.e. semantic finite differentiation. A second problem is that the model is often just jotted down, which means that the analyst has to play the role of an actual decrypter. The position is thus similar to the one described in the case of the communication theory variant which aims at standardizing Shannon's paradigm into blocks.²⁹

Standardizing Shannon's paradigm into blocks

Since it is possible to associate the same information to messages with different characteristics, any transformation of the initial message allows us to provide it *a priori* with the required properties. The aim of coding the *source* is maximum concision, while the purpose of coding the *channel* is completely different: protecting the message from channel perturbations. The message produced by the source first of all undergoes source coding, whose result should ideally be a message without redundancy; in other words, all subsequent symbols are independent, and all of the alphabet symbols have the same probability of appearing. The result of this coding is extremely vulnerable to perturbations because each symbol is essential in terms of message integrity. In order to make the message produced by the encoder of the source ideally invulnerable to channel perturbations, encoding of the *channel* is theoretically necessary which implies reintroducing redundancy. Suppressing the redundancy of the initial message by encoding the source, then reintroducing it in the channel encoding, might seem contradictory; the initial redundancy of the source, however, is not suitable *a priori* for the properties of the channel to which the source is connected.

Let us consider the case of *Jour, Contre-jour* by Gérard Grisey, an author who used the theory of information by Abraham Moles as the scientific basis for his composition approach. Grisey creates a compositional model with the aim of encoding the source, regardless of the transmission channels used. The result should ideally be a message encoding without redundancy. The message is then split and transmitted through two differently encoded channels: score and audio tracks. On the one hand we thus have a notational system, and on the other an analog sound recording system (Figure 4).

²⁸ ORCALLI, *La pensée spectrale*.

²⁹ See BATTAIL, *Théorie de l'information* and HAMMING, *Coding and Information Theory*.

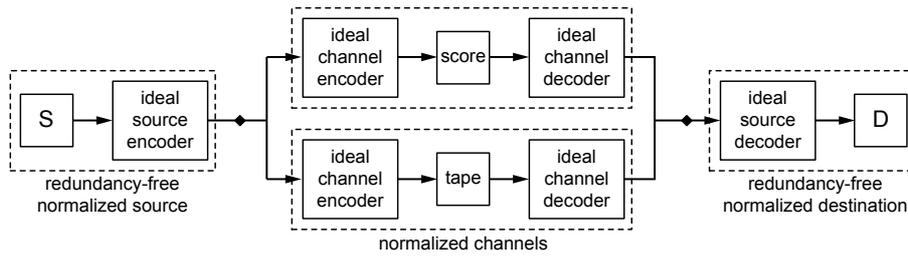


Figure 4. Shannon's paradigm standardized into blocks for *Jour, Contre-jour* by Gérard Grisey

Jour, Contre-jour by Gérard Grisey

In *Jour, Contre-jour* Grisey represents a dual process by means of a set of events at meso-formal level. The whole process consists of two macro-sections ('morning' and 'afternoon'), which are in turn divided into 10 sections; section one of the 'afternoon' represents 'midday'. Each of these sections is then divided into two parts, A and B (Figure 5). Part A is played exclusively by acoustic instruments, while part B is performed both by instruments, playing with noisy articulations, and to the electronic component on a four-track magnetic tape.³⁰

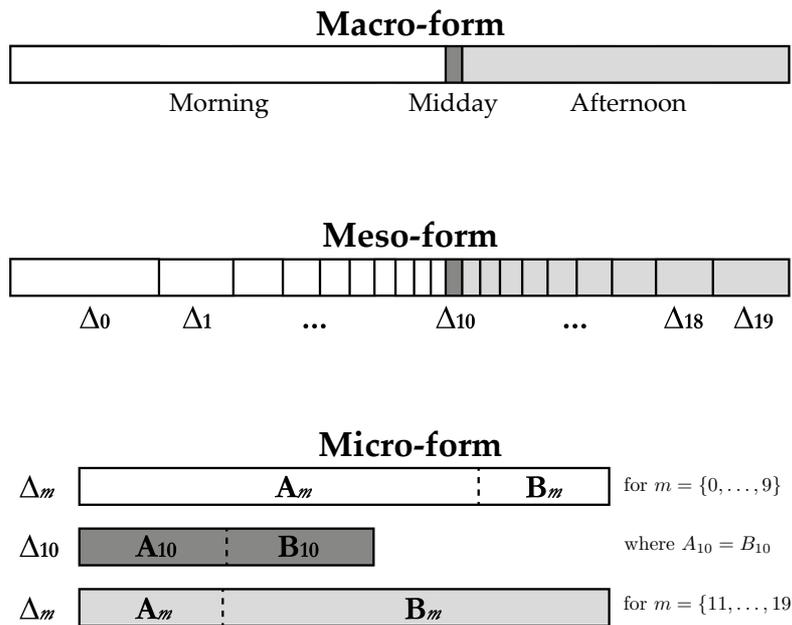


Figure 5. *Jour, Contre-jour*, structure of the work

The distribution of entrances, exits and intensity peaks of the sounds is regulated by a set of 'instants', whose time values in seconds (which are shown here as $x_{m,n}$

³⁰ For a complete analysis, see COSSETTINI – ORCALLI, «*Jour, Contre-jour*» and COSSETTINI – ORCALLI, *Diffractions*.

for parts A_m^J and $y_{m,n}$ for parts B_m^J) are determined by a table of coefficients ($k_{m,n}$ $m=\{1, \dots, 19\}$, $n=\{1, \dots, 10\}$), preordained by the composer in his sketches (see Table 1).

Table 1. Coefficients (first section $m = 240$ is not present). Values have been taken from the sketches – Paul Sacher Foundation-Basel – and rearranged here in a table

Δ_m	A_m	B_m	$k_{m,1}$	$k_{m,2}$	$k_{m,3}$	$k_{m,4}$	$k_{m,5}$	$k_{m,6}$	$k_{m,7}$	$k_{m,8}$	$k_{m,9}$	$k_{m,10}$
120	108	12	6,5	5	3,5	2	1,1	0,65	0,5	0,35	0,212	0,186
80	68	12	6	4,66	3,33	2	1,2	0,8	0,666	0,533	0,425	0,375
60	48	12	5,5	4,33	3,166	2	1,3	0,95	0,833	0,717	0,634	0,562
48	36	12	5	4	3	2	1,4	1,1	1	0,9	0,85	0,75
40	28	12	4,5	3,666	2,834	2	1,5	1,25	1,167	1,083	1,062	0,938
34	22	12	4	3,333	2,666	2	1,6	1,4	1,333	1,266	1,252	1,142
30	18	12	3,5	3	2,5	2	1,7	1,55	1,5	1,45	1,442	1,355
27	15	12	3	2,666	2,333	2	1,8	1,7	1,666	1,63	1,626	1,568
24	12	12	2,5	2,333	2,166	2	1,9	1,85	1,831	1,815	1,813	1,784
26,66	13,33	13,33	2	2	2	2	2	2	2	2	2	2
29	13	16	1,784	1,813	1,815	1,831	1,85	1,9	2	2,166	2,333	2,5
32	13	19	1,568	1,626	1,63	1,666	1,7	1,8	2	2,333	2,666	3
36	13	23	1,355	1,442	1,45	1,5	1,55	1,7	2	2,5	3	3,5
41	13	28	1,142	1,252	1,266	1,333	1,4	1,6	2	2,666	3,333	4
48	13	35	0,938	1,062	1,083	1,167	1,25	1,5	2	2,834	3,666	4,5
57	13	44	0,75	0,85	0,9	1	1,1	1,4	2	3	4	5
71	13	58	0,562	0,634	0,717	0,833	0,95	1,3	2	3,166	4,33	5,5
92	13	79	0,375	0,425	0,533	0,666	0,8	1,2	2	3,33	4,66	6
133	13	120	0,186	0,212	0,35	0,5	0,65	1,1	2	3,5	5	6,5

Figure 6 shows the development of the partial sums of the coefficients:

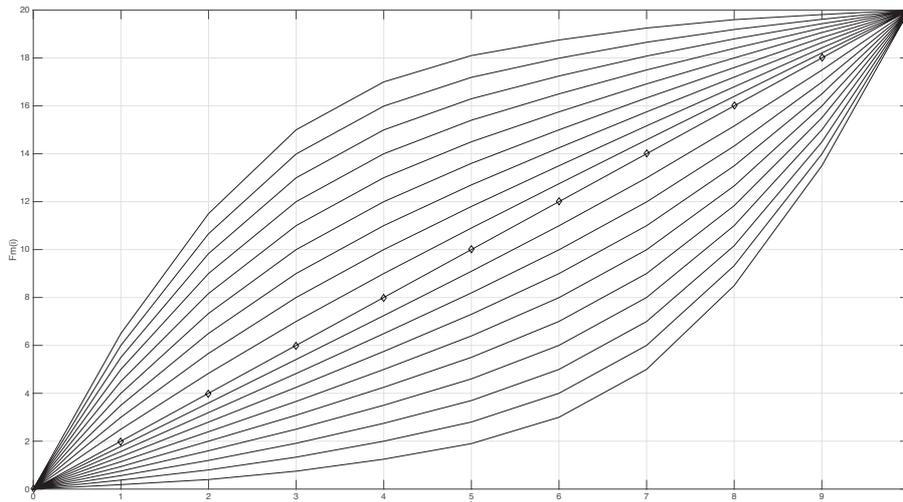


Figure 6. Development of the partial sums of the coefficients

Below is a highlight of the line which represents the harmonic points $F_{m=10}(i)=2i$:

$$F_m(i) = \sum_{n=1}^i k_{m,n} = \sum_{n=1}^i h_{m,n} + 2i \quad \text{for } i = \{1, \dots, 10\}$$

Going back to the standardization into blocks of Shannon's theory of information, the composition model developed by Grisey can be interpreted as a message produced by the source. We will thus start from the underlying concept expressed by Norbert Wiener that a model is a message and can be transmitted as a message.³¹ The point now is to study the encoding system used for the two different channels: score and magnetic tape.

Take, for example, part A of section $m=16$. The theoretical distribution of the instants of the intensity peaks for individual sounds is as follows:

$$x_{16,n} = \frac{A_{16}}{20} \cdot \sum_{i=1}^n k_{16,i}$$

$$A_{16} = 13$$

$$x_{16,n} = [0.49, 1.04, 1.63, 2.28, 2.99, 3.9, 5.2, 7.15, 9.75, 13]$$

In the score, time values are then represented – and approximated – using traditional music notation (Figure 7).

By the same token, in part B of section $m=9$ the theoretical distribution of instants where the intensity peaks are located is as follows:

$$y_{9,n} = A_9 + \frac{B_9}{20} \cdot \sum_{i=n}^1 k_{9,i}$$

$$A_9 = 12$$

$$B_9 = 12$$

$$y_{9,n} = [13.07, 14, 158, 15.247, 16.346, 17.456, 18.596, 19.796, 21.095, 22.495, 24]$$

The sounds are to a large extent recorded on magnetic tape. For the following audio montage, Grisey includes the values obtained from the model in a preliminary project for the production of the electronic part (kept at the Paul Sacher Foundation in Basel).

The analysis of the four-track master copy recorded by Grisey in 1981 at the Technische Universität in Berlin, however, shows some differences compared to theoretical time values (Figure 8).

³¹ WIENER, *The Human use*.

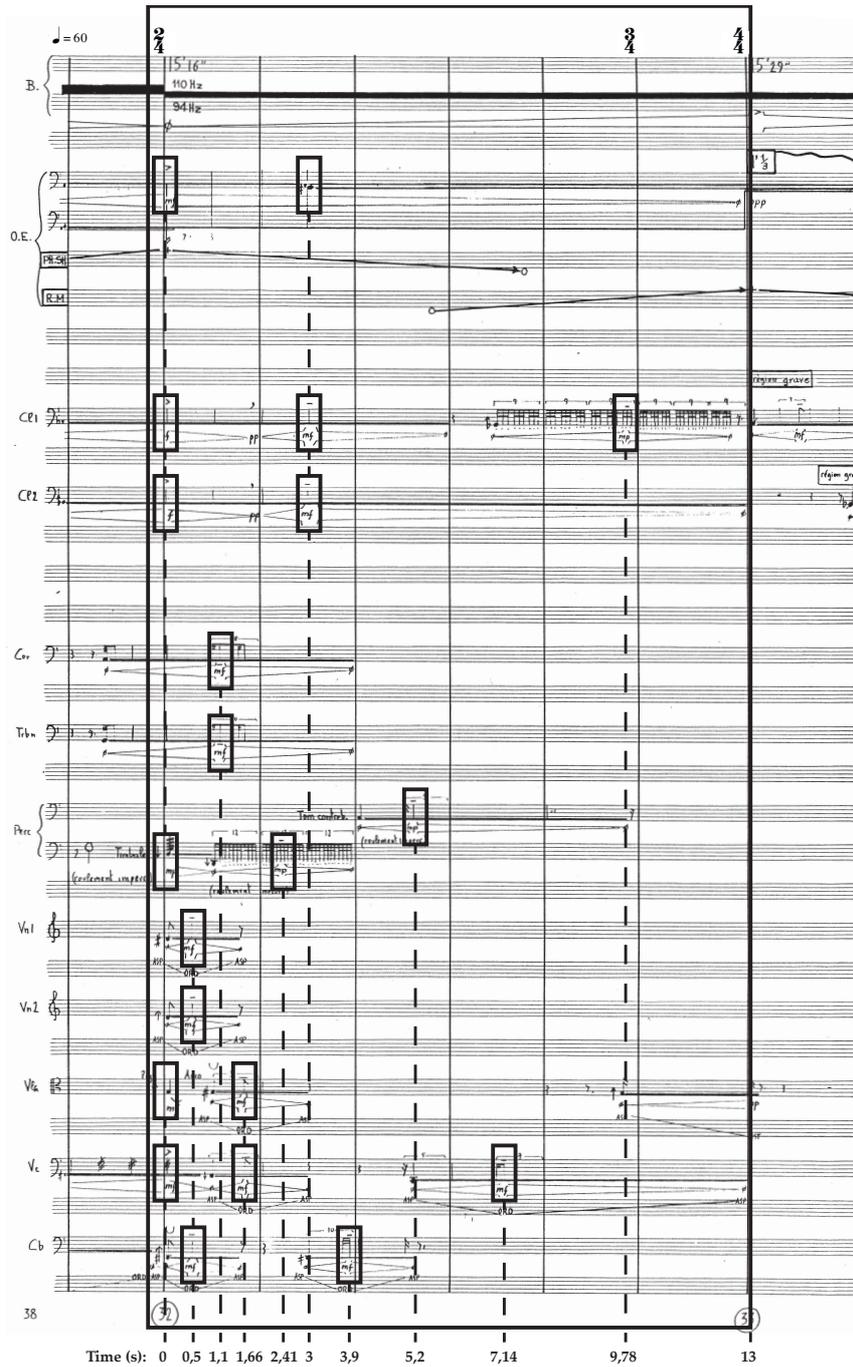


Figure 7. Distribution of intensity peaks $x_{16,n}$ in the score (in seconds). Section 16, number 32 (13''). Source: G. GRISEY, *Jour, Contre-Jour* (1981), published score. Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy

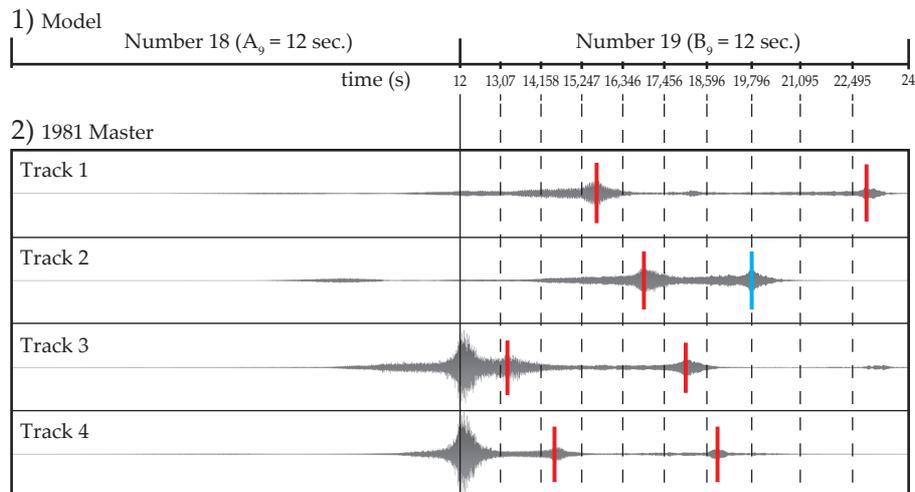


Figure 8. Electronic part: synchronization of events according to the model (section 9, numbers 18-19, duration 24 s.). (1) theoretical distribution of instants (in seconds); (2) master tape realized by Gerard Grisey e Folkmar Hein (Berlin 1981)

Tape regeneration

The feedback principle leads to an operational and conceptual level higher than the information level at stake when producing a preservation copy. For the reproduction of electronic and mixed music it is necessary to have methodological and technical tools for analyzing and interpreting the sources which are able to compare heterogeneous audio documents, scores, instruction sheets for mixing, programming files. As part of this process, the relationships between documents constitute the primary information element. A comparison of the sources available serves to highlight any invariants in the transmission process. The analysis, on the other hand, is focused on the formal constraints of the music and on their violations.

When working with analog audio recordings, it is necessary to bear in mind that the equipment used for their production is not 'perfect', because allowance should be made for tolerances and system limitations. In *Jour, Contre-jour* this issue comes to the fore in a disruptive way: deviations in terms of length and intonation found between tape and score cannot be attributed only to errors in copying the sources, but rather as elements constituting the basic audio materials for the electronic part. Non-linearity of the systems, noise, performance imprecisions (both instrumental and technological) become ingrained in the tape during the creative process and, as such, an integral component thereof.

An important contribution to the understanding of the creation process of the electronic part in the 1981 version is given by a study of the preliminary tape, on eight tracks, kept in the archives of the Technische Universität in Berlin which includes a pre-mix of preparatory audio materials. As confirmed by Folkmar Hein – the technician of the time –, this was the source used to produce the

quadriphonic tape to be used during concerts through mixing and dosing work 'in real time' on the tracks (Figure 9).

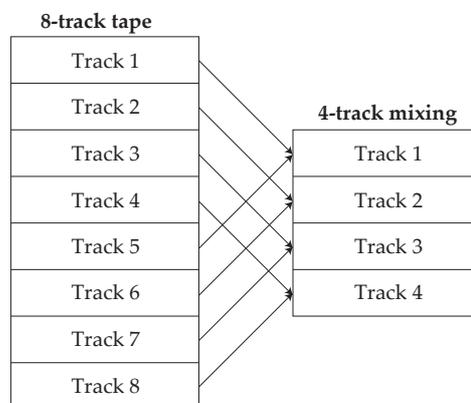


Figure 9. Mixing scheme: from 8-track preliminary tape to 4-track master tape

Evidence of this mixing work can also be found in the 'performance score', handwritten by Hein following precise instructions from Grisey, which includes the procedures required to 'play' the preliminary tape. This score does not make for easy reading because it involves complete knowledge not only of the structure of the music, but also of the characteristics of the equipment in the studio, their configuration and their interconnections. For example, the circled numbers refer to parts B of each section in the composition. The same numbering system is used on the back of the eight-track magnetic tape, written on an adhesive label and along a vertical line. The latter has to be aligned with a sign on the head block of the Telefunken M15A used for the mixdown in the Berlin studio. In this way, the beginning of the audio signal corresponding to the relevant section is exactly in the same position as the reading head (Figure 10).

Any numerical value without further indications refers to the Eckmiller W85 potentiometer levels in use at the time at the Studio, where an increase by 0 dB corresponds to position 12; this is the differential to be used for the negative calculation of relative gains (15 = -3 dB, 10 = +2 dB etc.)³².

Moreover, the quadriphonic mixdown, delivered to the publisher for performance which provided the basis for the whole audio source tradition, was produced using a Telefunken M10 tape recorded. The running speed of the latter is not regulated by oscillators because it is linked to the grid power frequency (which in Germany is 50 Hz), subject to oscillations as high as 1%, with an inevitable impact in terms of the duration and height of the recorded sounds. Between

³² The Eckmiller W85 potentiometers guaranteed attenuation on a scale from 0 to -85 dB. In the configuration of the system at the time, they were connected to Eckmiller V72 amplification modules which allowed for an increase by 34 dB, of which only 12 were used. Zero on the potentiometer scale thus corresponds to the absence of attenuation by the amplifier, therefore to an increase by 12 dB.

the composition model and its performance, a distance is created which cannot be reduced, caused by the specific characteristics of the technology used.

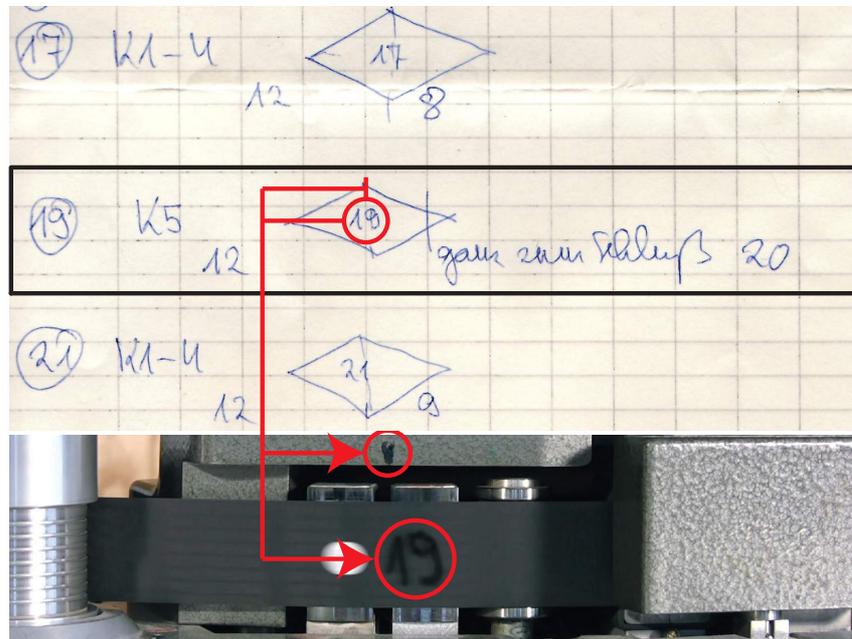


Figure 10. Mixing instructions (Technische Universität Archives, Berlin)

In *Jour, Contre-jour* the analysis of the composition model, considered as a set of formal constraints in the music and the historical-technological reconstruction of the production and reproduction system for the electronic part, have allowed us to recognize any errors in terms of channel transmission.³³ More specifically, in this case there are two channels in series, the first is the eight-track recording, the second the four tracks mix. The ‘noise’ in the channels has different origins; in this specific case it is caused by mechanical changes and production defects which have altered the organization of the message.

Impossibility of a reconstructive approach

The irreversible nature of mixing processes and the poor quality of four-track audio recordings have made the reconstructive approach using four tracks impossible. It has therefore become necessary to use a new strategy, which call *regenerative*.³⁴ The latter is made possible: (a) by reconstructing the theoretical model

³³ The study of the relationship between composition model and its implementation in musical scores and audio signals deserves to be discussed separately, not as part of this paper. Reference can be made to COSSETTINI, *Opere chiuse*.

³⁴ The term *regeneration* is based on a concept express by Gérard Battail (BATAIL, *An Outline of Informational Genetics*), where he suggests a variant of Shannon’s paradigm, making a distinction between *replication* and *regeneration*. Replication refers to a copy which matches the original genome as closely as possible, therefore ideally identical. Since the copy of a genome already

according to Grisey's sketches; (b) by the mixing patterns provided by Folkmar Hein; (c) by the eight-track recording kept at the Elektronisches Studio of the Technische Universität in Berlin.

Starting from the latter it has been possible to regenerate the four tracks based on the theoretical organization model of the composition: its abstract structure. It is therefore not a re-synthesis obtained directly from the model, but rather a regeneration of the four-track version using the original eight tracks. The message (model) encoded directly in the abstract (algebraic) production had undergone a set of changes during the transmission phase via channels (scores/audio-tracks). In this way the 'instantiations' on tape of *Jour, Contre-jour* fail to adhere to the general constraints established by the composer. The MIRAGE Laboratory thus served as an agent to correct this error based on the model represented by the algebraic encoding of the musical theory by Grisey. The tasks of observation, recognition and restoration have thus been fulfilled and unified through the *regenerative* approach. Regeneration thus provides a chance for critical editing, by virtue of the presence of a composition model which can be considered as a set of constraints for restoration (Figure 11).

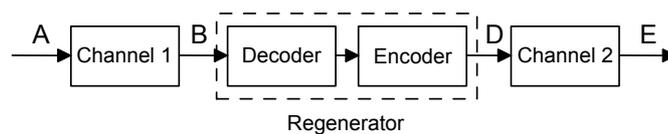


Figure 11. Regeneration process. A: input of the message (composition model used both for *Sortie vers la lumière du jour* and for *Jour, Contre-jour*), Channel 1: recording on eight tracks; regeneration work was completed by MIRAGE between B and D: the rewritten message that fits within the strict constraints of the model. Channel 2: new version on four tracks, as close as possible to the message received, possibly including some errors

In operational terms, the audio content of the eight-track tape was digitally remastered; the resources of digital editing were thus used to synchronize sound events with those taken from the model. Mixing work was then completed on the tracks based on instructions by Folkmar Hein (Figure 12).

affected by errors simply keeps the error of the original genome, it does not ensure reliable and long-lasting preservation of the genome. Regeneration, on the other hand, refers to a rewriting of the genome message, whereby:

- the rewritten message fits within the strict constraints of the genetic code; and
- is as close as possible to the genome message received, possibly including some errors.

Unlike replication, regeneration does not lead to a message which is true to the original. Nevertheless it is true to the genetic code, considered as a set of constraints. Implementing a regeneration process, unlike replication, is extremely demanding in terms of processing complexity.

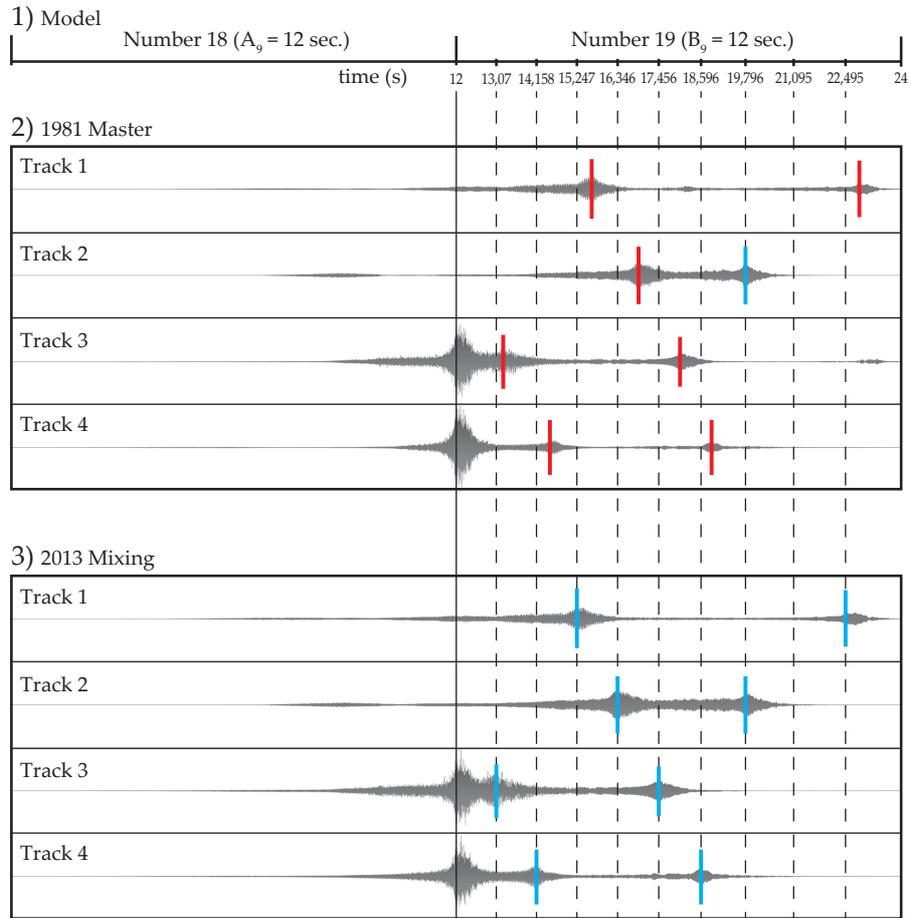


Figure 12. Electronic part: synchronization of events according to the model (section 9, number 18-19, duration 24 s). (1) theoretical distribution of instants (in seconds); (2) master tape realized by Gerard Grisey e Folkmar Hein (Berlin 1981); (3) master realized by MIRAGE Lab (Udine 2013)

As further control element, the new mix was compared with the one completed in Berlin in 1981, which presents interventions not included in the handwritten instructions, but aimed at highlighting intensity peaks of the recorded sounds (Figure 13).

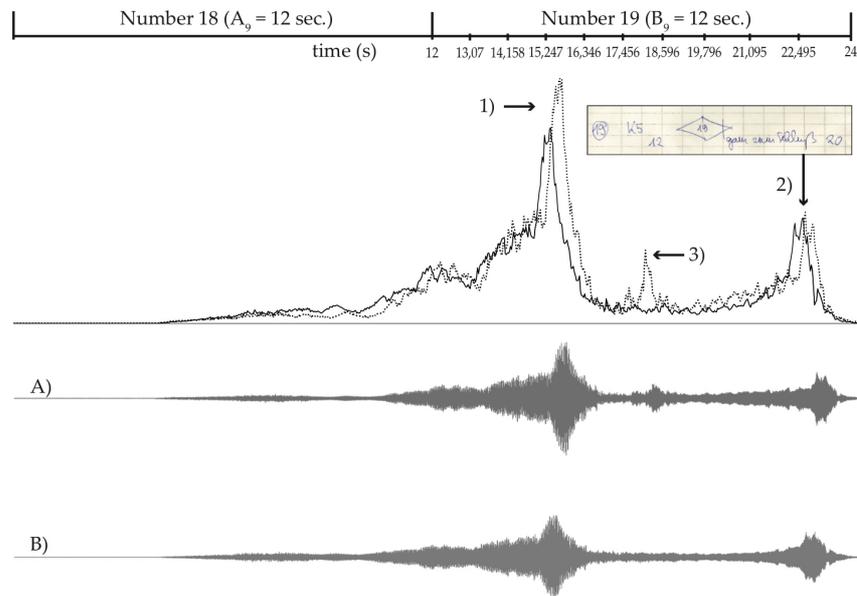


Figure 13. Gestures. (1) difficult to describe: an improvised musical gesture? (2) codified gesture; (3) crosstalk. Dotted line and waveform A: Berlin master; solid line and waveform B: MIRAGE restoration (section 9, number 18-19, duration 24 s)

Based on an intervention by the author, these ‘gestures’ were analyzed in a Matlab environment, then reconstructed in the new mix, leaving a discretionary margin suggested by perception factors. Whenever a gesture not associated with a constraint set by model was found, in order to comply with a source approved by the composer, the collation method was used and a reconstruction procedure followed.

The dangers of regarding preservation eugenically

The pervasiveness of Shannon’s communicative model also emerges in the *Standards, Recommended Practices and Strategies* published by IASA (International Associations of Sound and Audiovisual Archives) in 2005.³⁵ Through its reports, IASA attempts to raise awareness in respect of the goal of setting shared ethical principles, discouraging technologically inappropriate approaches and subjective choices which are technically not compliant with the level of current knowledge regarding active preservation. Among the practices recommended under item 6, is the following: «if several copies of a sound document are available, the best must be selected for the further preservation of its content». This position is confirmed and underscored again in 2009, in IASA-TEC 04, where the

³⁵ IASA-TC 03 *The Safeguarding of the Audio Heritage: Ethics, Principles and Preservation Strategy*.

term best copy is defined as the result of a selection among «copies of the same generation» (5.4.2.1).³⁶ The report does not further define the concept of ‘generation’, leading to the conclusion that it is meant in a generic sense. It is thus worth trying to gain an insight on the IASA recommendations.

The rule supported by IASA of selecting the *best copy* in order to preserve, among all specimens, the one which contains the best signal, means promoting – for merely technological purposes – a *eugenic* concept in audiovisual production.³⁷ If we then leave the area of mass-scale production and move into the world of musical composition, the ethics suggested by IASA becomes irreconcilable with the world of electronic music production. This is related, first of all, to the issue of variants and versions; here every copy, regardless of its being ‘good’, is value in itself and can be circulated through different channels. Also for audio documents there is the issue of vulgates: what often happens is that the ‘best’ record was never released, or seldom left the archives of the Studio where it was produced. The music is circulated through rented copies, restorations, editions on disc, sources which frequently show differences in respect of the original source. On the other hand, it is possible that one might come across a master audio copy which has been corrupted for various reasons, but which – unlike its ‘best’ copy – could include information with regard to the compositional work (splicing, interpolations of virgin tapes, etc.) and writings on the back of the tape which are not included in the copy but are nonetheless essential to recognize the composition process followed by the author. Generally speaking, the ethics of IASA applied to electronic music compositions would appear to be especially treacherous because it apparently introduces the eugenic perspective for the selection of art music, and thus for establishing the canon of all musical production of the twentieth century.

Variants in Bruno Maderna’s electronic music

Dimensioni II / Invenzione su una voce by Bruno Maderna is an example of ‘work in motion’, typical of Maderna’s electronic practice.³⁸ To compose this music, Maderna drew inspiration from a sequence of phonemes, chosen *ad hoc* by Hans G. Helms. Without specific reference to any language, the phonemes, intoned by the voice of Cathy Berberian, were articulated for the purpose of creating a field of expressive tension between live music and voice recorded on tape.

The piece was performed in public using different versions, for magnetic tape with live voice recording and then for magnetic tape alone. It was premiered on 9 April 1960 in Milan, at the Conservatorio Verdi, under the title *Dimensioni II*, where Cathy Berberian most likely sung live with the accompaniment of the magnetic tape; then it was performed on 2 May 1960, at the Creative Arts Division in San Francisco. On this occasion Berio, who was in the United States at the time,

³⁶ IASA-TC 04 *Guidelines on the Production and Preservation of Digital Audio Objects*.

³⁷ ORCALLI, *Tracce sonore*.

³⁸ See COSSETTINI – ORCALLI, *L’invenzione della fonologia musicale*.

organized a concert with some pieces of music from the Studio di Fonologia. Also in this case, Cathy Berberian was there. On 16 July 1960 the music was played in Darmstadt, for one of the concerts of the *Ferienkurse für Neue Musik*. Based on the archiving data of the tape recorded in Darmstadt, the music was given a new title *Dimensioni II – Invenzione su una voce (für Frauenstimme und Tonband)* and it was apparently performed without the live voice. Its duration was 18'53". On 21 September 1960 the music was played during the *V International Autumn Festival of Contemporary Music in Warsaw*, under the title *Invenzione su una voce*. For this performance it has been possible to refer to the live recording, where the voice of Cathy Berberian (who had returned to Europe) engages in a dialogue with her own recorded and electronically deformed voice; duration was 11'10".

During the 1970s *Dimensioni II / Invenzione su una voce* was performed on several occasions, but without a live vocal part: during the Nuova Consonanza Festival at the Accademia Filarmonica Romana; on the occasion of the Incontri Musicali Romani, under the title *Invenzioni su una voce (per nastro magnetico)*; on 13 December 1966, during the 1st International Music Exhibition in Milan (organized by Grossi), a piece of music was performed entitled *Invenzione per una voce sola*.

The music was possibly originally intended as development of the project, started with *Musica su due dimensioni*, aimed at establishing a dialogue between electronic component and 'natural' dimension; this then gradually changed: its duration was reduced, the title changed to *Invenzione su una voce*, there was no dialogue with the live voice (as shown by its performances after 1960), until in the end it became part of more extensive productions. Starting from 1964, there is evidence of the tape *Dimensioni II. Invenzione su una voce*, being added, totally or in part, to other music by Maderna: *Hyperion* (1964), *Ages* (1972), *Tempo libero* (1972).

Reviewing the history of *Dimensioni II / Invenzione su una voce* following the audio sources has allowed us to discover the distinctive traits of Maderna's electronic music production at Fonologia: they don't consist as much in the attempt of combining phonology and electronic music, but rather in a new interpretation of the interaction between composer and electronic equipment. Maderna soon realized that electronic technology did not necessarily lead to *opera aperta*, but rather it paved the way for the creation of a new form of 'work in motion' and of new connectivity among different works. *Dimensioni II / Invenzione su una voce* is the prototype of Maderna's idea of *global music*. In the cybernetic age, it would be essential to preserve the integrity of the musician's Self, and this would become possible thanks to a creative act joining in a single ongoing process the interpretation and deconstruction of a music composition.

The survey conducted by MIRAGE on the different audio sources of the work shows a surprising number of author's variants.³⁹

³⁹ *Ibid.*

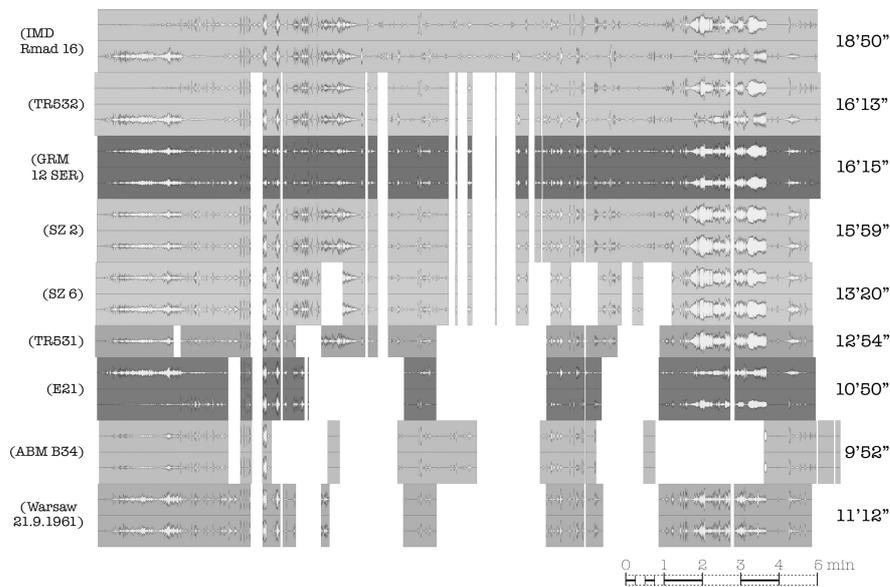


Figure 14. Nine significant sources of *Dimensioni II / Invenzione su una voce* (from the left: cataloguing numbers,⁴⁰ waveforms, durations). Audio content comparison

Figure 14 shows the comparison among nine significant sources. Audio files, obtained by digitizing the signal contained on the original carriers, have been split at the montage points and then vertically aligned. White gaps show the material removed at any physical revision of the original tapes.

Maderna on the web

Today the Internet is the primary venue of connectivity. Its leading position as data repository paves the way for a *re-mediation* process in a continuous flow of possibilities, from the mere transfer of contents from an old to a new medium, to the opposite extreme, when the original version is totally restyled; archival memory and widespread communication seem to mix in the uncertain threshold between mind and matter, subject and object, human being and machine. Much of the electronic music by Maderna is available online today, also through dedicated websites. This allows for a comparison among different sources, although it offers no guarantee as to their authenticity. Authenticity of a document is not a nominal element, it cannot be established even by the most reliable website,

⁴⁰ IMD: Internationales Musikinstitut, Darmstadt; TR: Tempo Reale, Firenze; GRM: Groupe de Recherches Musicales, Institut national de l'audiovisuel, Paris; SZ: Suvini Zerboni, Milan; E: Music Phonology Studio Archive, section E, Milan; ABM: Bruno Maderna Archive, Bologna; Warsaw: recording of the concert held at the *V International Autumn Festival of Contemporary Music in Warsaw* (copy provided by the Polish Composers' Union).

unless substantial evidence is provided as to the actual transmission of the document and can support its history.

A case in point is *Ages* (from William Shakespeare's *As you like it*) by Bruno Maderna and Giorgio Pressburger. Entering the words 'Ages' and 'Maderna' for a search on *Youtube* one can find a video containing a 10-minute abstract from a 1990 'performance version' of the radio-drama edited by the Tam Teatromusica Group and commissioned by RAI in Milan (<<http://www.youtube.com/watch?v=MU25WLZqQoQ>>). Following the links presented by *Youtube* you then reach the webpage of the director of the production, Michele Sambin. Searching for the word 'Ages' in his website, you then reach this page <http://www.michelesambin.com/contributo/ages>, with another version of the same video, footage of a rehearsal, duration: 23'06".

Other resources come from the official *podcasts* from RAI and the *blogs* of radio enthusiasts. For example, the following: <<http://www.rai.it/dl/RaiTV/programmi/media/ContentItem-32a1f81e-f286-4273-877a-38d1097beb88.html>>, an audio reproduction of the composition, published online as part of the cycle *I gioielli del Prix*, and <<https://www.tapatalk.com/groups/radiopassioni/prix-italia-1972-ages-di-giorgio-pressburger-e-bru-t3686456.html>>, the radio program hosted by Sandro Cappelletto and broadcast on Radio 1 on 10 October 2010. The audio content of the two programs is the same: a version of *Ages* lasting about 31 minutes. In the program hosted by Cappelletto, mention is made of the CD published for Stradivarius in 1994, which was probably the source used for broadcasting.

Finally, on the website *Classical music online*, an online platform directly populated by a *community* of registered users with the intention of creating an *online* archive, it is possible to find a version lasting 49 minutes and 30 seconds: <<https://classical-music-online.net/en/production/40467>>.

What is, then, the duration of Ages?

A study of the sources, carried out directly on tape recordings, has led to finding four versions: two of them long (duration: 36'43"), which differ only as regards the announcements after the first part of the composition; another version, possibly dating to before the approved one, showing differences in terms of processing and mixing of the sound materials (duration: 33'50"); and finally a longer one (duration: 31'16"). The latter most likely originates from the Fon170 tape of the Archives of the RAI Studio di Fonologia. The case of Fon170 provides several pieces of information. This copy was probably made at the Studio di Fonologia: the notes were probably handwritten by Marino Zuccheri; the writing «copia non tagliata» (unabridged copy) suggests the existence of a 'long' and a 'short' version of the composition, the latter having probably been abridged due to contractual reasons and radio time scheduling constraints. The 'short' version is the one which has been most widely circulated. As a matter of fact we find it in all editions on disc and in the *podcasts*. The emerging scenario, therefore, is one where the

circulated version of the work is different from the original authors' composition, who have kept, in their personal archives, the extended version.

The video uploaded on YouTube and on Sambin's website has a clear promotional purpose. It is no surprise, then, that the audio has been abridged. What about the version of *Classical music online*, though? The signal analysis shows that the audio section from 11'48" to 30'39" is repeated, in the identical way, twice. In this case, notwithstanding the theories which associate the Internet with brain neural structures, the variability of the music is not a result of musical innovation, but more prosaically of carelessness on the part of an IT 'copyist'.

Conclusions

The history of audio restoration shows four fundamental steps: (1) the shift from an ingenuous and subjective reproduction of sound to editing inspired by the ethics of a faithful reproduction of the recording; (2) the awareness of the interpretative nature of recognizing the value as source of a recording marks the shift from a purely ethical approach to critical knowledge; (3) the affirmation, also in the audio domain, of the value of the individual document as evidence of a musical work raises the question of intellectual and material responsibility: the restorer is called upon to reproducing a sound fabric which is as close as possible to the author's intent. The example of the regeneration of the audio tracks in *Jour, Contre-jour* by Grisey clearly shows the need for a theoretical approach; (4) finally, the study of Maderna's production shows that, also in the case of electronic music, Busoni's concept of the ideal identity composition=performance=interpretation still applies. The critical editing of his music paves the way for a new reflection on restoration. The continuity in Maderna's composition process, leading from *Dimensioni II / Invenzione su una voce* to *Tempo Libero* through *Hyperion, Ages*, shows that also critical editing of these composition necessarily needs to be regarded as a process.⁴¹

The critical editing of music is constituted on the fundamental principles that editing is critical in nature and that criticism, including editing, is based on historical inquiry.⁴² The difference between the critical editing of score and of recorded music is that the history of electronic music is indissolubly bound to its means of production, broadcasting and distribution. The work cannot reveal itself without the means to 'phenomenologize' it. As a consequence, critical editing cannot neglect the knowledge of technical instruments and of their history.

The examples presented in this paper show the tools that the critical editing of electronic and mixed music must include: a spectromorphological analysis supported by time/frequency and time/amplitude representations, a survey of the physical montage cues on the original carriers, a historical reconstruction of the

⁴¹ COSSETTINI – ORCALLI, *L'invenzione della fonologia musicale*.

⁴² GRIER, *The Critical Editing of Music*.

laboratorial practices of the time, research on the phenomenology of circulation of the documents, the interpretation of intentional and unintentional alteration to the signal. All those aspects are benchmarks that guide the task of editing. They define an 'operating space' that has its equivalent in the praxis of audio restoration.

We have seen that from an historical perspective the process of transmission of documents containing electronic music works cannot be traced back to Shannon's communication model: Sender -> Channel -> Receiver. We have also seen how the feedback 'Receiver <-> Sender' expected by the model in order to verify communication in 'space' cannot be established. It must be substituted by a historical-interpretative inquiry aimed at recognizing the musicological value of audio documents. In facing non homogeneous technological domains – analog vs digital – this recognition is made possible by a preliminary transfer of information between systems: a dia-system that converts audio signal, preserves documental evidences, and allows for analysis.

Three different levels are in competition: in the first one the message represents the sender to the receiver; the preservation of movement, i.e. the message, can be traced back to the Cartesian concept of the duplication of movement. In the second one the actors of communication are immersed in the technological and media context: the message cannot be isolated, nor entirely analyzed. The third one is where most communication processes take place today: information is exchanged within a system (e.g. the web) without taking into account the external observer; this implies a crisis in any process for the representation and interpretation of reality.

The model proposed by Pierre Schaeffer brings Shannon's model into the world of artistic production. The sender has a double role: an artistic one (Expression) and a productive one (Production); symmetrically, the Receiver takes in charge the role of Diffusion (channel, audience) and the Impact of communication on the end-user (listener, reader, performer). In the present global media scenario, the paradigms of Shannon's Information Theory still have important applications. Shannon's theory does not take in account the meaning of the messages transmitted, nor the significance of signs; it studies the condition for preserving integrity of the movement (message), and establishes the capacity of channels in order to obtain a representation that can be perfect for the receiver; its aim is to take advantage of channel limits to reduce the cost of communication.

The task of editorial criticism is to bring musical works back to life (both for publishing and performance). In the world of electronic and mixed music the technological system is an integral part of the compositional project. What audio recordings deliver to the editor is an evidence of the technical and theoretical world of the composers, which is to say their pre-post-history. As a consequence, editorial criticism cannot overlook the diachronic axis on which Schaeffer's model always lays. In analyzing the variations in time of the poles in Schaeffer's model, editorial criticism studies their differentials, and discovers continuity and singularities. From a historical perspective:

- (a) *Production* becomes the history of the systems of production, reproduction, and publishing;
- (b) *Diffusion* materializes itself in the documents, and becomes critical knowledge;
- (c) *Expression* in time becomes the evolution of musical theories, of techniques and compositional forms, and of style;
- (d) *Impact* of diffusion on the end-user becomes the Reception History.

BIBLIOGRAPHY

- ARBO, A. – LEPHAY, P.-E., *Quand l'enregistrement change la musique*, Hermann, Paris 2017.
- ATLAN, H., *L'organisation biologique et la théorie de l'information*, Éditions Seuil, Paris 2006.
- BACHIMONT, B., *Patrimoine et numérique: Technique et politique de la mémoire*, INA éditions, Paris 2017.
- BATTAÏL, G., *Théorie de l'information. Application aux techniques de communication*, Masson, Paris 1997.
- BATTAÏL, G., *An Outline of Informational Genetics*, Morgan and Claypool Publishers, San Rafael 2006.
- BAYLEY, A., *Recorded Music: Performance, Culture and Technology*, Cambridge University Press, New York 2010.
- BONNET, F.-J., *Les mots et les sons. Un archipel sonore*, Éditions de l'Éclat, Paris 2012.
- BOSTON, G., ed. by, *Guide to the basic technical equipment required by audio, film and television archives*, ed. by Coordinating Committee for the Technical Commissions of the International Organisations for Audio, Film and Television Archives., & International Federation of Film Archives, London 1991.
- CANOSA, M., *Per una storia del restauro cinematografico*, in *Storia del Cinema mondiale. Teorie, strumenti, memorie*, vol. V, ed. by Gian Piero Brunetta, Einaudi, Torino 2001, pp. 1069-1118.
- CLAYSON, A., *Edgard Varèse*, Sanctuary, London 2002.
- COSSETTINI, L., *Tracce di un contrappunto a due dimensioni*, in *Luigi Nono, Studi, edizione, testimonianze*, ed. by L. Cossettini, LIM, Lucca 2010, pp. 3-66.
- COSSETTINI, L., *Opere chiuse in sistemi aperti. Autopoiesi nella musica elettronica*, LIM, Lucca 2013.

- COSSETTINI, L., *Tracks in the deserts. Studying the electronic music by Edgard Varèse*, in *Sound voices and codes from the twentieth century. The critical editing of music at Mirage*, ed. by L. Cossettini and A. Orcalli, Mirage, Udine 2017, pp. 109-136.
- COSSETTINI, L., *Al gran sole carico d'amore thirty years on. For a restaging of Luigi Nono's musical theater*, in *Sound voices and codes from the twentieth century. The critical editing of music at Mirage*, ed. by L. Cossettini and A. Orcalli, Mirage, Udine 2017, pp. 349-367.
- COSSETTINI, L. – ORCALLI, A., *Témoignages sonores et critique des sources audiovisuelles*, «Technè», 37 (2013), *Conserver l'art contemporain à l'ère de l'obsolescence technologique*, pp. 72-78.
- COSSETTINI, L. – ORCALLI, A., *L'invenzione della fonologia musicale. Saggi sulla musica sperimentale di Luciano Berio e Bruno Maderna*, LIM, Lucca 2015.
- COSSETTINI, L. – ORCALLI, A., «*Jour, Contre-jour*»: *une métaphore lumineuse pour la composition du timbre*, in *Analyser les musiques mixtes*, ed. par A. Bonardi, B. Bossis, P. Couprie et V. Tiffon, Delatour, Sampzon 2017, pp. 197-236.
- COSSETTINI, L. – ORCALLI, A., *Diffractions. Analyse de l'œuvre musicale mixte Jour, Contre-jour de Gérard Grisey*, L'Harmattan, Paris-Torino 2018.
- DOBSON, R. – FITCH, J. – TAZELAAR, K. – VALLE, A. – LOMBARDO, V. *Varèse's «Poème Electronique» regained: evidence from the VEP project*, in *International Computer Music Conference (ICMC05) 2005*, pp. 29-35.
- ESCARPIT, R., *Théorie générale de l'information et de la communication*, Hachette, Paris 1976.
- FOERSTER, H. VON, *On self-organizing systems and their environments*, in *Self-organizing systems*, ed. by M.C. Yovitz and S. Cameron, Pergamon Press, Oxford 1960, pp. 31-50.
- FRANGE P.-H. – LACOMBE, H., *Musique et enregistrement*, Presses Universitaires de Rennes, Rennes 2014.
- GAYOU, E., *Musique et Technologie. Préserver - Archiver - Re-produire*, INA, Paris 2013.
- GERTICH, F., *Zur Betrachtung der Tonbandeinschübe in den Déserts*, in *Edgard Varèse: die Befreiung des Klangs*, hrsg. von H. De la Motte-Haber, Wolke, Berlin 1992, pp. 56-63.
- GODSILL, S. – RAYNER, P.J.W., *Digital Audio Restoration – a statistical model based approach*, Springer-Verlag, London 1998.
- GOODMAN, N., *The Languages of Art*, Hackett Publishing Company, Indianapolis 1984.

- GRIER, J., *The Critical Editing of Music*, Cambridge University Press, Cambridge 1996.
- GRISEY, G., *Jour, Contre-jour*, Ricordi, Milano 1981.
- HAMMING, R.W., *Coding and Information Theory*, Prentice-Hall, Englewood Cliffs 1986.
- IASA TC 03 *The Safeguarding of the Audio Heritage: Ethics, Principles and Preservation Strategy*, IASA, Amsterdam 2005.
- IASA TC 04 *Guidelines on the Production and Preservation of Digital Audio Objects*, IASA, Amsterdam 2009.
- IZZO, L., *La genesi compositiva del Poème électronique di Edgard Varèse*, in «Il Saggiatore musicale», 22/1 (2015), pp. 61-96.
- LYSLOFF R.T.A. – GAY L.C., *Music and Technoculture*, Wesleyan University Press, Middletown 2003.
- MACDONALD, M., *Varèse: Astronomer in Sound*, Kahn & Averill, London 2003.
- ORCALLI, A., *Orientamenti ai documenti sonori*, in *Ri-mediazione dei documenti sonori*, ed. by Canazza, S.; Casadei Turronei Monti, M., Forum, Udine 2006, pp. 15-94.
- ORCALLI, A., *La pensée spectrale*, in *Théories de la composition musicale au xx^e siècle*, ed. par N. Donin et L. Feneyrou, Vol. II, Symétrie, Lyon 2013, pp. 1511-1573.
- ORCALLI, A., *Traces sonores du XXe siècle. Pour une critique des sources audiovisuelles*, in *Musique et Technologique. Préserver - Archiver - Re-produire*, ed. by E. Gayou, INA, Paris 2013, pp. 33-74.
- ORCALLI, A., *Analyser la musique mixte. Théories et interprétations*, in *Analyser les musiques mixtes*, ed. par A. Bonardi, B. Bossis, P. Couprie, V. Tiffon, Delatour, Sampzon 2017, pp. 239-297.
- OUELLETTE, F., *Edgard Varèse*, Calder & Boyars, London 1973.
- SCHAEFFER, P., *Machines à communiquer 1. Gèneses des simulacres*, Seuil, Paris 1970.
- SEGRE, C., *ad vocem «Testo»*, in *Enciclopedia*, vol. XIV, Einaudi, Torino 1981.
- SHANNON, C.E., *Communication Theory of Secrecy Systems*, «Bell System Technical Journal», 28 (1949), pp. 656-715.
- STERNE, J., *The Audible Past. Cultural origins of sound reproduction*, Duke University Press, Durham and London 2003.
- STERNE, J., *MP3: The Meaning of a Format*, Duke University Press, Durham and London 2012.

TAZELAAR, K., *On the Threshold of Beauty. Philips and the Origins of Electronic Music in the Netherlands 1925-1965*, V2, Rotterdam 2013.

WIENER, N., *The Human use of Human Beings. Cybernetics and Society*, Houghton Mifflin Harcourt, Boston 1954.



NOTE BIOGRAFICHE

Luca Cossettini è ricercatore in Musicologia e Storia della musica. Le sue ricerche affrontano le problematiche dell'influenza esercitata dalle innovazioni tecnologiche sulla scrittura musicale del secondo Novecento, con l'obiettivo di sviluppare metodologie critiche e analitiche in grado di interpretare le nuove forme di scrittura introdotte dall'organologia elettronica.

Angelo Orcalli insegna Sistemi editoriali della musica all'Università di Udine (Dipartimento di matematica e informatica). Svolge attività di ricerca nel campo dei processi creativi e della morfogenesi nella produzione musicale contemporanea, della storia delle teorie musicali, dell'edizione critica di musica elettronica e mista, delle metodologie del restauro audio.

BIOGRAPHICAL NOTES

Luca Cossettini is researcher in Musicology and History of Music. He studies the influences of audio technology in the compositional processes of the second half of the 20th century, with the aim of laying the foundation for a critical and analytical methodology capable of interpreting and analyzing electronic and mixed music.

Angelo Orcalli teaches music publishing systems at the University of Udine (Department of Mathematics and Computer Science). His research is in the fields of creative process in contemporary music composition, morphogenesis in the musical writing of the twentieth century, history of music theory, critical editing of electronic and mixed music, and methodologies of audio restoration.