Sounds, Voices and Codes from the Twentieth Century

The critical editing of music at MIRAGE

Edited by
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MIRAGE

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CODA

Preface

The traditional history of sound is the history of musical instruments, the anatomy of vocal and hearing systems, musical gestures, well-established theories in treatises and its written notation codes. Can we safely say that more than 140 years of sound recording have managed to transform this historical background? And to what extent did sound recording influence the future of music?

The invention of the phonograph led to the creation of a history of sound events as well, which is examined in this book from a specific perspective: how is musical publishing effected when sound becomes a document, when it enters into public or private archives, becomes part of a catalog and it can be preserved, analyzed and re-edited. But there's more. This book also looks at the history of music. The latter has also changed because recording has affected performers and composers, creating new audiences and new repertories. More specifically, after World War II, recording technologies became fertile ground for music experimentation, first with analogue media and then with today's new digital media. The abrupt expansion of organology from its acoustic dimension to new forms of sound production has projected writing beyond its flat graphic dimension: new compositional practices were born from the relationship with the medium itself. The simple recording of sound events developed into a creative act by a composer who processes the audio and manipulates the carrier for artistic purposes. In fact, today's composers are able to work with different writing methods, moving with extreme ease among traditional notation systems, sound recording and processing technologies and sound synthesis in real time. The balance has shifted from music written using notes to a systemic concept of writing/sound production, giving greater attention to the performance dynamics of musical processes. The definition of writing, studying and editing music has changed drastically.

The restitution of recorded music is greatly in demand today by music publishing companies concerned about losing substantial parts of their catalogs because the conditions for playability of many documents are no longer met. The study of these repertoires poses deep-rooted problems to critical editing regarding access, recognition and the authenticity of sources. The main difference between the editing of scores and recorded music is that the history of the latter is indissolubly linked to its means of production, broadcasting and distribution. The work cannot be revealed without the means to 'phenomenologize' it. As a result, the editing of recorded music requires complete mastery of audio equipment and knowledge of its history.

For these reasons, we decided to develop this book around the idea of overcoming the ahistorical vision of traditional Communication models by exploring the complex network of continuous interactions between technological and historical-critical knowledge, as required by recognition and restitution of recorded music. Within this theoretical context, the diachronic axis on which communication always resides cannot be overlooked. When analyzing the temporal variations of the poles in the Communication models, editorial criticism studies their 'historical differentials', discovering continuity and uniqueness. Concepts such as 'Recognition', 'History of production systems', 'Critical knowledge', 'Evolution of musical theories, compositional forms and style', 'Reception History' and 'Music Listening History' are difficult to fit in the traditional Information theory, but they can be integrated and harmonized in a systemic approach to the critical editing of recorded music.

MIRAGE (http://mirage.uniud.it) conceives the critical editing of recorded music as the realization of one of the possible 'states' of the Work achieved through methods of historical-critical reflection innervated by Acoustics, Signal Processing models and Communication technologies.

This book contains contributions from researchers and Ph.D. students who conducted their research at MIRAGE.[1] It is divided into three parts. The first part is dedicated to the relationship between composers and the new media: from the first attempts made by Ernst Krenek to extend serial and Renaissance compositional techniques to the electronic medium, or Edgard Varèse's experiments in 'organizing sound' with new means, to Bruno Maderna's concept of 'global work' and Luigi Nono's theatrical practice with electronics, highlighting some key moments in the development of compo-

1 All the papers included in this book have been double-blind reviewed.

sitional thinking in the second half of the twentieth century and the issues related to the access, study and analysis of this repertoire. The second part presents preservation and restoration works completed by MIRAGE. The third part collects essays on the critical edition of electronic and mixed music by Luigi Nono, Gérard Grisey and Edgard Varèse. The papers outline a history of our institution, where technological and conceptual innovations contribute to developing our theoretical and operational methodology. A Coda concludes the book with a look at the future, defining a framework for the critical editing of recorded music, and the work that is needed for the analysis and restitution of musical masterpieces created in the digital age.

Luca Cossettini
Angelo Orcalli

Opening

Recorded music: from the ethics of preservation to the critical editing

Angelo Orcalli

THE BIRTH OF AUDIO RESTORATION THEORY

In 1991 UNESCO undertook the publication of a guide to the preservation of audiovisual documents (Boston 1991) with the aim of establishing a code of professional standards – similar to the *The Venice Charter for the Conservation and Restoration of Monuments and Sites* – which would provide an international framework for the regulation of the preservation, restoration and re-issue of analogue audio and video recordings. This was therefore the start of the definition of the ethics of the preservation of audiovisual documentary heritage. In particular, the criteria of the audio section of the *Guide to the Basic Technical Equipment Required by Audio, Film and Television Archives* aimed to counter the obsolescence of large archival collections: recordings on record, tape recordings of folk tradition events, radio and television recordings, recordings of plays and festivals. The approach to active preservation was summed up in the following specification: *the function of the archivist is to save, not to rewrite, history*; preservation therefore meant: a) ensuring the recovery of the recorded signal, while respecting the characteristics of the original format; b) ensuring the faithful transfer of the signal to digital media; c) not exposing the documents to arbitrary audio modernization processing.

The authors did not go into questions of the intrinsic value of the individual recordings, but focused on defining a basic level for preservation, irrespective of the characteristic properties of the documentary content. Significantly, the *Guide* does not offer specific instructions for the safeguarding and restitution of works of copyrighted music recorded on tape. The instructions in the *Guide* were driven, on the one hand, by the urgent need to save a heritage of endless hours of recording and, on the other, by an awareness that the resources made available for this undertaking by institutions would be limited.

The *Guide* bears witness to the gradual emancipation of the audio document as an independent source; it actually focuses on the cultural relevance of audiovisual documents in the oral tradition and shows renewed sensitivity towards a documentary heritage which is generally regarded by historians as minor material.

In the debate started by William Storm[1] and taken up, by Dietrich Schüller,[2] whose contribution to the *Guide* had indeed been far from irrelevant, there are topics which – also as regards terminology – refer back to preservation models developed by other disciplines. Expression such as *historical faithful copy* as opposed to *reproduction of the true voice of the performer* might sound ingenuous today but they actually reveal the complexity of issues opened up by sound recording. Giving a technical definition of *sound fidelity* was no easy task then, nor is it today.

The rhetoric of the juxtaposition between original sound and faithful copy was functional to the dynamic trends of the record industry, right from the outset. Suffice it to mention the advertising for Victor 1902 featuring the singer Geraldine Farrar: «which is which? You think you can tell the difference between hearing grand-opera artists sing and hearing their beautiful voices on the Victor», and similar adverts for the tenor Enrico Caruso (see Sterne 2003). The reproduction of the *true sound of an artist's work,* in its own right, can be listed among modern-day myths. The credibility of the record company was based on a sort of covenant, whereby the industry guaranteed to the audience the fidelity of sound reproduction as originally performed. Compliance with this covenant was ensured by ongoing investments in audio technologies, increasingly exciting and sophisticated. Captivating debates and an intense critical activity as regards issues of transduction and reproduction of sound featured prominently on the record reviewing scene after World War II. Cultured reflection, most of the time, juxtaposed in an ingenuous and manicheistic manner the *authenticity* of live performances (*Erlebnis*), to *technical reproduction* of the event, live and/or reconstructed

1 See *Focus on nr. 1,* p. 41.

2 See *Focus on nr. 2,* p. 44.

in a studio. Musical criticism at the time, imbibed in Cartesian spirit, lacked the essential paradigms to understand the complexity of the transformation and permutation game between reality and imagination which results in the strength of the reproduced sound image. The phenomenon of reproduction was considered only in terms of 'distinction' without accepting the 'confusion' which comes into play between reality and imagination: as part of the astonishing phenomenon of the sound and movie image, the illusion of reality is inseparable from the awareness that it is indeed an illusion, without this awareness jeopardizing the feeling of reality.

In the development of sound recording, a few trends had begun to emerge. The first expressed the 'positivist' ideal of a technically optimized image, in that it affirmed the 'truthfulness of nature'. In the age of 'preserved' music and of the 'reportage' of theatre and concert performances, phonographic realism seems to be based on a sort of sufficient persuasion agreement. Distortions are acceptable and 'fidelity' is seen as the absence of patently perceivable infidelities. Ever since the very beginning of recording, specific strategies and adjustment of the source (selection of performers and transformations of acoustic instruments depending on the capacities of the phonograph and of the microphone), were implemented in order to achieve a realistic effect (see Sernette 1934). The second option might be called 'illusionist'. The record industry in the 1960's and 70's pursued the ideal of an 'artificial nature', of a *rendu intensifié* (see Kalteneker 2014); its aim was to represent an ideal performance in an ideal space rendered stereophonically. The fidelity relationship is no longer based on the opposition of two separate processes: original sound *vs* copy; in actual fact the original sound is itself a technological outcome of reproduction, while the technology used defines its horizon of possibilities.

By the same token, and in certain respects in an antagonistic manner to both realism and illusionism, the ideal of the audio signal recording as independent creative act began to emerge: the recorded product considers not only its performer, nor is a live concert the sole point of reference for performance authenticity. The audio recording marks full independence of the medium which affirms itself as document of a musical composition. The composer's action is thus affected by the machinery. The outcome of its musical production, i.e. the magnetic tape with a recording of the electronic part of a composition, is filed with the publisher and distributed to be reproduced in concert. This process has resulted not only in copies, but also in remediation processes (e.g. from tape to record), restorations and, most notably, authorial *variants*. This has occurred both in pop music and in electronic and mixed musical experimentation.

The narrative of over-increasing fidelity would be incomplete without the narrative of low-increasing compression, both are part of history of communication technology and representation. Digital media encapsulate an accumulation of the auditive technology of the past. In an age of over-increasing bandwidth and processing power, industry sells the dream of verisimilitude through different strategies. High-definition TV, virtual reality, 3d cinema promise immersion, contemplation, aesthetic pleasure. At the same time industry produce a proliferation of low definition format (MP3 for example) to satisfy Internet market demand.

> [Compression] practices often begin close to economic or technical considerations, but over time they take on a cultural life separate from their original, intended use. As with the quest for verisimilitude, compression practices have created new kinds of aesthetic experiences that come to be pleasurable in themselves for some audience – from the distortion that is a side effect of electrical amplification in radio, phonography, and instrument amplification, to the imagined intimacy of the phone conversation, to the mash-ups that aestheticize the MP3 form and the distribution channels it travels. Histories of contemporary immersive technologies point to a multiplicity antecedents, going back centuries, even millennia (Sterne 2012, 5-6).

NOSTALGIA

The recommendation by the *Guide* to avoid signal processing with dedicated software came during a phase of growing interest on the part of record production as regards the re-issuing of historical recordings: concert events and performances by great artists of the past. The noble romantic sentiment of nostalgia thus became the best surrogate for melomaniacs without historical-critical background knowledge. Historical recording did not provide any new information, according to the technical definition by Claude Shannon,[3] but rather it acted in the sentimental sphere of nostalgia. By fixing the musical event on a carrier, time is 'returned' by the reproduction system and creates its own imagery. The record industry relied heavily on Benjamin's theories: being an artifact, a quality pertaining to reproducibility, the *aura*, could rise again from the nostalgia for authentic experience. It is from this feeling that the record industry derived the pattern of transforming goods into collectible items.

The recovering of vintage records, however, raised complex technical issues. The fidelity covenant was sustainable to the extent that the acoustic image exerted on the listener a degree of illusion sufficient to make sure that awareness of the latter was not jeopardized by the cumbersome perception of the transmission medium. All of the technologies for sound and voice reproduction make use of *transducers* for the purpose of transforming acoustic

3 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 (see Escarpit 1976). 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.

vibrations into physical movements which, by analogy, track the dynamics of the vibration phenomenon on physical carriers. These tracks, converted into other forms of representation (physical and/or digital), are in turn transformed into acoustic and thus sound vibrations. As with all forms of writing of sound and voice, transducers are artifacts which implement essential components of a historically determined theory of sound. Telephone, radio, phonograph, gramophone, tape recorder and all digital reproduction technologies have made use of transducers; the latter represent the historically determined level of sound knowledge. From an industrial perspective, the quality of transducers and transmission channels (supports for fixing a signal in time and space) necessarily needed to ensure the transparency of the medium in respect of technological progress. In the age of high fidelity the postulates of recording were well known. Firstly: no technically perfect transmission channel is achievable. Corollary: experience proves that a melomaniac's enjoyment decreases proportionally to the duration of the use of its transmission chain. Even a perfect channel is insufficient to ensure permanent enjoyment for an opera lover. Secondly: the enjoyment on the part of a melomaniac can generally be obtained only by means of a development in progress, an ongoing enrichment of the sound material provided (see Philippot 1964). We are not faced with technical need for improvements, but rather with the much more important need for striving towards an aesthetic ideal. The issue is therefore shifted from the technical to the interpretation level. The recovery of old recordings, however, on the other hand, dramatically highlighted the presence of the old carrier. The shortcomings in the old medium were mercilessly emphasized by new reproduction systems, and – what was even worse – perceived when listening as a source of uncontrolled noise and substantial signal downgrading. It is, however, in the nature of the new medium to make up to the shortcomings of the old and complement its advantages.

THEORIES AND TECHNOLOGIES FOR RESTITUTION

The record industry had not failed to notice that the time seemed to be favorable for launching the publishing project aimed at retrieving historical editions. In the 1980s and 90s signal processing technology had formidable theoretical and technological equipment, coming mainly from military uses during World War II (e.g. Andrej Kolmogorov in 1940 or Norbert Wiener in 1941). This technology had been widely developed by aerospace research, a result of the race to conquer space during the Cold War (e.g. Rudolf Kalman in 1958).

The history of *Spectrum estimation* goes back a very long way and has been pivotal for acoustic physics, electronics, the theory of information and control systems. In the 1960s it reached its peak through the use of electronic processors. The impact of the paradigms of information theory on the restoration of audio documents naturally led to considering the carriers for sound and audiovisual recording in general as transmission channels over time, as well as in space. The signal was thus perceived as a message which corresponded to the true sound of the source (voice of the performer, instrumental sound, etc.), which was also inevitably contaminated by the noise introduced in the transmission process in real- or deferred-time. The audio track (natural status of the signal), devised as one of the possible realizations of an aleatory process, is thus represented as the sum of the original unknown signal and of a noise component, produced both during the recording and the reproduction phase. In this way, from the point of view of audio restoration, the contours of a specific type of signal degradation forms were outlined. Although different in origin (acoustic, electromagnetic, environmental, etc.) they were traced back to the following:

1. Disturbances of a local type (impulsive) which affect only part of the signal (e.g. impulsive disturbances such as perceivable clicks in records) identifiable as discontinuity in terms of waveform;
2. disturbances of a global kind which affect the whole signal: these include, most notably, background noise, *wow and flutter* and some non-linear distortions.

The litany of the superiority of digital in respect of analog systems has convinced people that audio restoration needs the digital domain. To undermine this fashionable conviction it should suffice to remember the first manual editing techniques of magnetic tapes in the analog domain. In radio centers throughout the world, operating procedures involved editing ('cut and paste') mechanisms to remove local disturbances and flaws; on the other hand, to reduce degradations of a global kind (*hiss* or harmonic distortion), the signal was equalized in terms of frequency. Also in the analog domain, more significant results were achieved by using high-pass filters which made it possible to detect any impulsive disturbances with a spectral content located mainly at high frequencies; a low-pass filter was then used to remove the disturbances detected.

In the 1980s, DSP micro-chips became sufficiently powerful to handle the complex processing operations required for sound restoration in real-time, or close to real-time. This led to the first commercially available restoration systems, with companies such as *CEDAR* Audio Ltd in the UK and *Sonic Solutions* in the US selling dedicated systems world-wide to recording studios, broadcasting companies, media archives and film studios.

In a fundamental text about audio recording, Simon J. Godsill and Peter J. W. Rayner outlined the reasons which led them to apply Signal Processing to audio restoration.

> The introduction of high quality digital audio media such as Compact Disc (CD) and Digital Audio Tape (DAT) has dramatically raised general awareness and expectations about sound quality in all types of recordings. This, combined with an upsurge of interest in historical and nostalgic material, has led to a growing requirement for the restoration of degraded sources ranging from the earliest recordings made on wax cylinders in the nineteenth century, through disc recordings (78rpm, LP, etc.) and finally magnetic tape recording technology, which has been available since the 1950s. Noise reduction may occasionally be required even in a contemporary digital recording if background noise is judged to be intrusive.
> Degradation of an audio source will be considered as any undesirable modification to the audio signal which occurs as a result of (or subsequent to) the recording process. For example, in a recording made direct-to-disc from

> a microphone, degradations could include noise in the microphone and amplifier as well as noise in the disc cutting process. Further noise may be introduced by imperfections in the pressing material, transcription to other media or wear and tear of the medium itself. We do not strictly consider any noise present in the recording environment such as audience noise at a musical performance to be degradation, since this is part of the 'performance'. Removal of such performance interference is a related topic which is considered in other applications, such as speaker separation for hearing aid design. An ideal restoration would then reconstruct the original sound source exactly as received by the transducing equipment (microphone, acoustic horn, etc.). Of course, this ideal can never be achieved perfectly in practice, and methods can only be devised which come close according to some suitable error criterion. This should ideally be based on the perceptual characteristics of the human listener (Godsill, Rayner 1998, 1-2).

The technology of audio restoration is rooted in the prediction and filtering theory developed by Wiener: in fact, the techniques of noise reduction originate from the classic least-squares work of Wiener who laid the mathematical foundations for the development of most of the noise reduction methods. From a methodological point of view, one presupposes that in the removal of noise both the signal and the noise are *stationary* and hypothesizes that the noise is *additional* and *independent* from the signal: $z(t) = s(t) + n(t)$

The only knowledge we have is that regarding the power spectral density of the noise $P_n(\omega)$ which we had previously estimated. We try to estimate the waveform of the unknown musical signal $s(t)$, devoid of noise, by obtaining it both from the hypothesis that signal and noise are not correlated and from the knowledge of the power spectral density $P_z(\omega)$ of the observable signal $z(t)$ corrupted by noise.

In this case the optimal strategy consists in estimating the signal $s(t)$ through a linear minimum mean-square error estimation technique. This strategy leads us to apply Wiener's filter to the signal $z(t)$ with the aim of obtaining the estimated signal. The obtaining of the filter produces reduction in the frequency domain, depending on the relation between the spectral density of the observed signal $z(t)$ and that of the noise. We do not have the knowledge of the temporal evolution of the noise, but we have its auto-correlation function.[4]

It is known that the problem of the non-stationarity of musical signals can also be avoided thanks to the windowing technique: the majority of the broad-band noise reduction techniques can be traced back to the short-time spectral attenuation (STSA) developed during the seventies.

The results of STSA are related to the case of steady portions of musical sounds; yet it was the experimentation which developed with electronic music that highlighted the timbre value of the transient (note onset, percussions) of musical sounds. As Godsill, Rayner and Cappé have observed: «in STSA techniques the distortion manifests itself as a smearing of the signal waveform for low-level signal transients. This phenomenon as well as its perceptive consequences are amplified as the short-time frame duration increases. The analysis of such transient effects is made more difficult by the fact that

4 The autocorrelation function of a continuous-time zero-mean white noise process with a variance of σ^2 is a delta function given by $r_{nn}(\tau) = E[n(t)n(t+\tau)] = \sigma^2\delta(\tau)$.
The power spectrum of a white noise, obtained by taking the Fourier transform is given by:

$$P_n(f) = \int_{-\infty}^{\infty} r_{nn}(t)\exp(-j2\pi ft)\,dt = \sigma^2$$

Equation shows that a white noise has a constant power spectrum. A pure white noise is a theoretical concept, since it would need to have infinite power to cover an infinite range of frequencies. Furthermore, a discrete-time signal by necessity has to be band-limited, with its highest frequency less than half the sampling rate. A more practical concept is band-limited white noise, defined as a noise with a flat spectrum in a limited bandwidth.
In the aforementioned conditions of a process along a continuum, with $n(t)$: noise with average 0 and uncorrelated from the signal $s(t)$, the spectral power density of the unknown signal $s(t)$ can be calculated: $P_s(\omega) = P_z(\omega) - P_n(\omega)$, with $P_z(\omega)$ the power spectral density of the detectable signal $z(t)$ and $P_n(\omega)$ the power spectral density of the noise $n(t)$. An optimization process minimizes the distance between the response to $z(t)$ and $s(t)$ to calculate the Wiener filter transfer function:

$$W(\omega) = \frac{P_s(\omega)}{P_s(\omega) + P_n(\omega)}$$

Dividing numerator and denominator by the noise spectral power $P_n(\omega)$ and introducing the signal to noise ratio $\mathrm{SNR}(\omega) = P_s(\omega) \,/\, P_n(\omega)$, the result is:

$$W(\omega) = \frac{\mathrm{SNR}(\omega)}{1 + \mathrm{SNR}(\omega)}$$

Therefore, for additive noise, the Wiener filter attenuates each frequency component in proportion to an estimate of the signal to noise ratio.

there is no 'prototype' transient signal as simple and as pertinent as the pure tone was for steady sounds» (Godsill, Rayner. 1998, 35).

It is also worth mentioning that the use of short-time analysis of the signal is equivalent to the use of filter benches. Each channel is suitably attenuated in order to then synthesize the restored signal accordingly.

The signal removal techniques via software left many people skeptical. In many cases by attacking noise also ancillary signal characteristic of the historical recording system were deleted. The removal of this information conflicted with the principle of preserving knowledge of the technical-operating conditions which produce the recording. This debate was conducted in a very skilled way by George Brock-Nannestad.[5]

This aspect is particularly important from a preservative point of view. As Schüller has noted (see Schüller 1994), the press represents human thoughts thanks to the use of a system of symbols; a certain redundancy is intrinsic in an oral or written discourse. On the contrary, an audio-visual document is an analog representation of a state or physical event: every part of the document contains a high degree of information spread by the carrier. It follows that the loss of information caused by the degradations of the signal is not retrievable through the structure of a code.

The loss of information about the historical system entails a loss of knowledge about the structure of a language. Knowing the technical origin of a document and of its recorded track allows for comparative study, and not *a priori*, of alterations. The *error*, any deviation from the original reading, a driving philological factor, in the audio appears as transmission *noise*. With regard to audio documents, the publisher is confronted with the issue of separating the noise produced during the generation and transmission processes from unintentional alterations not attributable to standard equipment operation and to the technological level at the time. Here we have to make an important distinction between dynamical and measurement noise. Measurement noise refers to the corruption of observations by errors which are independent of the dynamics of the system. Generally, dynamical noise include much greater problems in data processing than does additive noise. For example, to store data electronically, they have to be converted into digital

5 See *Focus on* nr. 3, p. 48.

numbers. Even if the measurement have infinite precision, our digital data contain measurement noise of an amplitude which is half the resolution of the digital numbers. Note that the error due to digitization does not have the properties we usually expect from random noise. The distribution is uniform on a bounded interval, and the noise contributions are identical for identical measurement. Dynamical noise, in contrast, is a feedback process wherein the system is perturbed by a small random amount at each time step.

The idea behind audio restoration is basically to separate, in the recorded signal, the *intentional* noise from any *uncontrolled* noise, then – within the latter – separate the part inevitably generated by the recording/reproduction system from the one produced by anomalous behaviors of the system itself (faults, wear and tear, aging or bad state of repair of the tape, etc.). In the case of electronic music compositions, where production equipment is an integral part of the composition project, the question becomes even more complicated because noise, which cannot be coded using traditional notation, appears as musical material chosen intentionally.

The aim of signal integrity, according to Shannon's model of transmission, could therefore not include recognition of the document's authenticity and thus of its provenance, dating, reliability, and so on.[6]

6 Alain Carou wrote: «la récente mise à jour par l'Association internationale des archives sonores (IASA) de son code de déontologie des transfert a grandement à voir avec le développement de nouveaux outils de restauration et d'archivage dans le contexte numérique. Parmi ses principes fondamentaux figure l'impératif de conserver une copie dite "droite", c'est-à-dire où le rapport des fréquences n'a pas été modifié ("égalisation") et où aucun débruitage n'a encore été effectué. Le bruit doit être considéré comme partie intégrante du document dans son état premier. Ce principe est mis en application de façon systématique à la BnF : chaque document à transférer est lu dans les meilleures conditions possibles, numérisé et inscrit sur support avant toute «correction» du signal. Les restaurations destinées à rendre l'écoute plus aisée sont en effet tributaires à la fois de la culture auditive de leur temps et des performances des outils existants. On peut espérer que les outils de restauration du futur permettent un traitement plus respectueux encore que ceux d'aujourd'hui de l'historicité matérielle du document : si spectaculaires que soient les performances des systèmes actuels dans l'élimination des bruits, ils ne savent pas encore faire la part des bruits caractéristiques de défauts d'origine du document analogique. Distinguer le stade du transfert et celui de la restauration autorisera les auditeurs de l'avenir à repartir d'un document authentique. Sans doute les phonothèques ont-elles un rôle particulièrement important à jouer dans la défense de la notion d'"authenticité" appliquée au patrimoine sonore.

PREDICTIONS AND INNOVATIONS: ENGINEERS *VS* PHILOLOGISTS

The clear separation between signal and noise, and the very possibility of attenuation or even deletion of the latter as unwanted component *a priori*, is based on prototypes of the estimate problem: prediction, filtering and interpolation. Historically the issue of prediction had been resolved independently by Kolmogorov and by Wiener. Wiener's model, which has already been referred, revolved around the auto-correlation function, at same time a strength and weakness of the strategy in question.

Using a terminology which he probably inherited from linguistics and philology, in an essay written with Masani (Wiener, Masani 1958a and 1958b) Wiener introduced the word 'innovation' to indicate the prediction error at a given moment t. This variable includes all new information added by the t^{th} observation measurement of the signal when previous data are already available.

Even though the word innovation might sound picturesque within a temporal series framework, the mathematical approach does not hinder from noticing affinities between Wiener's approach and the methodology structure of Karl Lachmann's textual criticism: the common goal is to return a single message, obtained by projecting the information derived using data coming from traditional sources in a single (synchronic) space which could contain the whole (diachronic) process informing innovation. In textual criticism, the transmission of the text to the modern reader does not pass through a simple and direct channel, but through a system of multiple transmitters. In the Wiener's model, the transmission is the past history of the signal. The common goal is to produce a new text (message), by gradually estimating its content combining the outcomes of transmission channels (tradition in textual criticism) and establishing their correlation with the estimate, in order to

La défiance envers les falsifications permises par le numérique, innocentes ou non, n'est pas aussi vive pour le son que pour l'image animée. Des logiciels performants et faciles d'accès se répandent pourtant et contribuent à la prolifération potentielle de versions "modernisées" au statut peu clair. Ainsi, des métadonnées documentant le statut exact des documents numériques et leur mode de production sont-elles indispensables pour permettre aux institutions patrimoniales de garantir la valeur d'historicité par-delà l'évanouissement des originaux» (Carou 2002, 17.).

obtain a 'filtering' system (*emendatio* in textual criticism) which minimizes innovation errors. In textual criticism, the manuscripts include the original lesson as well as detaching themselves from it: they innovate; the different distribution of innovations might reveal and serve as a guide for text editing. It is therefore essential to distinguish between errors and *variants*.

Under the entry 'Philology' (*Enciclopedia del Novecento Treccani*, on-line) Gianfranco Contini wrote:

> La filologia, come disciplina storica si rivela sempre più acutamente involta, non si dirà nell'aporia, ma nella contraddizione costitutiva di ogni disciplina storica. Per un lato essa è ricostruzione o costruzione di un 'passato' e sancisce, anzi introduce, una distanza fra l'osservatore e l'oggetto; per altro verso, conforme alla sentenza crociana che ogni storia sia storia contemporanea, essa ripropone o propone la 'presenza' dell'oggetto. La filologia moderna vive, non di necessità inconsciamente, questo problematismo esistenziale (Contini 1977).

From his part Wiener realized that social and cultural occurrences are long and their spatial size is extensive, but on these fairly large space-time tracks the relevant sociological conditions are not constant, therefore the temporal data series usually necessary for statistical analysis purposes are not stationary. According to Wiener these are semi-exact sciences which should rely on historical, narrative methodology. In a paper entitled *Speech, Language, and Learning*, Wiener had taken a different approach with regard to language issues.

The topic of the relationship between information and language gave him a chance to clarify from a methodology perspective the difference between amount of information in an engineering sense and what comes into play with regard to human language.[7] Much progress had been made since then. It

7 To give the reader an idea of the extension of this debate, the section is reproduced below almost in its entirety: «In using the notion of amount of information, I want call you attention to what it really means. It means the amount of information that could be recovered from a message, if we have at our disposal a complete repertory of receiving apparatus, and if we use all that we can get and the very best that we can get. This is the notion of amount of information in engineering. The amount of information in ordinary conversation means the amount that we can get through to the person that is listening to it. These are two very

is still indisputable, however, that in a reconstructive approach we find all the strength of the practical value of entities which do not exist: by writing the formula signal = message + noise and separating the message as significant term in spite of its being non-existent, the theory of information follows the same wonderful utopia of the philologists or restorers of artworks who expect to reproduce not only the intention but also the real idea of the author.

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different quantities and yet one can be defined in terms of the other. [...] Well, with highly efficient coding there may be very little loss of information; however, there will probably never be a situation in which there is no loss information. This situation, then, means that in measuring amount of information we have two measures: amount of information going over the transmission system, and amount of information going over the larger system including the transmission system and receptor. [...] This situation can equally be the case when the receiving or the sending system is a human being. There is the stage of reception, where the message is taken off the air, take into the inner ear, and taken into those parts of the brain which we may regard as being in a more or less permanent assembly together with the inner ear. That I would call the phonetic stage. There is another stage, the semantic stage, and there we've got to be very careful in any question of measurement, because the semantic stage, we have to consider, contains as an essential part the long-time storage apparatus of the brain which we call memory, and we combine a statement just made with a recall form memory which is triggered by it. In this sense the mere acoustic reception does not represent the whole input, and since we are dealing acoustically with isolate system, the second law of thermodynamics does not hold necessarily, unless we interpret it in a form where the entire experience input of the individual is regarded as input. [...] Then, finally, there exists what we may call the behavioral level of translation, which is the only level we can work with very efficiently with lower animals, and really to a much greater extent than we often realize, is the only level we can work with in human being other than ourselves. At any rate, the output is a form of action rather than a form which we interpret directly as our own thought». Not without a certain ironical touch, Wiener concluded: «I do not think then, that is any fundamental opposition between the problems of our engineers in measuring communication and problems of our philologists. Our philologists and engineers both have the problems of studying the properties of a little black box with terminals where they don't know what is inside. This is a much less important problem for the engineer than for the philologist. The engineer, after all, can rip his box open» (Wiener 1950, 696-697).

A text by Aurelio Roncaglia, dated 30 years later, is an exemplary summary, using terminology taken from the theory of information, of some methodological differences: «l'esigenza cui risponde la critica testuale è, alla radice, una esigenza morale prima ancora che scientifica: la volontà d'attingere e il dovere di rispettare scrupolosamente, fin nei minimi particolari, il genuino articolarsi di sostanza e forma del testo-messaggio, inteso nella sua oggettività storica, come documento dell'altrui personalità. Si tratta non solo d'evitare ogni soggettiva

The alternative is a documentary approach focused on the traits and material history of the document as repository of a real cultural stratigraphy. From a metaphysical perspective of recovering the true sound of an artist, which is deeply rooted in the abstraction processes of Western alphabetical writing, the documentary approach sounds like giving up on this objective; it is therefore fair to say – paraphrasing Contini – that the restorer who follows Joseph Bédier's approach, despairs of being able to reach what is 'true', thus settles for what is 'actual' or present, which definitely includes a certain amount of truth or certainty.

manipolazione, ma d'eliminare in quanto possibile tutte le distorsioni che il messaggio-testo può avere subito nel corso della sua trasmissione dall'emittente che lo ha generato a noi che lo riceviamo. Nei termini tecnici della teoria delle comunicazioni, si tratta d'eliminare o ridurre al minimo ineliminabile il "rumore", assicurando la perfetta coincidenza, o almeno la maggior possibile conformità della ricezione all'emissione. Rispetto allo schema generale d'ogni comunicazione, il caso che qui c'interessa – d'un testo che giunge da altre età al lettore moderno – presenta alcune complicazioni peculiari e non irrilevanti. Per lo più, la trasmissione non è effettuata attraverso un canale semplice e diretto, ma attraverso un sistema – non prestabilito in partenza e non previamente noto al punto d'arrivo – di collegamenti di tali stazioni ripetitrici molteplici. Inoltre, il funzionamento di tali stazioni, a ciascuna delle quali possono metter capo più canali afferenti ed efferenti, non è puramente meccanico. Non si tratta, infatti, di macchine, ma di uomini: non solo soggetti a involontari sbagli, ma capaci di volontari interventi, sia per correggere veri o presunti errori di trasmissione, sia addirittura per adattare il messaggio a intenzioni personali o a circostanze ambientali non previste dell'emettente d'origine. Le alterazioni il cui testo è soggetto s'allargano così dal "rumore meccanico" (sviste di copia e accidenti esterni sopravvenuti prima o dopo la copia, come macchie o ablazioni) a un più insidioso "rumore semantico" (fraintendimenti e reinterpretazioni, nonché interventi correttivi e completivi, contaminatori o congetturali, intesi ad ovviare al rumore meccanico), fino a interferenze, sovrapposizioni o inserzioni di segnali nuovi, capaci al limite di trasformare radicalmente il messaggio primitivo. Di fronte a questa situazione, bisogna riconoscere con chiarezza e mantenere ben saldo che i due tipi d'edizione tra i quali oscilla la pratica e disputa la teoria – da un lato il ricostruttivo, fedele ai principi lachmanniani canonizzati *geometrico more* dal Mass (o perseguito attraverso procedimenti probabilistici anche diversi da quelli della stemmatica tradizionale); dall'altro lato il documentario, ancorato, secondo l'insegnamento bédieriano, a un "manoscritto di base" con eventuale ammissione d'interventi restaurativi rigorosamente circoscritta ai casi in cui risulti indiscutibile l'evidenza interna della corruttela e altresì il modo di sanarla» (Roncaglia 1978, 81-82).

FROM WIENER TO KALMAN

The development started by Wiener's works historically culminated in Kalman's filtering theory.[8] The approach by Wiener-Kolmogorov focused on expressly calculating the transfer function of the filter. Examining the issue in an in-depth manner, it becomes clear that the key element is the assumption that the signals at stake can be described using linear finite dimension systems. The fundamental innovation in Kalman's approach consists in introducing this type of models right from the start of the act itself of posing the question. The fundamental point in Kalman's filtering is the specification of a mathematical model of signals at stake. The filter has a fixed structure which is to a large extent predetermined by the model; this is exactly the contrary of the project approach for traditional digital filters, which is based on the concept of passing bandwidth and is – as a general rule – expected to be universal.

The shift to Kalman's approach reflects the changes that took place in the systems theory in the first decade after World War II. In classical control theory the attention was focused on the analysis and synthesis of the systems in terms of their input-output characteristics. The main instruments used for these problems were Laplace's transform and Fourier's transform. Great success was obtained by the state-space approach, which instead deals with the basic system that gives rise to the observed output. As Harold W. Sorenson has written, the state-space approach represents «in many ways a return to Gauss' approach, since he referred to the dynamic modeling problem as noted earlier.[9] Also, the state-space approach makes use of difference

8 See *Focus on nr. 4*, p. 53.

9 Sorenson refers to the astronomical studies which brought to the invention of the least-squares estimation described by Gauss in *Theoria Motus*. There was considerable controversy in the early 19th century regarding the actual inventor of the last-squares method. The conflict arose because Gauss did not publish is discovery in 1795. Instead, Legendre indipendently invented the method and published his results in 1806 in the book *Nouvelles méthodes pour la determination des orbites des coètes*. The first exposition of the method of least-squares by Gauss, which is to be found in *Theoria Motus*, is in connection with the estimation of the six coefficients which determine the elliptical orbit of a planetary body when the available observations exceed the number of parameters. His second exposition was presented in a series of papers from 1821, 1823 and 1826 which were collected together under

and differential equations rather than the integral equations of classical approach» (Sorenson 1970, 63).

Integral equations are usually used to connect the actual value of the function $f(t)$ with the accumulation, the addition and, therefore, the integral of the changes relative to all the values assumed by f in a previous time interval. An integral equation contains the history of a phenomenon and offers global information about it, while a differential equation expresses local relations, instantaneous in relation to time.

Kalman's main objective was to solve, in more general terms, Wiener's problem, which, as we have seen, was subjected to certain limitations: «the approach taken here differs from the conventional one only in the way in which linear dynamic systems are described. We shall emphasize the concepts of *state* and *state transition*; in other words, linear systems will be specified by systems of first-order difference (or differential) equations» (Kalman 1960, 17). With this approach:

> A single derivation covers a large variety of problems: growing and infinite memory filters, stationary and non-stationary statistics, etc.; difficulty disappears. Having guessed the 'state' of the estimation (i.e. filtering or prediction) problem correctly, one is led to a non-linear difference (or differential) equation for the covariance matrix of the optimal estimation error. This is vaguely analogous to the Wiener-Hopf equation. Solution of the equation for the covariance matrix starts at the time to when the first observation is taken; at each later time *t* the solution of the equation represents the covariance of the optimal prediction error given observations in the interval (to t). From the covariance matrix at time we obtain at once, without further calculations, the coefficients (in general, time-varying) characterizing the optimal linear filter (Kalman 1960, 17).

the title *Theoria Combinationis Observationum Erroribus Minimis Obnoxiae* (Gauss 1823). It was in these papers that Gauss presented the famous theorem that amongst all linear unbiased estimators, the least-squares estimator has minimum mean-square error. This is known nowadays as the Gauss-Markov theorem. The relevance of Gauss's second exposition to the theory of recursive least-squares estimation and to the concept of the Kalman filter lies in a brief passage where Gauss shows that it is possible to find the changes which the most likely values of the unknowns undergo when a new equation is adjoined, and to determine the weights of these new determinations (see Pollock 2000).

Kalman's filter represents the extension of the approach of Wiener's filter to the case of non-stationary signals. Audio signals and voice signals can also be approximately interpreted as locally stationary autoregressive (AR) and autoregressive moving average (ARMA) processes and, more precisely, as processes with slowly varying coefficients. By combining standard filtering procedures, developed for stationary signals, whose characteristics are well-known, with parameter estimation/tracking algorithms, numerous restoration techniques have been obtained. The AR and ARMA models have proved useful for the removal of impulsive noises and certain local disturbances. The studies of Maciej Niedzwiecki and Krzysztof Cisowski (Niedzwiecki, Cisowski 1996) have been directed toward the restorative use of Kalman's filter. They propose a new restoration strategy with a method aimed at going beyond the limitations found in the other techniques in relation to signals concomitant with outlier and whose parameters are unknown and/or time-varying: the task of simultaneous detection/tracking/restoration can be stated as a non linear filtering problem and solved using the theory of Extended Kalman Filter (EKF).

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; 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 (Canosa 2001, 1086). 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 require a study not only of the recordings, 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 becomes clear when audiovisual documents are sound recordings of electronic or mixed music, that is to say the result of a complex process involving an audio signal originating from different sources: live, from other audio documents 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:

- 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 carrier chosen on the basis of its destination (concert tape, disc, radio broadcasting, etc.);
- 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'.

THE DANGERS OF REGARDING PRESERVATION EUGENICALLY

The pervasiveness of Shannon's model also emerges in the standards, recommended practices and strategies published by IASA (International Associations of Sound and Audiovisual Archives) in IASA-TC 03 (Schüller 2005). 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» (Schüller 2005, item 6). This position is confirmed and underscored again in 2009, in IASA-TC 04, where the term best copy is defined as the result of a selection among «copies of the same generation» (Bradley 2009, item 5.4.2.1). 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.

In the case of discs, for instance, we are confronted with a tradition for many aspects similar to the one of the printed book production, and in a similar context it is not possible to ignore the contribution of textual bibliography, which since the 1980s has been examining the meaning of the term 'copy' as a product of a historical process creating similar or identical objects of a defined group (see Dane 2009; Fahy 1998). Textual bibliography has, therefore, tied the notion of copy to different stages of the process where items are produced along an editorial project. We have thus come to establish the notion of copy, and the bibliographical structures deriving from it, the ideal copy and ideal text, cannot be easily dismissed as product of the same 'generation' but their all but simple definition implies to take onboard concepts like edition, impression, issue and state, in other words the knowledge of the abstraction levels the systems of book mass production and marketing imply; in our case, for example, of disc: a copy as instance of an edition can have a meaning and a conceptual (and economical) value different from the item of a given issue of the same edition. Suffice it to think of matrixes exchange, started since 1901, between Victor Talking Machine Company and Gramophone & Typewriter Company, which has caused the production of copies from the same matrix and therefore from the same edition but belonging to different impression and issue processes. If we were to apply to active safeguard of these records the concept of best copy, regardless of production stages, we would end up giving a distorted or partial image of the entire disc history. Therefore, establishing like IASA suggests the rule of the best copy in order to preserve among all the items the one containing the best signal means promoting, for merely technological reasons, a eugenic selection of audiovisual production. If we then abandon the field of mass production and we enter the world of music composition, IASA ethics becomes irreconcilable with the understanding of the world of electronic music production. In the first place, for the problem of variants and versions for which each copy, regardless if it is 'good', has a value of its own and can have its distribution through different channels. Also for audio documents there is a problem with vulgates: often the 'best' source has never – or rarely – come out of the studio archive where it was produced. The work is spread through rented copies, restorations, recording editions, sources which not infrequently show differences with the oldest source. On the other hand, we could be facing an audio master for various reasons affected by corruptions but which unlike one of its 'best' copies shows information on editing (additions, interpolations of virgin tapes etc.) and writings on the tape backside not transcribed on the copy but nonetheless essential to recognize the compositional process the author followed and to restore, when played in a concert, the synchronization with vocal and instrumental parts. In general, IASA ethics applied to electronic music works thus would become especially insidious because it would introduce a eugenic criterion in choosing an author's work and therefore in establishing a canon of the entire music production heritage in the 20th century, as a century characterized by art's mechanical reproduction.

THE ACT OF RECOGNIZING

This short history of audio restoration shows that in no other place as in restoration does the methodology moment of *recognition* show all of its complexity. By its nature restoration operates in a tension field consisting of knowledge from historical research on the one side and mathematical models representing the recorded signal on the other.

From a musical standpoint the recording on tape of electronic music is a projection of technical-theoretical choices made by the composer. It is a sort of holographic image which, if illuminated, provides insight as to the multiple diffractions of the composition approach. Accepting the paradigms of complex thought, any criticism of audiovisual sources needs to be aware from the outset that comprehensive knowledge is impossible, thereby acknowledging a principle of uncertainty and incompleteness which enlivens this research with a permanent tension between aspiring to analytical knowledge and a non-parceled multidimensional view of occurrences. The recordings of electronic music have a monadology structure, they are historical items which, in order to be understood, need to be considered outside the *continuum* of history. It is indeed true that the philosophy of a given age is reflected in its technology; as a consequence complexity is revealed only in the extrapolated item, showing the hologram of the historical item which provides an insight as to all the historical points of strength and interests. With the monadology structure, Benjamin would say, the composition project finds a way of representing, inside it, its own pre-post-history.

As part of statistical filtering theory and its application, recognition translates into a theory of *identification*. The action of editing from a predefined medium setting actually requires representation instruments as well as a statistical estimate of the audio signal. This is where the representation models drafted by the theory of signals come into play; the latter are themselves the result of an adjustment process to new materials.

In order to give a discipline status to the set of audio research activities, Stephan J. Cottrell suggested the name *Phonomusicology*.[10] The reasons for

10 Cottrell says: «All of this suggests a variety of articulations between recording technology, musical performance and creativity in the recording context, which provide potentially rich sources of data for phonomusicologists in relation to the way in which technology

this are an interesting starting point for a reflection from a musicology perspective. The issues entailed by sound recording involve technological and historical-critical skills. The latter are expected to contributing to dispelling the popular myth according to which the question of restoring audio documents is conceptually very simple and can basically be traced back to the idea of improving the sound quality of a corrupted musical signal – in different ways and at different times – by various kinds of disturbances.

Below is a table which summarizes the multi-disciplinary complexity of the various issues and processes involved in the activity of a preservation, restoration and critical editing laboratory.

affects the final product. One way in which these interrelationships between musical practice and technology may be conceived is offered in Figure 1.

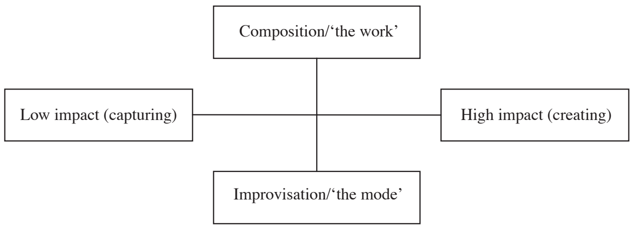

Figure 1. A possible schematic representation of the relationship between musical practice and recording technology.

The vertical axis posits a continuum between fixed composition and more fluid forms of improvisation. At its top end are those recordings which serve as single instantiations of pre-composed musical works for which many other instantiations would be equally valid: for example, where a given recording represents only one particular interpretation of a composer's score, but might also include recordings of other extant repertory such as well-known popular songs. At the opposite end lie recordings which serve as representations of traditions which are heavily reliant on improvisation. Here there may be no formal works as such, only agreed conventions within which improvisation may take place. Many musics would lie between these two poles. The other axis represents a continuum between a technological approach which essentially seeks to capture the performance, with the minimum amount of technological intervention, and one where the recording technology is essential to the creation of the work itself. Different recordings can be seen to occupy different positions on the grid, according to the particular relationship between musical practice and recording technology. Even different performances of the same piece, a Beethoven *Sonata*, for example, might be conceptualized as being in varied positions depending on the degree of technological intervention involved – the difference, for example, between a live recording using no edits and a heavily edited studio version» (Cottrell 2010, 9).

Historical critical approach	*Technological approach*
Sources (voice, instrumental sound, electronic signals, files, etc.)	Source (voice, instrumental sound, electronic signals, files, etc.)
Document–audio recording (witness)	Signal
Tradition	Transmission channel
Historical reproduction, listening and diffusion system/current system for reproduction, listening and diffusion: *dia-system*	A/D conversion and reproduction, listening and diffusion system
Acknowledging documentary value. *Recognition*	*Identification* of the source model
Innovations (errors and variants)	Innovation (estimate error)
Guiding error. *Recensio* and *emendatio*	Noises (global, local), distortions. Filtering
Authorial *variant*	The best copy
Authenticity	Integrity
Historicity of the musical composition	Automation of preservation processes
Uniqueness of documents-witnesses	Universality of models and filtering system
Restitution of the work	Audio restoration

Considering technological aspects compatible with the historical critical approach, we can say that the task of the critical editing of recorded music is to bring musical work back to life for publishing and performance, re-coded and re-presented according to the present media environment. These actions are carried on based on the knowledge of compositional thinking, of the modeling of sound and of the technologies of audio transduction and processing. The combination of these factors is considered in relation to the compositional project and to its authoriality, which are historically determined.

REPRESENTATIONS

The issue of representation is complex not only mathematical but also from an epistemology perspective. Traditionally also intrinsically unpredictable signals, such as the vocal signal, are treated and modeled in a deterministic manner, for example as quantities characterized simply by a certain harmonic content. In many applications, for example traditional telephones, this primordial way of describing data appeared to be sufficient.

It is well known, however, that in actual fact audio recording systems introduce aleatory elements: the signals detected as output from a microphone, the noise present in recording systems, the voltage fluctuations in a signal due to Johnson-Nyquist noise, the amplitude fluctuations in a radio signal due to accidental variations of medium propagation constants, the influence of electrical interference phenomena in recording systems, are all examples which give an intuitive idea of aleatory signal. In the analysis of automated communication and control systems aleatory signals play an important role. According to Giorgio Picci (see Picci 2003) there are two ways of approaching the subject: the purpose of a communication system is to pass on new information and if the temporal trajectory of the signal were known in advance there would be no point in transmitting it. On the other hand the purpose of a recording or control system, at least theoretically, is to eliminate the effect of uncertain variables or of parameters which might vary over time in an unpredictable way. If the development of the variables in a system to be controlled were known *a priori* it would not be necessary to build control systems.

From a methodology standpoint a distinction needs to be made between empirical entities and the mathematical representations of the latter: the models. The former are entities which can be known and defined only partially and in an approximated way. The model, the abstract mathematical entity, mainly in use in the filtering theory, is the stochastic process. An aleatory signal s is thus devised as a triplet $\{T, V, S\}$ where T is the time set, V is the alphabet or space of values of the signal, S is the sampling space. Each element in S is a trajectory of the signal, a possible implementation of the process, i.e. a function: s: $t \to s(t)$, where t belongs to T and $s(t)$ belongs to V. As a consequence each individual signal, set by a recording system, should be regarded as a possible implementation of a system generating aleatory signals. A precise vocal recording is nothing but a trajectory chosen within the universe of possible vocal messages.

Once the principle of the probabilistic description of the aleatory signal as stochastic process has been accepted, one needs to be able to concretely reconstruct this type of models. This is the purpose of the theory of identification.

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. Musical work itself is a process whose witnesses (recordings) are its 'states', defined by the constraints of the technology of the time and by the models of sound.

The historical survey on audio production system thus becomes a fundamental support because knowledge from outside the signal provides valuable information allowing for the avoidance of indiscriminate noise reduction procedures. Taking into account the approach whereby the reproduction-restitution of the document is based on the signal/noise duality is a necessity: just consider the in-house manuals of production centers, where all the information is collected to allow for better (depending on equipment tolerances and limitations) recording and reproduction, that is to say in order to allow the signal to 'overcome' transmission noise. When restoring an audiovisual document it is essential to consider the various kinds of noise. These are not universally classifiable in that they appear individually and specifically in each document unit. For this reason attention should be paid to the individuality of the document, which could be unique, making sure that the nature of the noise itself is not underestimated which could lead to its indiscriminate elimination. The reconstruction of the production process, in its various composition and technological phases, therefore becomes paramount for the interpretation of noises and of the final form of the electronic composition.

INTERNAL *VS* EXTERNAL KNOWLEDGE SOURCING

The ambition of the identification theory is to develop modeling methods for signals starting from the data observed. There are two contrasting approaches in this area: one tends to reject all knowledge outside the signal, the other instead accepts external information. The former starts from the recording and is essentially based on spectral subtraction techniques (see Cappé 1993). The latter relies strongly on Bayesian approach which considers unknown parameters as aleatory variables to which an *a priori* density function can be assigned. This probability function is ideally expressed based on some *a priori* knowledge before the data are observed. According to this strategy, subjective information factors are added to estimate parameters, which differentiates the Bayesian technique from traditional methods.[11] Bayesian approach has produced significant results in the field of audio restoration; nevertheless, with regard to audio restoration of electronic music, the use of restoration algorithms taking into account knowledge external to the signal is still problematic due to the intentional noise which is used as composition material.

The versatility and calculation capacities of processing systems, over time, have grown to greatly exceed those of analog calculation devices. With the computerized research on true sound, audio restoration leaves the field of acoustic-electro-mechanic analogies, of the modeling of vibrant systems conceptually connected to the transferring of energy and to the transmission of analog signals, in order to venture into the domain of the digital processing of audio signals. The removal of impulsive disturbances (transient noise) and the attenuation of broad-band noise, nowadays relies upon signal processing algorithms; yet, as it is known, once we rely on computerized interventions, we draw away from the pure transmission and memorization of information in order to enter the field of the virtual reconstruction of the audio signal. In this dimension it is possible to accomplish a number of descriptions of the sound reality by assuming different hypotheses on the signal nature. The algorithms dedicated to the noise reduction and the improvement of the quality of the signal are not neutral; they derive from a modeling of the

11 See *Focus on n. 5*, p. 58.

sound among the many possible, and therefore carry that degree of relativism that pervades all scientific research based on the construction of models. Model-based processing more or less consciously renounces a *unitary* and *objective* idea of scientific knowledge in favor of a more pragmatic vision in which the researcher's subjective responsibility emerges to a greater extent.[12] This approach is amply justifiable on an epistemological level and does not fail to have its effects on the restorer:

> Many signal processing techniques will be model-based, either explicitly or implicitly, and this certainly applies to most of the audio restoration algorithms currently available. The quality of processing will depend largely on how well the modeling assumptions fit the data. For an audio signal, which might contain speech, music and general acoustical noises the model must be quite general and robust to deviations from the assumptions. It should also be noted that most audio signal are non- stationary in nature, although practical modeling will often assume short-time stationarity of signal (Godsill, Rayner 1998, 3).

We must not forget that even the most sophisticated noise reduction methods inevitably interfere with the quality of the signal. Owing to the high degree of operational flexibility and the remarkable potentialities of the systems dedicated to the removal of audio signal disturbances, «indiscriminate application of inappropriate digital methods can be more disastrous than analogue processing!» (Godsill, Rayner 1998, 3).

Over the past thirty years audio restoration has increasingly been influenced by information media and research, with a pragmatic spirit, has been focused on the processing of signal degradation removal algorithms. As a consequence, there has been an inclination toward restricting the study of the sound content of a historical recording within the limits of an analysis of the digitized signal.

If aggravated, this approach can become deceptive even from the point of view of the processing of the algorithms, since it reduces the range of knowledge necessary to the modeling of the signal alterations and gives up a wealth of information useful to individuate the sound models assumed in

12 See *Focus on nr. 6*, p. 67.

the planning or in the programmes. I am referring in particular to the development of specific algorithms for the removal of non-linear signal alterations which need specific knowledge external to the signal. In philosophical terms, we could say that, in the specific field of restoration, algorithms for the removal of audio signal disturbances would be blind without a historical-musicological analysis, just as the latter would be void without the operational instruments expressed by the algorithms.

The developments of the digital processing of restoration seem to provide solutions to some of the problems connected to the time-varying character of traditional musical signals; in the field of the recording of acoustic sound sources the individuation of a sound model can be aided by knowing the physics of the instruments: leaving out the alterations introduced by sound recording systems, the indeterminateness seems thus to be circumscribed to the time range of the transients. On the contrary, in the specific case of electronic music restoration the intervention of historical-musicological knowledge proves to be a methodological assumption which cannot be renounced for the impossibility of otherwise deriving the sound models of the recordings. It is necessary to guide the restoration work with all the knowledge external to the signal, knowledge which is retrievable from the history of the compositional thought of electronic music and from the history of the musical technology connected with it. If conceived in this way, the restoration of electronic music on tape constitutes a field of the analysis of contemporary music.

INDUSTRY AND HOMOLOGATION OF SOUND

The industrial world has made all possible effort in eliminating any form of distortion which could jeopardize the functioning and control of production. This approach is apparent also in sound reproduction. The Western tradition has been working in the direction of an orthogenesis of sound. An example of this is the deconvolution technique used by Dayton C. Miller to eliminate the distortion produced by the recording horn which is based on *a priori* knowledge of the ideal sound spectrum (from an organ). The musical instruments in a traditional orchestra have reached technical perfection following a linear development which has not overturned the pattern of existing families of instruments, but rather merely enhanced and boosted their performance potentials. These technical conditions have led to homogeneity in musical writing and allowed European music to develop its creative universe and the related rituals within a stably defined fabric of media. Exercising the regulatory power on the relationships between sound and noise, music in the nineteenth century was able to gain unsurpassed ground in the hierarchy of arts; as a consequence it has become a form of representation of the possibility of building some kind of social order. This also explains the preference of musical theory for the phenomenon of acoustic resonance: the model based on harmonics provided a linchpin, though uncertain, with the theory of the existence of a 'natural' foundation for tonality. This concept – wrote Pierre Schaeffer in his *Traité*: «n'a constitué qu'à règlement d'usage, - fixer des norme, imposer de patrons, uniformiser des caractéristiques. [...] La musique, à l'instar de la physique, a consacré tout son effort culturel à 'normaliser' ce qui ne l'était pas par nature» (Schaeffer 1966, 245).

This need for standardization and approval is specifically cultural and rich in implicit values: controlling the balance status, discerning morphological and functional values, the prestige of conservation, preserving stability, eliminating irregularities.

Our industrial civilization, whose vocation is to institute the inter-subjectivity of musical practices, has tamed a virgin sound nature, creating tones which can be compared one with the other. Musical instruments have been designed and fine-tuned for this purpose, as has traditional *solfège*. Music and the industry have harmony in common which – according to Hugues Dufourt – is no longer the law of the skies but of hell. The laws of harmony warn that if non-linear functions are introduced without adjustment in a system, the course of the latter is perturbed, its sinusoidal functions deformed and distortion factors added. The whole enterprise of restoration seen as subtraction or attenuation of noise and distortions fits within this industrial logic. The industrial recovery also of the past is seen as technological improvement in the direction of restoring the linearity of the system.

After World War II, however, a reversal of these values occurred. Art started to follow innovation, thus striving for a gap, a break, ceaselessly producing information in Shannon's sense. Music searched for an expression in the form of science paradigm representations. Seduced by electronic media, in the search for the totality of the sound universe, music after World War II actually began a formidable search on noise. We are therefore before an aporia: the electronic music which is being restored presents noise materials and highly uncorrelated signals which are interpreted by the theory of time series as disturbances and alterations of the signal.

In the 1950s, musical research immediately after the destruction caused by World War II, had the ambition of recreating from scratch the whole musical knowledge. Abraham Moles, an acoustic physicist who theorized the electro-acoustic musical experimentation being studied by Schaeffer, went as far as suggesting to consider the auto-correlation function as a model formalized in memory, also in a musical sense. From this perspective, memory is not an archive, nor is it a document of the past; on the contrary – as part of information theory – it is an operational concept, a dynamic function anticipating the future. Therefore memory is seen as the ability to predict based on data observation.

For the objectives of the restoration of electronic music it is problematic that some composers – see Xenakis, for example – elaborated their compositional procedures by modeling them on stochastic processes (random-walk, Markovian sequences, Brownian motion, etc.) or embraced the poetics of *alea* or *opera aperta* – see Henri Pousseur with *Scambi* – and that, on the other hand, both the harmonic analysis generalized by Wiener and Kalman's recursive filtering had their humus in random processes. Whoever is involved in restoring this type of musical materials has the feeling that he is experiencing a cultural impasse, that he is in a vicious circle in which the foundations of the technology at disposal also conceptually belong to musical experimentation: the noise present in electronic music is generated intentionally by the composer by exploiting the mathematical models that are at the base of the noise individuation techniques in audio restoration. Here art and science converge so closely that there are no alternatives to restoration methodologies sustained by historical and musicological knowledge. They represent the only 'meta-language', without which it would be impossible to adequately talk about the 'objects' which restoration deals with.

From 1950-80, electronic and mixed musical production was rich and plentiful. Today, music publishers have to address the problem of the execution and staging of musical works on the audiovisual media figuring in their catalogs. All of these factors have led music critics to see audiovisual documents as primary source materials. The aim of reuse, however, remains problematic in the case of electronic and mixed works.

Twenty-five years after the drafting of the *Guide*, we can say that the emergency that was so strongly perceived by its authors has been partially overcome: procedures for transferring audio from analogue to digital domain can now be said to be firmly defined. Among the objectives of AD migration, the most important outcome has been easy access to audio files. Although the effects of the new forms of access are evident in the field of preservation, they are still not addressed methodically: the accelerated pace of digital communication tends to create an immediate link between what took place and the here and now. In particular, users of audiovisual documents are inclined to use current data without worrying over much about sources and authenticity, while they are interested in finding new relationships between what is produced and what is reproducible through immediate manipulation made possible by the digital medium. Nevertheless, ease of access has helped to increase interest in audiovisual recordings among historians and music critics. The reuse of audiovisual materials on radio television channels, in theaters and in festivals is very much on the agenda.

So, while from the point of view of active audio preservation techniques we can say that progress has been significant, much remains to be done in terms of the techniques and methodologies of recognition and reuse of the single recording. The uniqueness of the recording of an event consists primarily of the unrepeatable nature of the event itself, which therefore applies to the content also; while the uniqueness of a master recording of electronic music, produced for example in a radio laboratory in the fifties, is above all the product of the composer's direct editing on the medium: sometimes deliberately violating the recording standards of the period, it also demonstrates significant elements of the creative process of the work. Furthermore, the process of dissemination of recorded music under copyright took place through rental copies, concert editions, restorations, etc.; so there may be variants, versions and preparatory materials of musical compositions. The entire range of these documents relating to a work has a value in itself, regardless of the sound quality of the testimony. For these documents, the implementation of automatic and selective procedures is obviously hindered. By dispensing with repetitive exercises, automated processes also end up dispensing with authentic learning, an essential element of the recognition of the uniqueness of recordings. If ethics are linked to the discovery of the value of our actions, then a separation is needed between what can be entrusted to automation and that which, due to its uniqueness, is a challenge to our understanding of the new. The tension between technocratic and anthropocentric automation is not merely a theoretical concern: it involves the practice of laboratory technicians, who increasingly make repetitive choices that day by day undermine the value of their actions. This is reflected in the lack of attention to issues of recognition of the value of the single document and the subsequent decision not to implement restitution strategies for copyright works.

THE EMERGENCE OF A NEW *AURA*

When Benjamin began to analyze the world of technical reproduction of an artwork, the latter was still in its infancy. On the basis of the polarity *trace/aura*, 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 stresses 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. 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. 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.

The preservation and restoration activities on audio documents and the restitution/recovery of audiovisual products (electronic and mixed) have a conceptual range which in actual fact lies at a crossroads between hard sciences and technologies (theory of signals, audio technologies, chemistry-physics of carriers etc.) on the one hand and human sciences (ethics, ontology, aesthetics and interpretation in the two senses typical of music criticism and live performance) on the other. The act of recognizing the value of a recording normally derives from selecting properties which have the power of producing relevant cultural effects in the world. These properties emerge within a technological-historical setting, but they are not all attributable to the properties of the document seen as data transmission channel. Their complexity is responsible for bringing back preservation to within the boundaries of a strict approach to the audio document. From this perspective the ethics of preservation should not be focusing on the dynamics of how documents are produced, whereas the whole issue of filing audio sources should be left to automated procedures aimed at transferring the 'useful' signal.

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 recordings. 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, as already mentioned, to an ethical approach to restoration. Nevertheless, after the micro-temporal levels of A/D conversion had been highlighted in order to reproduce the recording 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 the interpretation moment in the development of technology and recording practice. It 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.

The ethics of audiovisual preservation are facing old problems in new and complex forms: a) the authenticity *vs* integrity of documents, b) the concept of noise, c) forms of access to audio. Issues that relate, in different ways, both to documents of digital origin and documents derived from analogue carriers. Three conceptual and operational levels can be defined today: 1) faithful transfer of the recorded signal applies to all documents. Generally, two systems are inevitably brought into contact in this process: the historic process and the re-mediation system. We can call the basic principle of this first level *dia-systemic*; 2) the second level requires awareness of the relativity of our knowledge. Improvements in technology and advances in our knowledge of the documents can infuse data formerly believed to be non-essential with important operational significance. Noise can become a signal: what we deemed to be a useful signal can be read in another cultural context as noise. This level is reached through the international exchange of information between archives and laboratories that are active in the audio field and beyond: experiences and practices arising in other domains of preservation and restoration may lead to useful comparisons. For this level, the basic principle is *feedback*. 3) For recorded copyright music the introduction of a third level is essential. Audio documents are, in this case, the projection of technical-theoretical choices made by the composer. The components of a musical work on an audiovisual medium are a kind of hologram of the multiple diffractions of compositional thought. It means that preservation must achieve a new level: a return to the concert life of the work. The ethics of respect for the author and for works of artistic merit are supported, in this regard, by a principle that, based on what we have said so far, can be defined as *holographic*. These principles can be made operative through restorative approaches to audio documents:

1. The *preservative* approach considers all the information presented in the document as an artifact. It aims to preserve the documentary unity. The process of re-mediation here uses the new digital medium to represent, immediately and fully transparently, the information and material characteristics of the original document as it came to us. This approach seeks to answer the question: what is the document like?
2. The *documentary* approach focuses on the form of each document, on the interplay of relationships in its sound fabric and, in the case of several witnesses of the same work, between the documents themselves, on the production equipment and techniques, the compositional practice and the authorial bases. The documentary approach aims to create accurate editions accompanied by a review of the sources. The documentary approach therefore answers the question: where is the sound fabric of the document?
3. The *sociological* approach is based on study of the characteristics of historical systems of storage and distribution of sound; it aims to provide a historical reconstruction of the recording as it was heard at the time, with the goal of writing a history of listening habits. It answers the question: how was the published document perceived?
4. The *reconstructive/regenerative* approach considers the production of the document in terms of intellectual and material responsibility. Its aim is to recreate, also through the study of the genesis of the work, a sound fabric that reflects, as far as possible, the intention of the author. It achieves its goal through *collatio* of witnesses and the study of tradition and can 're-generate' the sound fabric on the basis of multi-track (*master*) sources, data provided by the score – in the case of mixed music – and authoritative mixing notes.
5. Finally, the *aesthetic* approach considers the potential of the work in relation both to its use by the recording industry and its performance. Its goal is the commercial edition or processing of audio formats for representation. It is a functional interpretative approach to the conditions and procedures of listening, of the event and of the performance of the moment. The aesthetic approach answers the question: how can the document be transformed?

Among the possible interpretations of re-mediation of audio documents, these approaches give a systematic view where the prefix ‘re’ acquires paradigmatic value: re-mediation and innovation are encapsulated in the feedback and transformed by it. ‘Re’ may consist, not only of the terms repetition and copying, but also of the sense of production of otherness: a system of reproduction, reorganization and regeneration that not only addresses the past, but looks also to the present and the future.

Focus on nr. 1: William Strom and the two 'legitimate directions' of re-recording

As is well-known, it was William Storm (Belfer Audio Laboratory and Archive, Syracuse University) who focused on the problem of standardizing the procedures of restoration in an article which has become famous for the numerous controversies it arose (Storm 1980). Storm individuated two 'legitimate directions', two types of re-recording which are suitable from the archival point of view: 1) the sound preservation of audio history, and 2) the sound preservation of an artist.

The first type of re-recoding (Type I) represents a level of reproduction defined «as the perpetuation of the sound of an original recording as it was initially reproduced and heard by the people of the era» (Storm 1980, 7). Storm's contribution aimed not only at raising the archivist's interest from the simple collecting of audio carriers to the information contained in the recording, but also at highlighting the double documentary value of re-recording with his proposal for an audio-history sound preservation: on one hand, he wanted to offer a historically faithful reproduction of the original audio recording by extracting the sound content according to the historical conditions and technology of the era in which it was produced; on the other hand, he wanted to document the quality of sound reception offered by the recording and reproducing systems of the time. These two instances, conceptually joined in a single type of re-recording, had induced Storm to prescribe the use of original and optimum playback equipment. The aim of history preservation is to first hear how records originally sounded to the general public.

The second type (Type II) of re-recording was presented by Storm as a further stage of audio restoration, as a more ambitious research objective, conceived as a coherent development of Type I: the knowledge acquired through audio-history preservation provides the sound engineer with a logical place to begin the next step – the search for the 'true' sound of an artist. Preservation of the 'sound of artists' represents a conceptual leap which transcends the limits of a historically faithful reproduction of the recording. In other words, there is the pretension to be able to reconstruct the original 'voice' by inverting the chain of dynamical analogies on which the various phases of recording in the various types are based: the acoustic-mechanical model, the acoustic-electro-mechanical model etc. (see Storm 1980). From the data obtained from the comparison with all the previously experimented solutions and from the development of new technical solutions for the extraction of the signal from the original recording, Storm affirmed that «an accumulation of the data should eventually lead to a definition of the characteristics – those of the artist compared to those of the original recording medium» (Storm 1980, 10). In spite of the objectives of standardizing the procedures proclaimed by Storm, the Type II direction *de facto* leads the restoration toward a process of interpretation of the recording which is hardly reducible to a technical protocol, but which can, instead, be assimilated to a philologically- and historically-based investigation. Storm also seems convinced of the asymptotic character of his methodological course when he affirms that:

> Once the noises and anomalies have been scientifically determined and documented, selective filtering and equalization can then be used far more objectively. This does not mean that one will necessarily like the way the record sounds. But it does establish a foundation on which to begin constructing a playback curve that better approximates reality (Storm 1980, 9).

The philosophical standard on which Type II re-recording is founded is also stated by influential experts working in the field of the restoration and preservation of works of art. If we reread the terms of the famous 'cleaning controversy' which arose back in 1946 after the cleaning of the paintings of the National Gallery, we will find in the methodology adopted, for example, by Helmut Ruhemann, who at the time was in charge of the cleanings at the National Gallery, a philosophical standard which, under certain aspects, resembles Storm's standard. Among the guide rules for the restorer, Ruhemann states that: «he must try to recover as far as possible the original appearance of a painting where it is obscured. The intention of the master is the guiding standard» (Ruhemann 1968, 148). Without specifically considering the history a painting has gone through, but by relying mostly on a series of prevalently technological controls and operations, Ruhemann followed the objective of rediscovering the aesthetic message that the artist had entrusted to the chromatic variations. The principle according to which the paintings are to be presented as much as possible in the 'state in which the artist intended them to be seen', seems obvious and indisputable – as Cesare Brandi noted – and, especially in the field of painting, it is the most insidious pretension that can be made.

> Né un conservatore né un restauratore può pretendere tanto, appunto perché è una *pretesa*, un'indimostrabile pretesa quella di poter risalire ad un supposto aspetto originario di cui la sola testimonianza valida sarebbe l'opera *allorché fu compiuta*, ossia senza il trapasso nel tempo, ossia un'assurdità storica (Brandi 1963, 101).

As we all know, the crucial point was the removal of the patina which, according to Brandi, was an integral part of the history of a painting. Nothing authorizes us to think that the removal of the patina, aimed at restoring the painting with the artist's original intention, does not destroy the latter instead: that is to say, the artist's desire «di spegnere la iattanza della materia» (Brandi 1963, 102) with glazes so as to obtain a softer chromatic balance. In open controversy with the supporters of the London cleanings, Brandi (and, with him, many other art historians, among whom Ernst Gombrich) stigmatized the blind aim of integral cleaning to treat the work of art as if it were outside of art and history and could become reversible in time through a series of technological and objectively documentable operations. Therefore, since Storm asserts an idea of restoration which will restore the real sound of the artist, his line of thought seems similar to the approach adopted by the restorers of the National Gallery and poles apart from the idealistic and historicist outlook of the Italian school. The best way to understand the choices and, more generally, the cultural policy adopted by the National Gallery is to consider Ruhemann's observations on the reproducibility of a work of art. He promoted, in fact, a campaign for the realization of natural-size reproductions of previously cleaned masterpieces, in order to perpetuate their memory in case of an atomic destruction.

FOCUS ON NR. 2: ‘SAVE HISTORY, NOT REWRITE IT’

In the *Guide to the Basic Technical Equipment Required by Audio, Film and Television Archives* (Boston 1991) commissioned by UNESCO, we find, together with the philosophical standard ‘save history, not rewrite it’, the types of audio restoration proposed by Storm. Yet the audio section is clearly influenced by the new formulations made by Dietrich Schüller. Schüller’s works (Schüller 1991) move from a different methodological point of view, «which is to analyze what the original carrier represents, technically and artistically, and to start from that analysis in defining what the various aims of re-recoding may be» (Schüller 1991, 1014). Schüller skates over the importance of documenting the quality of audio reception in order to reconstruct the history of musical perception: the only case where the use of original equipment is justified is in the exotic aim to reconstruct the sound of a historical recording as it was heard originally. Instead he points directly toward defining a procedure which guarantees the re-recording of the signal’s best quality by limiting the restoration work to the minimum. Having set aside the general philosophical themes, Schüller goes on to an accurate investigation of signal alterations which he classifies in two categories: *intentional* and *unintentional*. The intentional alterations include recording, equalization, and noise reduction systems (*Dolby, dbx* dynamic expanders/reducers, etc). The unintentional alterations are further divided into two groups: the first group includes those caused by the imperfection of the recording technique of the time, resulting in various distortions (linear, non-linear, and modulation distortions caused by the uneven movement of the recording medium, poor signal-to-noise ratio); the second group of unintentional alterations is caused by misalignment of the recording equipment, for example, wrong speed, deviation from the vertical cutting angle (as is often found in cylinders) or misalignment of the recording heads resulting in wrong track positions and azimuth errors on magnetic tape (see Schüller 1991).

The choice whether to compensate for these alterations or not reveals different restoration strategies. Historical faithfulness can refer to various levels:

A. The recoding as it was heard in its time (Storm's Type I);
B. the recording as it has been produced, precisely equalized for intentional recording equalizations, compensated for eventual errors caused by misaligned recording equipment and replayed on modern equipment to minimize replay distortions (Schüller 1991, 1016).

Schüller's position on the use of reproduction systems of the time is radically different from that of Storm. Without betraying the ethic criterion of historical faithfulness, Schüller demonstrated that preservative re-recording had to be carried out with a modern equipment to minimize replay distortions: «it is a false though widespread belief that equipment used at the time of the production of the carrier is the best for re-recording. Generally, the opposite is true: mechanical and, where applicable, electrical parameters of modern equipment exceed those of older equipment sometimes by several orders of magnitude» (Schüller 1991, 1015). Storm also ratified his position on this point by adding an I.A Type in agreement with Schüller's critique on the use of playing equipment of the time: these positions successively came together in the *Guide*'s operational synthesis.

From the synthesis of the two positions we can derive another lesson: the restorer must use the most technologically modern reproducing system after having ascertained with appropriate measures (SNR, etc.) that the equipment chosen also possesses – even in relation to the audio format that has to be read – a technical level capable of extracting a higher signal quality than that of the original equipment.

Type B re-recording defines a historically faithful level of reproduction which from a strictly preservative point of view is a preliminary to any further possible processing of the signal. The compensation of signal alterations uses knowledge which is external to the recording; therefore, even in the operations provided for by Type B, there is a certain margin of interpretation since a 'historical' acquaintance with the document is called into question alongside a technical-scientific acquaintance: well-known are, for example, the difficulties involved in individuating the equalization curves of records and magnetic tapes recorded without adapting to international standards (respectively, RIAA, IECC, or NAB). The need for a historical investigation also comes up when we have to determine with precision the adequate rotation speed for the reproduction of records. However, owing to the fact that it refers to intentional alterations conceived to be reversibly compensated for, most of the information provided for by Type B is retrievable from the history of audio technology, while other information is instead experimentally inferable with a certain degree of precision. The restoration work can thus be carried out with a good degree of 'objectivity' and represents an optimal level within which the standard for a preservative archive copy can be defined.

The need to standardize the operations on the preservative copies is also suggested by the digital evolution of the formats: the archivist must abandon the old concept of striving for the 'eternal carrier' and substitute it with a philosophy aimed at safeguarding the «contents of the carriers in digital form to ensure the 'eternal' ability to produce subsequent generations of identical copies (clones)» (Schüller 1999, 619). This induces us to limit, in preservative copies, operations on the signal which could be irreversible if the originals were lost or made illegible. This is particularly true for the electronic music.

After having established an operational criterion with which to carry out preservative re-recordings based on stable procedures and derived from an objective knowledge of the degradations, Schüller individuated a third level of historically faithful reproduction, the C level: «the recording as produced, but with additional compensation for recording imperfections caused by the recording technique of the time» (Schüller 1991, 1016). While the compensations of type B are commonly accepted and must – Schüller writes – be carried out, in type C, instead, they have to do with the area of equalizations «used to compensate for non-linear frequency response, caused by imperfect historical recording equipment and to eliminate rumble, needle noise, or tape hiss» (Schüller 1991, 1016). These are operations which elude standard operational criteria and must therefore be rigorously documented by the restorer, who must write out accurate reports in which he specifies both the equipment and systems used as well as all the restoration phases.

Schüller then circumscribes the interpretive level to the field of the interventions that go beyond the archivist's work. In the phase of recording, the true sound of the artist undergoes a series of transformations, beginning from the acoustic imprint of the hall, to the manipulations of the *Tonmeister*, a new type of *Korrepetitor* as Adorno had predicted. This type of compensation must not regard the archivists.

> Sound archives are dedicated to the preservation of audio documents. Whenever re-recording (or transformatting) becomes necessary, it must be done with historical faithfulness in mind. Careful documentation of all procedures is imperative. Reissuing historical records by the record industry is another matter. If reinterpretations are carried out, they have to withstand artistic and aesthetic criticism (Schüller 1991, 1016).

Storm's principle that ideally, all of these compensations, if applied, must be based on an objective knowledge of respective imperfection and on the capacity for precise counteraction is thus reaffirmed. On this point Schüller adds: «while it is comparatively easy to detect and compensate for azimuth misalignment, for example, the objective knowledge of non-linearities of a given but unknown recording device may be difficult to obtain» (Schüller 1991, 1016).

With the term 'non-linear' we commonly intend those distortions of the signal, such as, for example:

- Non-linearity in amplifiers or other parts of the system which gives rise to inter-modulation distortion;
- cross-over distortion in class B amplifiers;
- saturation due to recording overload;
- tracing distortion in gramophone recordings: the result of the playback stylus tracing a different path from the recording stylus;
- deformation of grooves in gramophone recording.

It is not clear if, with regards to the acoustical recording device mentioned in reference to level C, Schüller also wanted to include the distortions produced, for instance, by a horn combined to a diaphragm, which are typical of recording set-ups before 1920. In any case, the type C compensations belong to a field in which the historicized study of the dynamical analogies and of the transducers which have allowed the evolution of sound reproduction is preeminent. This implies a process of reverse engineering which is based on a knowledge of the history of technology and of industrial production.

Because of the complexity of a historical-technical interpretation of the parameters which are approached by the compensation procedures established by level C, Schüller actually re-opens the interpretive problem indicated by Storm with his Type II.

FOCUS ON NR. 3: THE IMPORTANCE OF ANCILLARY INFORMATION

The studies of George Brock-Nannestad (Brock-Nannestad 1997) are in line with the modeling of the degradations through reverse engineering. In these studies he examines the re-recording of acoustic records (pre-1925 recordings) and, in particular, the strong line spectrum in the recording transfer function and unknown recording speed. Brock-Nannestad goes back to the first studies in the acoustics of sound reproduction and, in particular, to the scientific works of Dayton C. Miller (Miller 1922), whom we must recall as the first to attempt to retrieve the 'true sound' once it had been recorded. Miller wanted to obtain a sound without the distortions produced by a horn combined to the diaphragm of the recording system.

> It is well-known that the response of a diaphragm to waves of various frequencies is not proportional to the amplitude of the wave; the diaphragm has its own natural periods of vibration, and its response to impressed waves of frequencies near its response in degrees depending upon the damping. The resonating horn also greatly modifies waves passing through it. Therefore, it follows that the resultant motion of the diaphragm is quite different from that of the original sound wave in the open air (Miller 1922, 143).

The process of recovery of a signal convolved with the impulse response of a communication channel, or a recording medium, is known as deconvolution or equalization. One of the early papers on blind deconvolution was on dereverberation of old acoustic recordings. Early acoustic recorders, had a bandwidth of about 200 Hz to 4 kHz. However, the limited bandwidth, or even the additive noise or 'scratch' noise, are not considered to be the major causes of distortions of acoustic recordings. The main distortion on acoustic recordings is due to reverberations of the recording horn instrument. An acoustic recording can be modeled as the convolution of the input audio signal $s(t)$ and the impulse response of a linear filter model of the recording instrument $h(t)$:

$$z(t) = s(t) * h(t) + n(t)$$

or in the frequency domain as:

$$Z(f) = S(f)H(f) + N(f)$$

where $H(f)$ is the frequency response of a linear time-invariant model of the acoustic recording instrument, and $N(f)$ is an additive noise. Multiplying both sides of the equation with their complex conjugates, and taking the expectation, we obtain:

$$E\left[\, Z(f)\, Z^{*}(f)\, \right] = E\left[\, (S(f)\, H(f) + N(f))\, (S(f)H(f) + N(f))^{*} \right]$$

Assuming the signal $S(f)$ and the noise $N(f)$ are uncorrelated, the equation becomes:

$$P_Z(f) = P_S(f)\, |\, H(f)\, |^2 + P_N(f)$$

where $P_Z(f)$, $P_S(f)$ and $P_N(f)$ are the power spectra of the distorted signal, the original signal and the noise respectively. From the equation an estimate of the spectrum of the channel response can be obtained as

$$|\, H(f)\, |^2 = \frac{P_Z(f) - P_N(f)}{P_S(f)}$$

In practice, this is implemented using time-averaged estimates of the power spectra (Vaseghi 2002, 427-428).

Despite the fact that Miller is aware, at least in theory, of the non-periodic nature of many musical sounds and that he does not neglect the 'noise' component present in them – an attention which was quite unusual in his time –, at the basis of his experiment there is, however, a stationary concept of sound which is essentially based on Fourier's model of serial representation. By assuming the discrete sound spectrum of the organ as his known reference model, Miller was able to obtain the spectral correction curve with which to compensate for the distortions caused by the system, that is to say the inverse of the frequency response function of the acoustic reproduction system, in the above-said conditions of stationarity. It is a laboratory study on the analyses of sound provided by the Phonodeik technology. The paradigm of substantial reversibility of sound phenomena is fully reflected in the classical harmonic analysis. Yet, beyond all epistemological considerations, for however important and illuminating it is on the technology of the time, Miller's study cannot be immediately generalized; the field of restoration cannot, in fact, be limited to scientific knowledge verified in a laboratory, but must confront itself with a wide array of industrial products. If we consider that the amplitude of the distortions produced by the acoustic recording systems can vary from one recording to the other, it is easy to understand how the deconvolution of the acoustically recorded sound implies the acquisition of technical data on the horn and diaphragms used for every single recording. This requires a very vast knowledge of the equipment and of the industrial patents, from which to derive the information on the transformations undergone by the true sound in passing through the mechanic filtering of the recording system. To this data we must add the historical reconstruction of the operational situations in which the recording engineer worked: the positions of the horn at the time of the recording, the type of musical instruments involved, etc.[13]

Brock-Nannestad's methodology can be summarized in a few words: «the desired signal from a record is only one part of all the information it contains and the ancillary information is very important because it determines the quality of the desired signal that may be obtained, if you know how to use it» (Brock-Nannestad 1997, 3). This approach has some similarities with the orientation of genetic criticism that seeks to identify the production process of a composition not only through the texts but also through explicit and implicit metatexts. Since audio recording, like any form of writing, cannot reproduce its own movement – that is to say the act of recording itself (this can only be done by including other recordings) – Brock-Nannestad wants to achieve the goal of the 'true sound' studying not only the recorded message but also the operating modes of engraving systems, the intentional and unintentional signals which represent the writing apparatus.

In order to be consistent and have scientific value, the restoration work requires a complete integration between the historical-critical knowledge – which is external to the signal – and the 'objective' knowledge – which can be inferred by examining the carrier and the degradations individuated in the analysis of the signal. In order to achieve such a level, we are necessarily induced to both make hypotheses on the sound and to reconstruct the historical conditions of its reproducibility.[14] Every operation of restoration is thus inevitably an interpretation of the audio document.

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13 On these issues see the historical-technical analysis by Owen, Fesler 1983.

14 Essential for a history of audio reproduction technology are Hunt 1962; Hunt 1954; Kellogg 1927; Kennelly 1923; Maxfield and Harrison 1926; Olson 1943; Seymour 1918

An interesting attempt to avoid the problem of the variability of recording systems is well represented by the pioneer works of Thomas G. Stockham, Thomas M. Cannon and Robert B. Ingebretsen (see Stockham, Cannon, Ingebretsen 1975), who in the sixties proposed a deconvolution technique in order to restore the existing sound from the distortions of the horn-diaphragm recording system. According to the authors, the analysis of a number of sample acoustic recordings shows that the sound engineers of the time were able to reduce the non-linear distortions of the recording system to the minimum. Consequently, the modeling of the recording horn system as a linear filter is acceptable.

In terms of functions, it means that the convolution of the voice waveform $s(t)$ with the impulse response of the recording system $h(t)$ defines the waveform of the recorded voice: $v(t) = s(t)*h(t)$, or with Fourier transform $V(f) = S(f)H(f)$, according to the usual input/output relationship of linear systems but ignoring the additive noise. If we pass to the logarithm, the above relation becomes: $\log(V(f)) = \log(S(f)) + \log(H(f))$.

The idea of obtaining $H(f)$ by exploiting the average properties of a consistent number of recordings made with the same equipment mainly clashes with the fact that the answer of the system $h(t)$ varies from one recording to the other. If we subdivide $v(t)$ into time intervals of the order of half a second, we obtain a consistent number of segments of the recording to be restored. In order to attenuate the errors of segmentation, we then recur to the usual windowing technique. In this way, we construct a set of intervals $v_i(t)$:

$$v_i(t) \approx [w_i(t)s(t)]*h(t) = s_i(t)*h(t)$$

or with Fourier transform:

$$V_i(f) \approx S_i(f)H(f).$$

If we pass to the logarithm $\log(V_i(f)) \approx \log(S_i(f)) + \log(H(f))$ and evaluate the average on all the intervals, we obtain the relation:

$$\frac{1}{N}\sum_i^N \log(V_i(f)) \approx \frac{1}{N}\sum_i^N \log(S_i(f)) + \log(H(f))$$

In order to obtain the deconvolution, all we have to do is remove the term:

$$\frac{1}{N}\sum_{i}^{N}\log\left(S_i(f)\right)$$

Even better, it is sufficient to figure out its real part. The authors do not think it necessary to carry out the correction of the phase distortion since the human ear scarcely perceives the variations of this parameter. The solution individuated is thus the following: «this goal is reached by processing a modern recording of a musical selection similar to the one to be restored in a manner identical to that just described. The recording mechanisms used to make modern recordings, [...] called prototypes, possess virtually flat frequency responses» (Stockham, Cannon, Ingebretsen 1975, 680).

The nullification of the term $\log(H(f))$ in the case of a prototype recording that has a flat-frequency response offers the key for isolating the term:

$$\frac{1}{N}\sum_{i}^{N}\log\left|\left(S_i(f)\right)\right|$$

which can therefore be removed by subtraction. «The basic assumption of course is that the prototype recording has the same statistical characteristics as does the original singing to be restored» (Stockham, Cannon, Ingebretsen 1975, 681). This is like saying that the recordings of different performances of the same score averagely possess the same statistical qualities.

Notwithstanding the perplexities that this hypothesis can arouse, interest remains high, even under a historical profile, for the methodological basis of this research project which employs digital processing without holding back knowledge external to the signal. As Olivier Cappé has observed: «même avec une modélisation simple de l'effet du pavillon sous la forme d'un filtrage linéaire, il est nécessaire de recourir à des informations externes à l'enregistrement pour caractériser le défaut» (Cappé 1993, 14).

The comparison between score and recording leads us to yet another consideration: the score, intended as a set of symbols, possesses a degree of redundancy superior to that of the corresponding audio signal produced by the musical performance; in fact, the acoustic content of the sounds emitted during the performance offers a very wide spectrum of information that transcends the instructions present in the notation signs.

Focus on nr. 4: from Wiener to Kalman

Let us consider some of the major developments of estimation theory preceded the introduction of the Kalman filter. Ronald A. Fisher introduced the idea of maximum likelihood estimation and this has provided food for thought throughout the subsequent years. Andrej N. Kolmogorov in 1941 and Norbert Wiener in 1942 independently developed a linear minimum mean-square estimation technique that received considerable attention and provided the foundation for the subsequent development of Kalman filter theory.

In Wiener–Kolmogorov filter theory, Gauss inference that linear equation must be available for the solution of the estimation problem is elevated to the status of an explicit assumption. As Harold W. Sorenson pointed out (Sorenson 1970, 65), there are many conceptual difference between Gauss' problem and the problem treated by Wiener and Kolmogorov. Not the least of these is the fact that latter considered the estimation problem when measurement are obtained continuously, as well the discrete time problem.

In the discrete domain, this is schematically the situation. We consider the problem of estimating the signal $\mathbf{s}_n$ from measurable data $(z_0, z_1, \ldots, z_n)$, where $\mathbf{s}_n$ and z_i are related through the knowledge of the cross-correlation functions. Assume that the estimate of $\mathbf{s}_n$, say $\widehat{\mathbf{s}}_{n/n}$ is to be computed as a linear combination of the data z_i, that is:

$$\widehat{\mathbf{s}}_{n/n} = \sum_{i=0}^{n} H_{n,i} z_i$$

The filter gains $H_{n,i}$ are chosen so that the mean-square error is minimized, that is, choose the $H_{n,i}$ in such way that:

$$M_n = E[(\mathbf{s}_n - \widehat{\mathbf{s}}_{n/n})^{\mathrm{T}} (\mathbf{s}_n - \widehat{\mathbf{s}}_{n/n})]$$

is minimized. It is known that the condition necessary and sufficient for $\widehat{\mathbf{s}}_{n/n}$ to minimize M_n is that the error in the estimate, $(\mathbf{s}_n - \widehat{\mathbf{s}}_{n/n})$ be orthogonal to the measurement data:

$$E[(\mathbf{s}_n - \widehat{\mathbf{s}}_{n/n})\, \mathbf{z}_i^{\mathrm{T}}] = 0 \qquad i = \{0, 1, 2, \ldots, n\}$$

This leads to Wiener-Hopf's equation usually written like this:

$$E[\mathbf{s}_n \mathbf{z}_i^{\mathrm{T}}] = \sum_{j=0}^{n} H_{n,j} E[\mathbf{z}_j \mathbf{z}_i^{\mathrm{T}}] \qquad i = \{0, 1, 2, \dots, n\}$$

This equation must be solved for the $H_{n,j}$ in order to obtain the gains of the optimal filter. Wiener assumes an infinite amount of data and considers the process stationary. The resulting equation were solved using spectral factorization.

In *Discovery and Invention: The Newtonian Revolution in Systems Technology*, Kalman reconstructed the theoretical path which led him to discovering the filter that was named after him:

> Wiener was a mathematician of vast intellectual culture, but he had a superficial understanding of mathematics as living and growing knowledge. As it turned out, this was also my luck. Wiener filtering (initially called "extrapolation and interpolation of time series") was formulated with impeccable mathematical precision, with some perfunctory asides in the direction of the calculus of variations but without any feeling for, any attention, even lip service, to the "big picture". I, too, was blissfully innocent of seeing the big picture. (This always takes some time). But I was not afraid to think mathematically. Soon I noticed serious flaws in Wiener's formulation.
> Two of these flaws were the following:
> 1) He took it for granted that statistical gadgets (like the time correlation function) are the right way to encode quantitative uncertainty.
> 2) He was under the impression that a system description (like the transfer function) is exactly the same as a system in a concrete physical sense.
> About the first flaw: this may have been the claim, or hope, of large-sample statistics in the early 1920s, but that hope was no longer credible 20 years later. It was absurd to think that data from aggregate statistical procedures are necessarily preferable to data from physical measurements, and equally absurd to imagine that direct processing, say, averaging, of physical data would be enough to get rid of noise.
> Nonetheless, a whole subculture, especially at MIT, arose around playing with, computing with, and examining on correlation functions. Thus, if Wiener organized his main contribution to filtering around correlation functions, he was certainly not out of the MIT mainstream. But that didn't impress me. It seemed mathematically unnatural. [...]

I took a rigidly pure mathematical point of view. I simply defined a stochastic signal source consisting of a linear system and discrete white noise, thereby "postponing" the thorny problem of how to bring in real data to validate such an abstract model. As I realized fairly soon, the thing that I have blithely postponed touched upon the core of the Newtonian revolution, except that classically the problem was dealt with only in the exact case of noise-free data (exact = noise free = nonstochastic = deterministic). My signal source was almost deterministic, a concrete system with its physical parameters given *a priori*; stochastics entered into the picture only as the white noise in the environment of the system. Wiener may have believed that statistics has already solved this problem, simply by inventing correlation functions. But correlation functions do not fit nicely into the Newtonian scheme. It is very hard to carry out the step: stochastic data → model if the stochastic data is a correlation function. Indeed, the correlation function may turn out to be the wrong kind of condensation of data when our main interest is finding mathematically natural models. This problem is still poorly understood 50 years later. [...] Now we are at the heart of the Newtonian revolution. We are asked to re-place the behavioral description (transfer function or correlation function) of a system by a mathematically equivalent real thing, a physical, explicit, realizable system. This kind of thinking was foreign to Wiener, but it was natural and easy for me. My inspiration came in part from the investigation of nonlinear systems by Nicholas Minorsky (1885–1970), Russian–American engineer/mathematician, and in part from one of my later mentors, Solomon Lefschetz (1884–1972), Moskva-born, French-educated, American mathematician, who, after the age of 70, was concentrating all his energies on reviving mathematical research on nonlinear ordinary differential equations. Starting as an MIT undergraduate, for some 10 years I had been working hard to establish for myself first the obvious relations and then the precise equivalence between transfer functions and linear vector differential equations. By the early 1960s, this resulted in a nice generalization of Newton's theorem:

Linear systems described by a transfer function matrix
⇔
linear vector differential equations
(which are completely controllable and observable).

This new theorem, although not yet in its final form when researching was very helpful in guiding me through the huge though quite straightforward exercise of redoing Wiener the right way, at the end of which was the discovery of the Kalman filter (Kalman 2003, 835-836).

Let us summarize the Kalman filtering problem and its solution. Schematically, the system considered is composed of two ingredients. Firstly we assume that the state is described by $\mathbf{x}_{k+1} = \boldsymbol{\Phi}_{k+1,k}\, \mathbf{x}_k + \mathbf{w}_k$; then that the data in the measures are related to the state by $\mathbf{z}_k = H_k\, \mathbf{x}_k + \mathbf{v}_k$; where $\mathbf{w}_k$ and $\mathbf{v}_k$ represent independent white noise sequences. The noise sequences have zero mean and satisfy the conditions of orthogonality.

An estimate $\widehat{\mathbf{x}}_{k/k}$ of the state $\mathbf{x}_k$ is to be computed from the data $(z_0, z_1, \ldots, z_k)$ so as to minimize the mean-square error in the estimate. The estimate that accomplishes this is to be computed as an explicit function only of the measurement $\mathbf{z}_k$ and previous best estimate $\widehat{\mathbf{x}}_{k-1/k-1}$. This approach leads to a recursive solution which provides an estimate that is equal to the estimate obtained by treating all the data simultaneously but it reduces the data-handling requirements. The estimate of the signal $\mathbf{s}_k = H_k\, \mathbf{x}_k$ is given by:

$$\widehat{\mathbf{s}}_{k/k} = H_k \widehat{\mathbf{x}}_{k/k}$$

The solution to this recursive, linear, mean-square estimation problem can be obtained through the principle of orthogonality. This equation system is known as the Kalman filter. The estimate is given as the linear combination of the estimate predicted in the absence of new data, or:

$$\widehat{\mathbf{x}}_{k/k-1} = \boldsymbol{\Phi}_{k,k-1} \widehat{\mathbf{x}}_{k-1/k-1}$$

and residual $\mathbf{r}_k$. Thus, the mean-square estimate is:

$$\widehat{\mathbf{x}}_{k/k} = \boldsymbol{\Phi}_{k,k-1} \widehat{\mathbf{x}}_{k-1/k-1} + K_k [\mathbf{z}_k - H_k \boldsymbol{\Phi}_{k,k-1} \widehat{\mathbf{x}}_{k-1/k-1}]$$

The gain matrix K_k can be considered as being chosen to minimize:

$$E[(\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k})^{\mathrm{T}} (\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k})]$$

and is given by:

$$K_k = P_{k/k-1} H_k^{\mathrm{T}} (H_k P_{k/k-1} H_k^{\mathrm{T}} + R_k)^{-1}$$

The matrix $P_{k/k-1}$ is the covariance of the error in the predicted estimate and is given by:

$$P_{k/k-1} = E[(\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k-1})(\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k-1})^{\mathrm{T}}]$$

The $P_{k/k}$ is the covariance of error in the estimate $\widehat{\mathbf{x}}_{k/k}$:

$$P_{k/k} = E[(\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k})(\mathbf{x}_k - \widehat{\mathbf{x}}_{k/k})^{\mathrm{T}}] = P_{k/k-1} - K_k H_k P_{k/k-1}$$

These equations form the system of equation comprising the Kalman filter (see Sorenson 1970).

To conclude, in a paper in honor of the 80th birthday of Kalman, Oleg A. Stepanov wrote:

> The engineering community still continues the debates about the relation between the Wiener and Kalman filtering algorithms. The followers of frequency domain methods, which are extensively used in Wiener filtering, insist on the advantages of these algorithms, whereas those who make use of state space techniques defend the merits of the Kalman filter. [...] An indisputable advantage of the Kalman filter is the possibility to solve problems of optimal nonstationary filtering of Markov processes for finite time. For stationary filtering problems in the steady-state mode, both approaches result in the same solution for the same problem. It is a matter of liking whether to choose this or that approach in solving these problems; the preference often depends on a school to which the scientist or engineer belongs. In the case when a researcher has to deal with stationary problems in practice, the frequency approach is definitely advantageous owing to its clearness and simplicity: in some situations it is possible to consider various combinations "by hand" without using a computer. The designers of technical systems fully realize how difficult it is to go from elegant formulas to an operable algorithm. [...] The successful implementation of this or that type of algorithms depends, first of all, on how much the chosen approach fits the problem being solved. At the same time, the possibility of implementing an algorithm depends significantly on a designer's persistence and competence. It can be said with assurance that engineers and designers who have a good command of both Kalman and Wiener algorithms have the advantage over specialists who have mastered only one of these approaches (Stepanov 2011, 104).

FOCUS ON NR. 5: TOWARD PARAMETRIC MODELS

Probabilistic Models

Musical data have some common characteristics, but they may also vary a lot from one instrument to another, or because of changing recording conditions. Statistical methods are very powerful for modeling sound sources and other entities in music because they can handle their variability. Even a single sound source produces a great variety of sounds, and it cannot be modeled deterministically. The main concept in statistical methods is that of random variables which are characterized by a probability density function (PDF).

Random variables are extremely useful in signal processing because they can model the lack of certainty about a physical phenomenon. Imagine we have a good model for some process: for example, a 'pure sine' acoustic waveform generated by an electronic instrument. A model for the pressure signal recorded is given by the following discrete time sine model:

$$x(n)= a\cos(2\pi k_0 nT + \Phi_0)$$

where $x(t)$ is the signal pressure and k_0 is the sine waveform frequency, T is the sample step, Φ_0 is the initial phase, and a is the amplitude.

It is clear that the recorded pressure signal will not fit exactly the model, and that it will deviate from it. As these deviations may have various causes (air temperature/pressure in-homogeneity, non purely sinusoidal loudspeaker behavior when emitting the sound, digital to analog conversion artifacts, etc.), it is unrealistic to model them deterministically, and a random model can be used. A possible such model is:

$$x(n)= a\cos(2\pi k_0 nT + \Phi_0)+ e(n), \text{ for n}=\{1,\dots, N\}$$

where $e(n)$ is a so-called additive random noise with a given PDF. Including this noise in the model is aimed at modeling the deviations of the recorded data from the model. In the general case, it is assumed that $e(n)$ is a stationary white noise, or *independent identically distributed* noise; that is, the noise at any time n_1 is statistically independent of the noise at any time n_2 and their

PDFs are equal. More precisely, the joint PDF of the noise samples equals the product of the PDFs of each sample. Writing the noise samples as a vector:

$$e(n)=[e(1),\dots,e(N)]^{T}, \text{ for } n=\{1,\dots,N\},$$

we have:

$$p(e)=p(e(1)),p(e(2)),\dots,p(e(N)),$$

with:

$$p(e(1))=p(e(2))=\dots=p(e(N))$$

Finally, since the noise is aimed at modeling small deviations around the sine model, it is assumed to be zero-mean. Equation defines a probabilistic signal model and directly yields the likelihood function.

Parametric Models

In parameter estimation we suppose that a random process X_n depends in some well defined stochastic manner upon an unobserved parameter vector θ. If we observe N data points from the random process, we can form a vector:

$$\mathbf{x}=[x_1,x_2,\dots,x_N]^{T}$$

The parameter estimation problem is to deduce the value of θ from the observations $\mathbf{x}$. In general it will not be possible to deduce the parameters exactly from a finite number of data points since the process is random, but various schemes will be described which achieve different levels of performance depending upon the amount of data available and the amount of prior information available regarding θ.

Generally speaking, in a parameter model, the observed data $\mathbf{x}$ are generated as a function of parameter θ plus an additive term e_n, modeled as casual error. As a consequence, therefore:

$$x_n=g_n(\theta)+e_n$$

with $g_n(\theta)$ being a deterministic function and not necessarily linear. For linear functions of the parameters it is possible to write:

$$x_n = \mathbf{g}_n^{\mathrm{T}}\theta + e_n$$

Here $\mathbf{g}_n$ is a M-dimensional column vector and the expression is written synthetically as follows

$$\mathbf{x} = \mathbf{G}\theta + \mathbf{e}$$

where $\mathbf{G} = [\mathbf{g}_1^{\mathrm{T}}, \mathbf{g}_2^{\mathrm{T}}, \ldots, \mathbf{g}_M^{\mathrm{T}}]$ (see Godsill 1998). The columns of $\mathbf{G}$ form a fixed basis vector representation of the data, for example sinusoids of different frequencies in a signal which is known to be made up of pure frequency components in noise:

$$x(n) = \sum_{m=1}^{M} a_m \cos(2\pi k_m nT) + b_m \sin(2\pi k_m nT) + e(n) \quad \text{for } n = \{1, \ldots, N\}$$

Given M sinusoids immersed in Gaussian noise, M known, the model can be represented with the parameters:

$$\theta = [a_1, b_1, \ldots, a_M, b_M]^{\mathrm{T}}$$

and with:

$$\mathbf{g}_1 = [\cos(2\pi k_1 1), \sin(2\pi k_2 1), \ldots, \cos(2\pi k_M 1), \sin(2\pi k_M 1)$$

The unknown parameters are the frequencies $\mathbf{k} = [k_1, \ldots, k_M]$, the amplitudes, the initial phases and the variance σ_e^2 in Gaussian noise.

In audio restoration, the linear self regressive model AR:

$$x_n = a_1 x_{n-1} + a_2 x_{n-2} + \ldots + a_p x_{n-p} + e_n$$

where $\mathbf{a} = [a_1, \ldots, a_p]^{\mathrm{T}}$ is the vector of the p coefficients of AR, plays an important role. It is often used for detecting and removing impulsive noises (clicks); the basic principle is that, if the signal is replaced by an impulse, since the latter is not correlated to the surrounding signal, it will cause a wider error than expected. Therefore, if the reverse filter AR is applied to an AR signal corrupted by an impulse and the output of the prediction error sequence observed, in the moment when the impulse is present, a wide value can be expected, whereas for the other values over time the error will be small.

Let us consider the model proposed by Godsill to represent the signal affected by impulsive disturbances:

$$y(t) = s(t) + d(t)v(t)$$

where $y(t)$ represents the available signal and $s(t)$ the non-noise signal. The individual click is $v(t)$ and $d(t)$ is an index function which acquires a unit value at the level of samples affected by a disturbance and zero elsewhere.

If the musical signal $s(t)$ is described as a locally stationary AR process whose input is the white noise $e(t)$

$$s(t) = \sum_{i=1}^{p} s(t-i)\, a_i + e(t)$$

The current value of the signal with discrete time $s(t)$, $t = \{1,\ 2, \ldots\}$, is shown by means of a linear combination of its p previous samples to which the term $e(t)$ of white noise is added.

Assuming that the noise signal $y(t)$ has provided a sufficiently reliable estimate of parameters a_i the following expression can be derived from the model:

$$e(t) = y(t) - \sum_{i=1}^{p} s(t-i)\, a_i - d(t)\, v(t)$$

without any disturbances $(d(t) = 0)$ is $y(t) = s(t)$ and the previous expression is simplified:

$$e(t) = y(t) - \sum_{i=1}^{p} s(t-i)\, a_i$$

which highlights that by applying to $y(t)$ the whitening filter:

$$A(z) = 1 - \sum_{i=1}^{p} a_i z^{-i}$$

It is possible to outline the trajectory of $e(t)$ which under these conditions should have the characteristics of white noise.

Parameter estimation

We assume that a random process depends in a clearly defined manner on a non-observed parameter. The problem, therefore, is deducting the value of the parameter from the observation of a certain amount of data. Given the aleatory nature of the process, the observation of a finite number of data in general will not make it possible to deduce the precise values of the parameter. Statistical science had devised several strategies for this purpose. One of the most historically successful is the method based on estimating the maximum likelihood which treat parameters as unknown constants in respect of which no *a priori* information is acquired. The observed data $\mathbf{x}$ is considered random and it is often possible to calculate the probability density function of $\mathbf{x}$ when the value of θ is known and likelihood is defined as conditional probability:

$$L(\mathbf{x};\theta) = p(\mathbf{x} \mid \theta)$$

It is worth noting, nevertheless, that in actual fact likelihood is implicitly conditional to the model chosen. Hence the maximum likelihood estimated for θ is the value of θ which results in the maximum likelihood in relation to the observations $\mathbf{x}$.

In linear models it is easy to calculate the likelihood if we know the probability density of the noise (casual errors) $p(\mathbf{e})$, where $\mathbf{e} = \mathbf{x} - \mathbf{G}\theta$. Since the Jacobian value of this transformation: $\mathbf{e} \rightarrow \mathbf{x}$ is one, then the likelihood is expressed directly:

$$L(\mathbf{x};\theta) = p(\mathbf{x} \mid \theta) = p_{\mathbf{e}}(\mathbf{x} - \mathbf{G}\theta)$$

If the elements in the vector e are taken to be independent and identically distributed (iid) and Gaussian, and if $\sigma_{\mathbf{e}}^2$ is the variance, the result is:

$$p(\mathbf{e}) = p_e(e_1), p_e(e_2), \ldots, p_e(e_N) = [1/(2\pi\sigma_e^2)^{N/2}] \exp[-(1/(2\sigma_e^2))\, \mathbf{e}^{\mathrm{T}} \mathbf{e}]$$

Therefore the likelihood $L(\mathbf{x};\theta)$ is expressed:

$$L(\mathbf{x};\theta) = p(\mathbf{x} \mid \theta) = p_{\mathbf{e}}(\mathbf{x} - \mathbf{G}\theta) =$$
$$= [1/(2\pi\sigma_e^2)^{N/2}] \exp[-(1/(2\sigma_e^2))\,(\mathbf{x} - \mathbf{G}\theta)^{\mathrm{T}}(\mathbf{x} - \mathbf{G}\theta)$$

This leads to expressing the expression of log-likelihood $l(\mathbf{x};\theta)$ (which facilitates calculations):

$$l(\mathbf{x};\theta) = -(N/2)\log(2\pi\sigma_e^2) - (1/(2\sigma_e^2))(\mathbf{x}-\mathbf{G}\theta)^{\mathrm{T}}(\mathbf{x}-\mathbf{G}\theta) =$$
$$= -(N/2)\log(2\pi\sigma_e^2) - (1/(2\sigma_e^2))\sum_{n=1}^{N}(x_n - \mathbf{g}_n^{\mathrm{T}}\theta)^2$$

The maximum likelihood is calculated by assuming that derivatives in respect of θ are equal to zero:

$$\theta^{\mathrm{ML}} = (\mathbf{G}^{\mathrm{T}}\mathbf{G})^{-1}\mathbf{G}^{\mathrm{T}}\mathbf{x}$$

Maximizing this function in respect of θ corresponds to minimizing the quadratic sum of the sequence of noise:

$$E = \sum_{n=1}^{N}(x_n - g_n^{\mathrm{T}}\theta)^2$$

This leads precisely to the known criterion for estimating the least squares.

The originality of this method, in conclusion, consists in establishing a pertinent value of an unknown variable starting from the observation of the aleatory variable. The optimal value of the parameter for a given pattern is the one which maximizes the likelihood of the pattern in question.

Jérôme Segal studied the theoretical pathway which led Fisher to paving the way for modern statistical methods. It is well known that the professor of Eugenics Ronald A. Fisher:

> Il à introduit son concept d'information, partant des problèmes concrets relatifs à l'analyse d'échantillons statistiques pris dans des cultures agronomiques. S'affranchissant de la tradition qui voulait qu'on utilise les théorèmes de Bayes comme l'archétype du raisonnement inductif formalisé. [...] Le problème que se pose Fisher dans sa publication de 1922 relève la théorie de l'estimation : il s'agit de pouvoir 'estimer' à partir des échantillons relevés, les valeurs des paramètres caractéristiques des distributions de probabilité d'une population hypothétique (par exemple pour le calcul de paramètre m et σ d'une loi normale). Il propose dans ce cadre un 'traitement quantitatif de l'information apportée par un échantillon', qui, s'il ne s'applique pas encore à tous les cas, permet déjà des applications dans les choix des courbes d'erreurs qui permettent de considérer l'échantillon comme étant le plus

> représentatif possible de la population envisagée. Le qualificatif 'pertinente' ('relevant') qu'il utilise pour qualifier l'information que l'on cherche à isoler dans la masse des données est à rapprocher de son intérêt pour la génétique qui l'amène, dés 1918, à étudier les 'relevant genes'. [...] [Fisher] utilise souvent l'expression 'relevant genes' pour préciser les gènes qu'il convient de conserver dans les générations successives pour parvenir à 'les améliorations de la race', but première de tout eugéniste, qu'il s'agisse d'un eugénisme positif favorisant les meilleurs éléments d'une population au d'une eugénisme négatif empêchant 'les moins apte' de se reproduire. Dans sa publication de 1925 consacrée à la 'Théorie de l'estimation statistique' Fisher reprend son travail sur la notion d'information, il donne d'abord un exemple de calcul d'une quantité d'information dans le cas de deux estimations différentes du paramètre σ d'une loi normale à partir d'un même échantillon de n valeurs observées (Segal 2003, 34-36).

Philosophy of Bayesian Method

Godsill and Rayner say:

> Recall that ML methods treat parameters as unknown constants. If we are prepared to treat parameters as random variables it is possible to assign prior PDFs [probability density function] to the parameters. These PDFs should ideally express some prior knowledge about the relative probability of different parameter values before the data are observed. Of course if nothing is known *a priori* about the parameters then the prior distributions should in some sense express no initial preference for one set of parameters over any other. Note that in many cases a prior density is chosen to express some highly qualitative prior knowledge about the parameters. In such cases the prior chosen will be more a reflection of a degree of belief [...] concerning parameter values than any true modelling of an underlying random process which might have generated those parameters. This willingness to assign priors which reflect subjective information is a powerful feature and also one of the most fundamental differences between the Bayesian and 'classical' inferential procedures. For various expositions of the Bayesian methodology and philosophy. We take here a pragmatic viewpoint: if we have prior information about a problem then we will generally get better results through careful incorporation of that information. The precise form of probability

distributions assigned *a priori* to the parameters requires careful consideration since misleading results can be obtained from erroneous priors, but in principle at least we can apply the Bayesian approach to any problem where statistical uncertainty is present.
Bayes rule is now stated as applied to estimation of random parameters θ from a random vector $\mathbf{x}$ of observations, known as the posterior or *a posteriori* probability for the parameter:

$$p(\theta \mid \mathbf{x}) = \frac{p(\mathbf{x} \mid \theta)\, p(\theta)}{p(\mathbf{x})}$$

Posterior probability

Note that all of the distributions in this expression are implicitly conditioned upon all prior modeling assumptions, as was the likelihood function earlier. The distribution $p(\mathbf{x}|\theta)$ is the likelihood as used for ML estimation, while $p(\theta)$ is the prior or *a priori* distribution for the parameters. This term is one of the critical differences between Bayesian and 'classical' techniques. It expresses in an objective fashion the probability of various model parameters values *before* the data $\mathbf{x}$ has been observed. As we have already observed, the prior density may be an expression of highly subjective information about parameter values. This transformation from the subjective domain to an objective form for the prior can clearly be of great significance and should be considered carefully.
The term $p(\theta|\mathbf{x})$, the posterior or *a posteriori* distribution, expresses the probability of θ given the observed data $\mathbf{x}$. This is now a true measure of how 'probable' a particular value of θ is, given the observations $\mathbf{x}$. $p(\theta|\mathbf{x})$ is in a more intuitive form for parameter estimation than the likelihood, which expresses how probable the *observations* are given the *parameters*. The generation of the posterior distribution from the prior distribution when data $\mathbf{x}$ is observed can be thought of as a refinement to any previous ('prior') knowledge about the parameters. Before $\mathbf{x}$ is observed $p(\theta)$ expresses any information previously obtained concerning θ. Any new information concerning the parameters contained in $\mathbf{x}$ is then incorporated to give the posterior distribution. Clearly if we start off with little or no information about θ then the posterior distribution is likely to obtain information obtained almost solely from $\mathbf{x}$. Conversely, if $p(\theta)$ expresses a significant amount of information about θ then $\mathbf{x}$ will contribute less new information to the posterior distribution.

The denominator $p(\mathbf{x})$, sometimes referred to as the 'evidence' because of its interpretation in model selection problems [...], is constant for any given observation $\mathbf{x}$ and so may be ignored if we are only interested in the relative posterior probabilities of different parameters (Godsill, Rayner 1998, 73-74).

Choice of priors
One of the major criticisms levelled at Bayesian techniques is that the choice of priors can be highly subjective and, as mentioned above, the inclusion of inappropriate priors could give misleading results. There is clearly no problem if the prior statistics are genuinely known. Difficulties arise, however, when an attempt is made to choose prior densities to express some very subjective piece of prior knowledge or when nothing at all appears to be known beforehand about the parameters. In many engineering applications we may have genuine prior belief in terms of the observed long term behavior of a particular parameter before the current data were observed. In these cases there is clearly very little problem with the Bayesian approach. In other cases subjective information may be available, such as an approximate range of feasible values, or a rough idea of the parameter's likely value (Godsill, Rayner 1998, 78-79).

Focus on nr. 6: Restoration actions and restorer's responsibilities

In the world of audio recording a restorer has to deal with documents (items such as cylinders, disks, tapes, movie soundtracks, etc.) whose contents are not immediately apparent; on the contrary they are totally illegible, silent and unusable without the relevant reproduction equipment. What analogies can be then established between the world of audio restoration and the other fields of restoration and retrieving documents from the past?

Regardless of the formats and technical solutions, generally speaking an audio document can be regarded as a propagation channel, that is to say the medium to transmit over time (and space) any information produced by a sound source: sound and voice are recorded onto a carrier in the form of an audio signal and/or data, with the addition of printed (or written) information regarding the content, format, technique used, provenance, recording date, etc.: the carrier is often kept inside casings which include texts, graphics and notes referring to both the content (metadata), and to the production technique. The external review of the document, therefore, is an essential instrument, also for the audio restorer as well as for the historian and philologist, to be applied to the new writing medium, where the opposition between right *vs* wrong is replaced by signal *vs* noise.

The audio track serves the purpose of recording the energy of acoustic waves which is transformed through a transduction process into mechanical and/or electro-magnetic energy. The system completes analog encoding of the source for optimal use of the material recording carrier configurations with a view to including the largest possible amount of information units. An example of this are analog equalizations designed to underscore weak-intensity high frequencies to make sure that they could be distinguished from that of the noise on the recording carrier. The audio track is thus a representation of the signal which is intended to be transmitted and stored over time, which is coded in order to improve the signal/noise ratio. There are two possible interpretations, dual in nature, of the noise phenomenon. If the signal is considered in relation to the sound source, the noise is a degradation, either local or global, of the recorded signal; on the other hand, if we consider the signal in respect of the system and of the recording process, noise can be regarded as an uncontrolled signal. With this duality in mind, it is possible to schematically outline various types of noise:

- N_s (system noises) divided in turn into two groups: a) N_{sr} noise introduced by the recording system during the transduction process of the source and/or signal coding; these are usually signals and distortions of the sound source, intrinsic to the mechanical or electro-mechanical structure of the system. They are calculated according to the system's own tolerance levels; b) N_{se} noises and distortions produced by the signal recording equipment, circuiting, signal amplification systems, impedance levels, etc. In the case of electronic music the source partly already appears as signals generated according to synthesis models, filtering, modulations, etc. Mention should also be made of what could be called 'montage' noises, which are of the utmost importance with regard to the composition process.
- N_x (external noises) introduced into the recording by the external environment: these signals are often hard to detect; they might corrupt the signal to the extent that equipment, electric connections and audio recording cables have not been sufficiently screened and protected from electro-magnetic interferences: signals introduced by external air conditioning systems, voltage fluctuations and high noise levels of the power grid. Also these noises, in most cases, are not intentional and may depend on the technology used.
- N_e (errors) and N_f (faults) are noises produced by unexpected alterations in the system: recording errors and production faults which prevent symmetric scanning of recording/reading processes. N_e and N_f are noises which could have been avoided if the recording had been made with the accuracy allowed by the available technology at the time.

Mention should also be made of transmission channel noises, that is to say the output of the production system, the audio document in charge of recording diffusion:

- N_c (transmission channel): noises caused by the nature of the materials and by any carrier/recording channel faults. The material nature of the carrier, for example, is the cause of the broadband background noise. In the case of tapes, the sources of noise found at the moment of recording include: 1) broadband noise caused by the discretization of magnetic particles; 2) modulation noise, caused mainly by imperfections in the magnetic macro-domains and whose width is related to that of the recorded signal; 3) *crosstalk*. These noises do not have an absolute value because they depend on the technology used at the time the document is produced.

Then there are noises introduced by the document transmission process:

- N_t (transmission process): noises due to deterioration, alterations, faults, deformations of the document during the transmission process which brought it to us. N_t depends, therefore, on the history of each specimen.

The track recorded onto the carrier is thus the analog reproduction of the recorded signal and of the elements which perturbed the document's history.

Finally, it is also necessary to consider the noises introduced by the systems set up to read the document and recode the signal:

- N_r (re-mediation system): these are all signals and noises intrinsic to the mechanical and electro-magnetic structure of the equipment used for reproduction purposes, as well as A/D conversion noises, for example sampling, quantization and reconstruction of the signal.

The S_{tr} signal, when it reaches us, consists of the transduction and coding of the source S, plus the system noises to which noises are added due to faults, errors in recording, external noises, noises from the carrier and those introduced by the document transmission and re-mediation process:

$$S_{tr} = S \oplus N_s \oplus N_x \oplus N_e \oplus N_f \oplus N_c \oplus N_t \oplus N_r$$

The symbol $\oplus$ indicates that, generally speaking, the sum of noises cannot be regarded as a normal addition of signals: it often happens that the various noises have become stratified in a way which is complex and not at all linear. The nature of the noises has been intentionally described in a schematic manner to allow the restorer to work on objectively articulated factors.

1) Responsibility for decoding the analog signal S_{tr}

The first task of the restorer is to analyze the signal, identify the coding and physical characteristics of the recording carrier which made it possible to differentiate the information units.[15] It is therefore necessary to set up a system to read the document which is able to decode the signal, correctly compensate all intentionally introduced alterations during the encoding phase of the analog signal (equalization, noise reducers, etc.), then extract the audio information, measure and control the data acquisition process.

During this phase decisive choices are made for the future of the document, because the track is read in a cultural and technological setting which differs in many respects from that of the time when it was originally recorded. The restorer works on the synchronic reality of the document, but in setting up the reading equipment considers the diachronic reality of the technology of the production system. Therefore recognizing the original format and selecting the reproduction/listening equipment are crucial: it is necessary to ensure access to the original track compatible with the historical production/reproduction system of the original document. The reproduction system chosen must be able to extract the whole frequency band of the recorded signals, as well as acting as measurement tool and check the reproduction parameters. There are several factors involved here: running speed of the tapes or rotation of the disks, selecting the number of channels (monophonic, stereophonic, quadraphonic), the equalization curve.

A review of sources also necessarily requires recognition and analysis of the (ancillary) signals introduced during the recording phase by the production system itself; the latter need to be preserved during transfer onto the new carrier. It thus becomes apparent that an essentially synchronic view typical of communication and enunciation theories is conceptually insufficient. The historical distance, the diachronic moment, cannot be underestimated exactly in order not to betray the fundamental task for correctly

15 According to John Pierce by coding and encoder reference is made to any signal transduction technique for the signal in a form suitable for transmission. The encoder is a microphone and thus, by symmetry, the loudspeaker is regarded as a decoder. Nevertheless, reference is traditionally made more frequently to signal transducers and intentional alterations, which include the forms of equalization, the types of noise reducers, etc. (see Pierce 1961).

interpreting a signal: the restitution of that 'period of time' which the recording had created.

There are two 'filters' involved in the reading of a document: technology and history. Both of them add new information about the history of the recording and analyzing the document. This is why a restorer needs to be extremely knowledgeable as regards historical systems, laboratory record production practices, as well as the ability to detect specificities in each document specimen.[16]

The responsibility of the restorer during this phase involves a second aspect: identifying forgeries. Thanks to technical skills it should be possible to verify, within certain limits, whether a document – for example a tape – has been tampered with, and the signal intentionally altered with a view to modifying or indeed even forging the original recording.

In philology the word authenticity specifically refers to the relationship between a text and its author; this relationship may be certain and documented, or alleged and to be verified (or impossible to prove). Equivalence in terms of audio requires the ability to trace back the specimen to the issue by a specific record house (which chose the performer), to recording at home or in a studio, etc. All this requires knowledge of the repertoires and catalogs of the record editions and of production organizations.

16 The phenomenology of document transmissions shows that generalizations ought to be avoided: each document has its specific features, and the definition of an ideal standard regardless of the carrier and analysis of the recording would lead to unacceptable compromises from the point of view of preservative restoration ethics. The amount of information contained in a document, apart from the meaning of the message it contains, is associated with the recording system used. This is what George Brock-Nannestad highlighted when he openly criticized the statistical approach to the definition of algorithms for noise reduction. The Danish sound engineer remarked that the noise intended to be removed is actually an integral part of the information contained in the document; every recorder, in actual fact, adds to the signal a set of secondary information specific to the system. The more refined and complex the instruments and interventions involved in the recording process become, the more technical information is included in the document; as a consequence it becomes more difficult to select the compensations to be introduced in the signal if insufficient documentation is on hand. From this perspective it is essential to extract from the signal the ancillary information related to the noise N_s introduced by the recording equipment and techniques, then compare these data with historical information about the audio document and recording system used to produce it (see Brock-Nannestad 2001).

2) Transferring a signal $S \oplus N_s \oplus N_x \oplus N_e \oplus N_f \oplus N_c \oplus N_t$ from the analog to the digital domain

The transfer from one *medium* to another through digital encoding, which is being widely used today for the purpose of making it easier to use documents, can be in fact regarded as the equivalent of a genetic change. The question is not reproducing the specimen of an issue,[17] for example by producing a copy which is as faithful as possible of a record of which one has the matrix or a counter-type, an operation which is done in the media field itself, but rather re-writing the signal contained in the original document (source specimen) onto another carrier designed for another coding and reproduction system. It is a form of re-mediation which needs to meet the constraints of analog coding and the technological conditions of new systems which carry new listening modes. To quote Michel Foucault, A/D re-mediation involves a change in materiality of the order of institutions, as well as the possibility of re-writing and transcription itself because it places the signal within very diffident diffusion environments: just think for example of the way in which recordings are used on the Internet.

This audio transfer process from the analog to the digital domain already outlines further responsibilities. First of all, from a technical perspective, the A/D conversion transforms the representation of a signal from continuous to discrete: the degree of accuracy with which the values of signal amplitude (quantization) are read and the sampling frequency used affect the faithful restitution of the original.[18] To carry out these operations, knowledge about the new encoding and recoding forms is required.

17 The passage from one *medium* to another opens up a set of extremely different issues than those related to producing a physical copy of the document. In the case of documents which are rare samples of phonotypical editions, duplication, for example of records, has been widely adopted. Before the introduction of digital coding, recording houses themselves, if they decided to re-edit an old issue and did not have any specimen available, nor had they kept the recording matrix, referred to national libraries for a specimen from which a counter-type could be extracted, and thus publish new editions or issues.

18 As is well known, the Harry Nyquist and Claude E. Shannon theory subordinates the possibility of exactly reconstructing a signal starting from its samples to the condition that the sampling frequency should be greater than or equal to double the extension, strictly limited, of the signal itself. This is why, with A/D conversion systems, the signal is subjected

The transfer of the original document separates the document itself from its original materiality. What is needed, therefore, is a re-collocation which preserves the audio data set and all the information included in the earlier document. It is essential to take photographs of the documents (for audio tapes a video needs to be made of the tape while it is running, while for the record surfaces it is necessary to take pictures of microscope scans), casings, labels, booklets, notes, etc. In the future these data might allow for a reconstruction of the document's identity.

The integrity and identity of the document are entrusted to the restorer who delivers into the hands of the librarian the document in its new carrier and format. Apart from collecting all documentary information to allow for its identification in the new format, the restorer needs to conduct technical checks as to the integrity of the file.

3) Documentary restoration: the restitution of $S \oplus N_s \oplus N_c$

The preservative copy of a document which is produced for filing purposes includes the transcription in digital format of S_{tr}; the restorer, when producing it, shall have to make sure that the signal is pre-filtered in order to avoid what is known as *aliasing*; then the sound fabric compromised by the perturbations incurred during the creation and the transmission of the original document needs to be reconstructed by retrieving the $S \oplus N_s \oplus N_c$ signal. In the case of gramophone records, for example, the S_{tr} signal will thus be filtered by acquiring the passing bandwidth of the original carrier; the it will be treated in accordance with the constraints defined by the historical recording systems. These operations are carried out using the resources provided

to pre-filtering during the acquisition phase which makes sure that the bandwidth is limited. This is indeed one of the reasons why sound engineers usually recommend high sampling frequencies, 96 kHz or above, which make it possible to treat, without producing any reconstruction errors, signals with a band frequency of 48 kHz at least. This strategy meets the idea of preserving, in preservative copies, any ancillary signals intentionally introduced in high frequency regions of the recording (for reasons related to inertia in the systems and thus to coding, e.g. tape bias). These signals, in turn, can produce unintentional inter-modulations, which means that the pre-filtering also affects N_s.

by the audio signal processing systems; they aim at retrieving a signal which is as close as possible to the original which might have been affected, in some circumstances, by unintentional alterations.

The restitution of the signal depends on the ability to detect and resolve any corruption issues caused while the document was being produced and transmitted, then compensating the effects on the signal of faults, defects and noises in excess of the original recording system's tolerance levels. Considering, therefore, its constraints and the historical conditions in which the recording took place, whenever possible, any random errors can then be corrected.

4) The true (new) sound of the artist

Documentary restoration is the basis for digital documents adjusted to the new media environment which requires different audio quality levels. This operation alone, however, is not sufficient for dissemination of the composition: the latter needs to be supported by means of new signal replications. In this case it is fair to say that the documentary access copy ensures long-term saving of the message.

In order to listen to a documentary copy it is necessary to have digital reproduction equipment; this leaves substantial space open for interpretation, which might also involve sound direction/projection techniques, because the decoding forms used to transform the electric signal into sound and the diffusion systems are indeed different and subject to change.

Within this framework the restorer might be faced with the issue of whether more incisive signal processing work is appropriate, over and above the constraints posed by the historical reproduction system; this means deciding whether the true objective is recreating the 'true sound of the artist' without system noises, or stating the viewpoint that the message from the source, once captured and incarnated in the physicality of the channel (carrier) is bound to maintain the condition imposed by a certain technology, so that documentary approach limitation are impossible to overcome.

In the first instance reference is made to a reconstructive approach, and the production of the document is considered from the point of view of intellectual and material responsibility: the restorer attempts to recreate, also by studying the origin of the record or of the electronic music, the corresponding sound fabric which is as close as possible to the author's intention, or – with regard to records – of the performers. In practice this is done by *collatio*, based on the study of documents from the same record production, or in the case of electronic music by comparing the different sources. It is a working model deeply rooted in critical editing where the authorial value of the 'work' is particularly strong. In the audio area Storm was the first to hint at reconstruction. In the 1980s the reconstruction pathway was rough from an operating perspective; today, on the contrary, it seems possible, thanks to the digital processing of sound which allows both for reconstruction of the recording from parts of different documents of the same edition, and for de-convolution and re-synthesis work based on models.

With regard to the restorer's responsibility in relation to the algorithms dedicated to audio disturbance removal, the general assumption is that they are not neutral: they derive from one of the many possible sound modeling forms and are subject to the degree of relativism typical of similar researches. Contemporary technology, in actual fact, releases signal processing from the model seen as physical representation of reality. In most applications the mathematical model serves the purpose of providing a synthetic template which includes the dynamic and statistic characteristics for signal description: almost always mere mathematical descriptions of the signal trajectory observed; sometimes this can be an advantage, nevertheless it is never indispensable to attribute to them some physical interpretation, more or less mediated (see Picci 2003). It is without doubt an effective approach, especially when the signal model is known; in the case of historical documents, however, it is a strategy which leads the restorer beyond documentary truth. Proceeding by models entails a substantially pragmatic view of knowledge, where the 'subjective' responsibility of the restorer is involved. Nevertheless it should be underlined that today commercial audio restoration tools are 'closed' and predefined and allow us to operate even with a substantially reduced degree of awareness as to the algorithms underlying the software used. With the software becoming more and more complex, the weight of increasingly abstract data has also grown; as a consequence operability may be guaranteed provided that simple interfaces or communication protocols are defined. Any restorer working with new restoration software needs to rely not only on the ear of a musician but, even though the specific tasks involved computer programming are not called for here, consideration heeds to be given to the responsibility of knowing exactly what is being done when using a certain tool; otherwise the old *adage* applies according to which *qui facit quod non sapit diffinitur bestia.*

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Part I
Composers and Media

A Babel in music

Research on musical language and electronic means in the incomplete Oratorio *Spiritus Intelligentiæ Sanctus* by Ernst Krenek

Luca Cossettini

The purpose of this essay is to show that, in terms of contents and the historic time when it was composed, *Spiritus Intelligentiæ Sanctus* for two voices, narrator and electronic sounds (1956) by Ernst Krenek[1] belongs to an extremely significant period within the author's composition approach trajectory: its being incomplete is a clear sign of the linguistic-musical crisis which the composer was experiencing at the time, of the irreconcilability between the moment of abstract formalization and that of being confronted with production media which – in just a few years' time – would be revolutionizing the way of thinking and producing music.

PREMISES

The idea of writing a Pentecost Oratorio had occurred to Krenek at the end of the 1940s. The first drafts of a text[2] and of the work's structure can be found in the journals of that period. These documents bear witness to how difficult it was to conceive this Oratorio. There is even a sense of frustration, possibly due to the intrinsic limitations of acoustic means, revealed by Krenek

1 The work can be listened to on the original LP edition by Deutsche Grammophon (Ernst Krenek, Gottfried Michael Koenig, *Spiritus Intelligentiae Sanctus*, Klangfiguren, Deutsche Gammophon, Hannover, 1958, LP 16134) or on bootleg CD collections dedicated to electronic music. A copy of the tape filed with the publisher UE (Vienna) is kept at the Krenek Archive in Krems an der Donau.

2 It is possible to view the sketches kept at the Krenek Archive. Here we find a series of references to Bible verses ordered by topic and transcripts from the Bible in English and Latin.

himself in a paper called *In 1954*, written in 1976 for the Mexican journal *Talea* (Krenek 1976). Musical construction was thus late in taking shape; at the same time the author became convinced that the sounds he envisaged to express the deep religious feeling of the composition could not be found in traditional musical instruments.

In the autumn of 1955 Krenek was able to visit the Studios of Westdeutscher Rundfunk (WDR) in Cologne, having received funding with the help of Herbert Eimert. It was his first encounter with electronic music technologies, but the disclosure of the possibility of the electro-acoustic medium was a fundamental turning point in his project: «I knew immediately that this was the medium in which I should be able to realize what I had imagined for my oratorio» (Krenek 1976). He stayed in Cologne until the spring of 1956: this gave him barely enough time to complete the first section of his Oratorio *Spiritus Intelligentiæ Sanctus*. Although incomplete, the work was broadcast on the 30th of May 1956, together with *Gesang der Jünglinge* by Stockhausen.

Krenek approached electronic music after a long theoretical reflection. Already in 1937, in *Über neue Musik* (Krenek 1937), the composer had expressly raised the issue of the legitimacy of new language forms in music; his theory was based on logical-mathematic concepts. After the Anschluss he emigrated to the United States where he was able to review and analyze this concept in depth, leading to the drafting of *Music here and now* (Krenek 1939), which included the ambitious project of a general theory of music to encompass all sound languages of any kind, using conceptual tools derived from mathematical thinking. Starting from non-Euclidean axioms, following the rules of logical inference, it had become possible to develop new geometries, and theoretical physics was thus able to observe the external world deriving its interpretation from *a priori* formal assumptions; in the same way also music could return to being a science halfway between mathematics and physics. Having been freed from the nineteenth-century naturalist approach, musical languages could now follow Hilbert's assumption: axioms are not eternal truths but rather free propositions of the human mind, which only require properties of independence and compatibility. It is exactly through *Foundations of Geometry* by Hilbert (Hilbert, Bernays 1934 and

Hilbert, Bernays 1939)[3] that Krenek reaches the turning point which is suitable, by analogy, for establishing a general theory of music.

According to Hilbert:

> We imagine three distinct categories of things. The things in the first category we shall call points and designate by A, B, C…; the things in the second category we shall call straight lines and designate by a, b, c…; the things in the third category we shall call planes and designate by α, β, φ… We conceive of these points, straight lines, and planes as having certain mutual relations which we indicate by means of such words as 'are situated,' 'between,' 'Parallel,' 'congruent,' 'continuous.' The exact, and for mathematical purposes complete, description of these relationships is achieved through the axioms of geometry (Hilbert quoted in Krenek 1939, pp. 205-206).[4]

The general theory of music, in Krenek's opinion, could start as follows:

> We *imagine* three different categories of things. The things in the first category we shall *call* tones, the things in the second category chords, and the things in the third category melodies. We *conceive* of the tones, chords, and melodies as having certain mutual relationships which we *indicate* by means of such words as 'high', 'low', 'interval', 'consonance', 'dissonance', 'contrary motion', 'inversion', and so forth (Krenek 1939, 206).

3 Probably, when he formulated for the first time his axiomatic theory about music in *Über neue musik*, Krenek was not aware of the mortal blow inferted six years earlier (1931) to Hilbert's program by Kurt Gödel with his Incompleteness Theorems; he was also possibly not aware of the fact that Wittgenstein, at the end of the 1930s had gone beyond the reflection phase which culminated with the publishing of the *Tractatus logico-philosophicus*; in any case the scientific and philosophical knowledge which he proved to have are undoubtedly substantial within the constantly outdated scene of musical theory studies.

4 This text does not correspond exactly to the English version. It is extremely likely that it could be an English translation by Krenek from the original in German, *Grundlagen der Geometrie*. This is by no means secondary: Krenek translates (and highlights in the following lines using italics) Hilbert's *wir denken* (i.e. thinking but also imagining) with *we imagine*. Unfortunately the Krenek archive, in the library which belonged to the composer, does not include books by Hilbert.

Here 'notes', 'chords' and 'melodies' correspond to abstract notions. In the same way as 'point', 'straight line' and 'plane', they are not real objects whose natural qualities are being studied. Based on these assumptions, to a certain extent, it is possible to organize musical language according to axioms and inference rules, leaving it free from the outside world.

Formal logic is therefore absolutely binding, necessary and sufficient for musical meta-language, whereas it is not sufficient for propositions concerning for example dissonance, inversion, etc.

> Naturally the propositions of a musical theory are also subject to general logic, since they are expressed in words and must make sense. But it is obvious that propositions about dissonances, inversions, and retrogressions need not necessarily express anything of service to music, even if they are unobjectionable from the standpoint of logic (Krenek 1939, 207).

The analogy with mathematics stops here: through formal logic it is indeed impossible to explain the poietic and aesthetic processes or how music is received. The validity of a musical system, therefore, does not exclusively pertain to its internal consistency because – by its own nature – music is independent of the language constraints of general logic; regardless of how precisely this has been developed, it needs to find confirmation within the practical sphere.

> Propositions circumscribing a musical sphere are correct only if real music can be produced on the basis of facts presented by them. That is why a concrete theory which is valid for a particular sphere cannot be constructed until a corresponding consolidated practice in the sphere is available. A system of musical axioms can never be established in theory until it has been demonstrated in practice (Krenek 1939, 207).

A reflection phase is opened as regards the crisis of formal system which can be divided into three stages. The first phase focuses on developing new composition languages which should in some way be able to deal with the crisis of the dodecaphonic system. The treatise *Studies in Counterpoint. Based on the Twelve-Tone Technique* (Krenek 1940) is the first comprehensive handbook describing composition based on the twelve-tone technique as a method formalized by Arnold Schönberg; it constitutes the final act with a great experience and the beginning of composition approaches which are pragmatic, even though they can be placed on a continuum with the historic roots of writing.

The research on the rotation principle was then applied consistently for the first time in *Lamentatio Jeremiæ Prophetaæ* for mixed chorus *a capella* dated 1940-1941; this paved the way for the second stage which found its most comprehensive expression in 1960 with the groundbreaking essay *Extents and Limits of Serial Techniques* (Krenek 1960), in whose introduction reference is made to Werner Meyer-Eppler as being the first to use the term parameter in a musical setting. These are its general principles. By 'rotation' reference is made to a procedure in which «the elements of a given series systematically and progressively change their relative positions according to a plan which in itself is serially conceived in that the changes occur in regular phases» (Krenek 1960, 211).

This principle is inspired by the Greek-Hellenistic theory, more specifically by the transposing of the double *A* octave, the 'perfect major system', onto each of the seven degrees along an ascending diatonic scale; within the complex of transposed systems (therefore linked to a specific pitch with regard to all the others), the perfect major system becomes a tone/mode. The tone/modes are thus diversified only in terms of pitch, based on which they take on an ethnic denomination (Doric, Phrygian, etc.). In the heptadic complex,[5] the common octave underscores in each of the tones/modes a different form (one of its seven possible placements of tones and semitones). Projected onto the perfect major system, the octave forms appear to be generated by rotation of the intervals (upward movement of the lower sound).

With this procedure, and infringing the obligation of complete rows of twelve tones, Krenek intended to reduce the strictness of the dodecaphonic method, although keeping to its boundaries, also in order to have the possibility of diversifying the harmonic qualities in the various composition sections. The sets obtained by rotation may not always be used in their integrity, if required by formal construction, which results in a freedom

5 The seven original tones/modes distributed across the levels of a diatonic scale within one seventh, were later increased to eight, thirteen, and finally fifteen, at a distance of one semitone each (see Cleonide 1895 and Zanoncelli 1990).

greatly exceeding the constraints of writing rules as introduced in the *Studies in Counterpoint*.

Finally, the choice of electronic music can be seen as an attempt to bridge the hiatus between formal language and the physical world of sounds.[6] As had already become apparent from the limitations of logic, the system which finds a model is a medium.

THE ORATORIO

In its original formulation, the Oratorio *Spiritus intelligentiæ Sanctus* was supposed to be a reflection about the ability to understand (*intelligentia*) divinity by means of the Holy Spirit. The project was initially divided into three separate parts:

1. The fall of Adam and Eve from the Garden of Eden because they had tasted the forbidden fruit (Gen. 1-3); the building of the Tower of Babel, punished with the subsequent confusion of tongues (Gen. 11); the Great Flood (Gen. 6-9); and Abraham's submission to God's will (presumably Gen. 17);[7]
2. the prophecies in the Old Testament about the coming of the Holy Spirit (the Valley of dry Bones in Ez. 37, the story of Saul in Sam. 11-16 and the prophecies of Isaiah in Is. 11);
3. the parts of the Gospel heralding its presence (especially John 15, 26); and finally the story told in the Acts of the Apostles about the visitation by the Holy Spirit on Whitsunday, which ends the confusion of tongues and leads to the understanding of God's word (Acts 2).

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6 The studio work was carefully prepared in advance. In the extensive correspondence between Krenek and Eimert (preserved at the Krenek Archive in Krems an der Donau), the author asks Eimert for details on acoustic and psychoacoustic phenomena, as well as on the equipment and on the sound generation and processing techniques of the time (see Cossettini 2013, 89).

7 In the sketches there is only one reference to Abraham and no mention is made of Isaac.

Krenek actually only completed half of the first part in the initial project. *Spiritus intelligentiæ Sanctus* thus significantly ends with the confusion of tongues.[8]

The final text, in a centonization process which was so widespread as to include sixteenth-century religious motets and beyond, combines non-subsequent verses and also some taken from different books in the Bible; it is circularly open and closed by the initial stanza of the anonymous liturgical hymn *Veni creator spiritus*, attributed by some to Rabanus Maurus, archbishop of Mainz in the first half of the 9th century, and generally sung at Matins and Vespers on Whitsunday. The words of this hymn frame the Biblical text within Christian orthodoxy, serving the same function as psalmody in minor doxology. The hymn, whose content is in any case referred to in its incipit, is theologically dense, devoid of imagery and uses a sometimes difficult technical terminology. The original metrics (iambic dimeter) is eliminated through the triple repetition of *veni*, symbol of the Trinity where the Holy Spirit is one of the Persons. The biblical text is suspended after the prohibition of eating the fruit from the tree of knowledge with a meditation moment – as is typical

8 For years Krenek attempted to complete his Oratorio, but unsuccessfully. He tried to start working on it again in Cologne, but failed to receive the necessary financial backing. It also seems that his presence in the German studio was not particularly appreciated, especially after the controversial paper in *Die Reihe*: the 'young generation' of European composers from the Darmstadt 'school' – first and foremost Stockhausen – did not take kindly to his criticisms and thus tried to exclude Krenek from the European musical scene. This tension often resulted in direct confrontations between Krenek and the 'younger generation', and is very clearly described by John Lincoln Stewart in his biography about the composer (Stewart 1991, 296). Just as unsuccessful proved the attempt to complete the Oratorio at the RAI Studio di Fonologia musicale in Milan. The equipment in this studio was not the same as in Cologne, but most importantly the musical environment was different. The composers who worked there (e.g. Luciano Berio, Bruno Maderna, Luigi Nono) had reached other forms of 'poetic expression', now distant from the juxtaposition between pure electronic music *vs* concrete music. Within this setting, Krenek would have been confronted with hostility against electronics reduced to serial combinatory. Krenek was probably aware of this situation and, from a letter to Berio dated 3 May 1957 (Krenek Archive, Krems an der Donau), it appears that he was by then resigned, no longer having expectations as regards the possibility of completing the Oratorio and going back to working with electronic media any time soon.

of the Oratorio form – consisting of a section from the German edition of *The Concept of Anxiety*[9] by Søren Kierkegaard:

> Unschuld ist Unwissenheit. Der Geist ist träumend im Menschen. In diesem Zustand ist Friede und Ruhe, aber es ist zu gleicher Zeit etwas anderes, welches nicht Unfriede und Streit ist; dann es ist ja nichts da, damit zu streiten. Was ist es denn? Nichts. Aber welche Wirkung hat Nichts? Es gebiert Angst.

The structure of the piece can be schematically outlined as follows: the verse from the hymn *Veni creator Spiritus* (I) includes: the story of the Creation and Fall from Paradise with Kierkegaard's comment (A), an electronic 'canon'[10] (B) and the story of the building of the Babel tower and the confusion of tongues (C). Its general form is IABCI. The characters are God (male voice), humans (rendered through the overlapping of different female voice lines), and the narrator (female voice except for Kierkegaard's comment which is left to the male voice). The hymn is sung by the female voice. The voices are always accompanied by electronic sounds.

The meaning of this work is unequivocally defined in a note kept among the composer's sketches, where we find the associations: «Creation = knowledge = death» and «Kierkegaard = innocence in ignorance». The pivotal point of the individual events is a choice whose consequences cannot be foreseen, which implies a contrast between intention and result. In the completed part there are two «positive attempts» – «eating from the tree» and «Tower of Babel» – leading to negative effects – «driven from Parad.[ise]» and «confusion»[11]. The incomplete section was expected to include decisions with positive consequences, at the beginning of the path of faith and redemption which, thanks to the Holy Spirit, would finally lighten the burden of human knowledge in the Grace of divine Knowledge. In Kierkegaard's approach, therefore, the choice between God and sin is thus the basis of his

9 *The Concept of Dread* in the first English translations.

10 The composer himself, in his theoretical writings, defined as 'canonic' the construction principles of the work and of its electronic section in particular (see Krenek 1960 and Krenek 1974).

11 From the composer's notes kept at the Krenek Archive.

work,[12] also mentioned in the title by the word *intelligentiæ* with regard to the Holy Spirit. In Kierkegaard the theory propounded in *The Concept of Anxiety* (1844) and in *The Deadly Disease* (1849) refers back to the issue of knowledge. Its symbol is Adam who, before eating the fruit, lives in ignorance: the spirit in him is as in a dream; however, exactly due to the fact that – in his state before knowledge – he is not aware of good and evil, he cannot know rationally what it means to infringe God's prohibition. It is exactly this divine prohibition that makes him aware of the possibility of choosing freely. Adam feels that there is something else, which is neither restlessness nor fight, because there is nothing to fight against: it is the nothingness before knowledge that produces anxiety. Therefore, anxiety is the condition preceding any choice and which inextricably accompanies it; it presupposes the original sin which leads to the Fall from Eden and to humans sinning. Humanity, through the experience of nothingness feels that it is a synthesis between soul and body. By lapsing into sin, however, this synthesis falls apart and humans lose their freedom, which may be regained only through repentance and redemption. Anxiety in itself does not cause good or evil, it merely accompanies the choice: between safety in God through faith, or perdition in sin, with suicide representing the definitive horror.

The quote from Kierkegaard reveals a tormented religious feeling, which carries with itself the weight of the daily renewed choice, without any solution: being limited only to its initial part, *Spiritus intelligentiæ sanctus* leaves out the blessing of Grace, the cleansing from Original Sin, actually focusing on the dramatic moment of the impenetrability of forbidden knowledge and on the unintelligibility of sin.

The question arises of what could have led Krenek, who – after abandoning it for some time during his youth – had always professed a strong faith in the Catholic doctrine, to accepting the interpretation of Genesis by Kierkegaard, considering that – as noted by the Stigmatine priest Cornelio Fabro in the translator's note at the end of the Italian edition of the text – his theory

12 At the time Krenek wrote his Oratorio, the reading of Kierkegaard was mediated by what is known as Kierkegaard Renaissance, more specifically the work by Karl Barth, Karl Jaspers and Martin Heidegger (see also Fabro 1988). Heidegger in particular mentions and reinterprets the concept of anxiety in *Die Grundbegriffe der Metaphysik*, 1929/1930 (Heidegger 2004).

about original sin deviates from the Protestant concept as much as it differs from the Catholic perspective. Kierkegaard, who in his *Deadly Disease* opposed the 'mythologizing' of Christ by Hegel's left wing followers, also reduces to a myth the biblical narration of temptation. This is clearly confirmed both by the denial that original sin is something hereditary – given that it is stated that every human being is in exactly the same condition as Adam – and by the elimination in the work of the Devil as part of temptation (see Fabro 2007). It is impossible for Krenek not to have grasped these substantial anti-Catholic and anti-Protestants elements in Kierkegaard, in general and most notably in *The Concept of Anxiety*, first of all because of his philosophical and theological knowledge;[13] also it is necessary to bear in mind that, in the fragment used, immediately after «Der Geist ist träumend im Menschen», «the spirit is in humans as in a dream» there is the comment: «this view is in perfect accord with that of the Bible, and by refusing to ascribe to man in the state of innocence a knowledge of the difference between good and evil it condemns all the notions of merit Catholicism has imagined» (Kierkegaard 1944, 37).

Krenek had become closer to the Church again towards the end of the 1930s after supporting the revolutionary left in Austria for some time[14] and as a reaction to Nazi aggressiveness in his country. Over the years he reached a religious approach which he defined as «Left-Catholic» (Krenek 1974, 42) characterized by a specific political position which he never rejected later. His approach to religion is not dogmatic, but rather based on the constantly renewed choice, in daily actions, between God and sin. Religious inspiration thus becomes dominant in his production, as part of a pathway which moves parallel to his composition technique developments: starting from *Charles V* (1933), where the events in the Emperor's life are told through the sacrament of confession (Penance) and dodecaphonic principles are followed for the

13 Krenek also started, without completing them, philosophical studies at the University of Vienna. With regard to theology and knowledge of the Bible, the composer's musical production and theory leave no room for doubt.

14 In his work of the 1920s this political position emerges clearly. An example of this is *Das geheime Königreich* (1927), where the main character is a king who, having become aware of how ephemeral power is, abdicates and retreats to a life in the forest, in communion with nature, or *Der Diktator* (1926), where the figure of Mussolini can be clearly recognized.

first time, to *Lamentatio Jeremiæ Prophetæ* (1941) where a 'rotation' principle is defined, and becoming more mature in later productions, up to *Spiritus intelligentiæ Sanctus*, where seriality is applied to the electronic medium.

His research, however, was long and tortuous, full of afterthoughts, and of fine-tuning towards a perfection level which was possibly unattainable.

THE MUSIC

On several occasions, in his writings, Krenek indeed outlined the model underlying his work (see Krenek 1960, 1974, 1976 and 1982),[15] although in some points it remains not totally comprehensible. The composition sketches at the Krenek Archive in Krems help clarify the composition mechanism and, most importantly, lead us to understanding how the author resorted to some undetermined and unpredictable aspects which are typical of the electronic medium, but found also in the serial interval rotation technique. There still remain, however, a few points to be clarified.

The religious topic in the text is reflected in its musical structure. On a melodic level, the pitches derive from the initial expansion of a three-note chord, symbolizing Trinity (Figure 1).

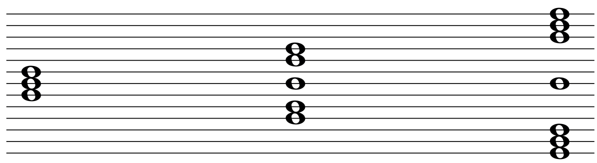

Figure 1. The musical representation of the Trinity and of Creation (processing of sketches by the composer. Krenek Archive, Krems and der Donau).

The Creation is symbolically represented by a new five-note chord, obtained by adding two notes, above and below the initial chord, which leads to an increased tension. The full accomplishment of creation is finally expressed by

15 An interesting analytical introduction attributed to the composer himself (without quoting the original source) can be found in Vlad 1958.

a seven-note chord (seven being the symbol of time and the number of gifts from the Holy Spirit), formed by adding two more notes.[16] Holding on to the central note of the 'divine' chord, expression of the Creator's love and of God's presence on earth, there emerges a system consisting of thirteen tones.

Krenek places the common central sound at a frequency of 330 Hz. He distributes the thirteen notes within the octave in order to have equal intervals ($\sqrt[13]{2}$). This scale is then transposed into different octaves to cover a frequency ranging from 30 to 7280 Hz, to which the three overtones are added at 7680 Hz, 8548 Hz and 11764 Hz, produced in the same way (Figure 2). From this basic frequency material, Krenek then extracts some heptachords which, alternatively overlapping by junction and disjunction[17] along a basis-scale, result in the system onto which music writing is developed. The system used for what the composer calls instrumental interlude in the central section of the work is explained by Krenek himself (Figure 3) (Krenek 1960, 220). In his sketches we find an application of this model to several heptatonic patterns, with an exploration of all possibilities for rotation in the series.

Along the basis-scale there is a melodic movement with seven tones, where the direction of movement and the number of 'levels' within each of its intervals remain constant: from the initial note it moves up to the subsequent third and fourth degree, goes back to the second, then up to the sixth, down to the fifth, and finally up to the seventh. The melodic series is then reproduced starting from the last sound reached; given the structure of the basis-scale, the interval extensions vary, while the general pattern remains the same. This process is based on the rotation principle because, after reproducing the melodic series thirteen times, it ends on the initial note (with the octave transpositions).

16 Krenek follows the simplest approach to traditional symbolism – where three is associated with God or the world of the spirit, two with matter, five with Creation (to include the material and spiritual spheres), six to perfection, but also to generating the universe, and seven with the Holy Spirit – without ever becoming an actual esoteric mysticism of numbers.

17 Conjunction and disjunction are technical terms in ancient musical theory. In Krenek's system the heptachords are linked by conjunction when the higher tone of the first corresponds to the lower of the second, by disjunction when between them there is an interval which is equal here to $\sqrt[13]{2}$.

30	32	33	35	37	39	41	44	46	49	51	54	57
60	63	67	70	74	78	83	88	92	97	102	108	114
120	127	134	141	149	157	165	174	184	194	205	216	228
240	253	267	282	297	313	330	348	368	388	409	431	455
480	506	534	564	594	627	662	697	735	776	818	863	910
960	1013	1068	1127	1188	1254	1322	1393	1471	1551	1636	1725	1820
1920	2025	2137	2254	2377	2507	2644	2787	2941	3103	3274	3452	3640
3840	4050	4274	4508	4754	5014	5288	5574	5882	6206	6548	6904	7280
7680		8548						11764				
1	2	3	4	5	6	7	8	9	10	11	12	13

Figure 2. The temperament in thirteen semitones of Spiritus intelligentiæ Sanctus *(table found among the author's sketches. Krenek Archive, Krems and der Donau).*

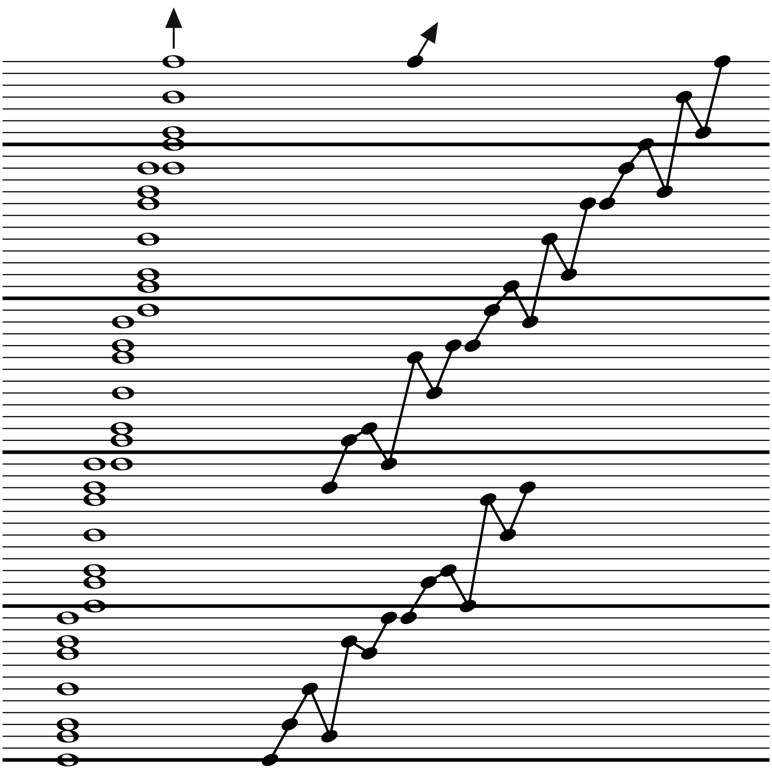

Figure 3. Rotation in the heptatonic system of Spiritus intelligentæ Sanctus.

In his paper *In 1954* the author writes that his main source of inspiration behind the canonic idea underlying the composition of *Spiritus intelligentiæ sanctus* had been the *Missa L'homme armé* by Josquin des Prez (Figure 4),[18] of which he admired mensural canons in particular: the same melodic line was followed, to different extents, changing *tempus* and *prolatio*.

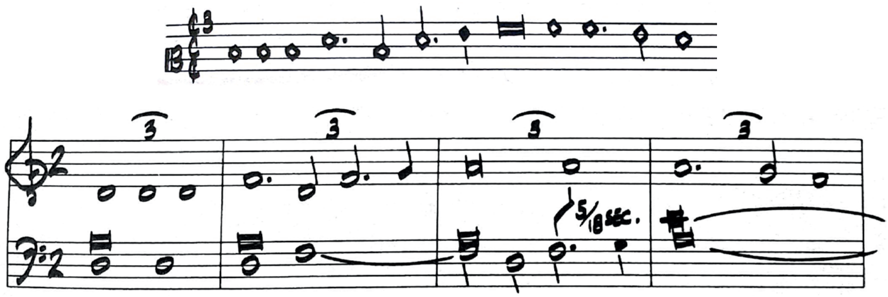

Figure 4. Ernst Krenek's transcription of Missa L'homme armé super voces musicales *by Josquin de Prez.*

It is exactly on the control of temporalities that Krenek sees the potential of electronic media: time is fixed here on the measurable space of the magnetic tape; controlled variations of the running speed on the tape recorder while recording the original materials create, during the reading phase at nominal speed, different temporalities and transpositions which can then be made to overlap with mixing techniques.

The composer's sketches there include a huge amount of calculations and breakdown tests of the work structure into basic time units. After some attempts with common denominators using the same symbolism underlying melodic material construction (more specifically the number thirteen, considered as being derived from the Holy Spirit and universe creation symbols), Krenek chose a division into eleven (the cosmos and its genesis), which – in the central section – he applies both to the meso- and to the micro-form (Figure 5).

18 Krenek studied medieval and Renaissance music for a long time during his research at Vassar College in Poughkeepsie, New York, between 1939 and 1942.

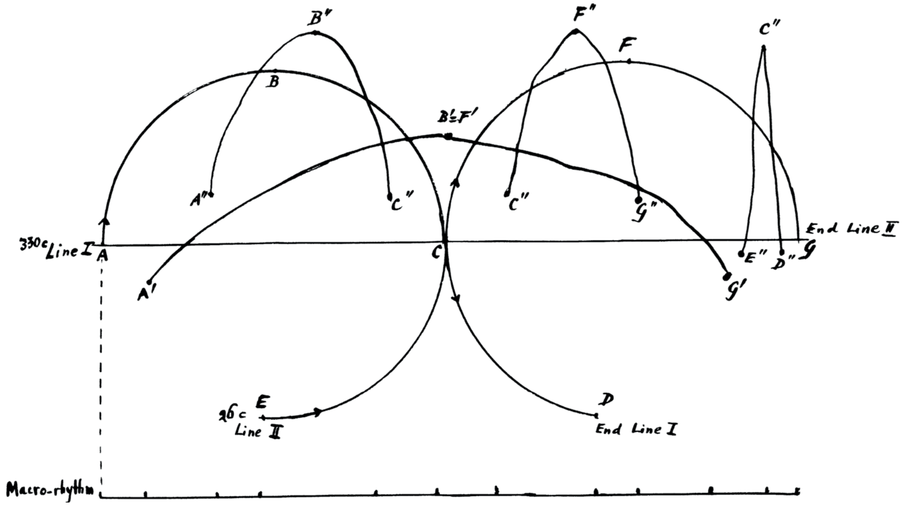

Figure 5. Canonic imitations and structuration of the time form in Spiritus Intelligentiæ Sanctus *(from Krenek 1960, 222)*

Krenek thus structures the canon into eleven basic time units, which he called «Macro-rhythm». They define the main moments of articulation: the entries of imitations between 'voices', the peaks, the intertwining points, etc. The duration of individual musical events is calculated by relating the said division within the individual segments. At meso-formal level, each voice concludes the serial rotation after ninety-one notes (13x7). In order to assign a time value to each note, Krenek repeats the time series of eleven values for eight times (88); in this way the three final notes for each voice are excluded. At micro-formal level, on the other hand, the overlapping of melodic structures with seven notes and rhythmic patterns with eleven values, sets of an intersection mechanism similar to the medieval distinction between *talea* and *color*.

The disconnection between the models used respectively for the structuring of pitch and time, researched by the author himself through subsequent tests and improvements, on the one hand dissolves the religious symbolism and on the other side allows for the concatenation and development of the meso-form which – following the division principles used for the melodic material – would have proceeded by separate and self-contained blocks.

In this way the mechanical repetitiveness of structures is excluded, without losing sight of the composition unit.

Such formalization of time structures, however, can be found only locally within the macro-form, whose construction is dictated by dramatic needs and therefore disconnected from the serial system. It does not show the same internal consistency which is found for the structuring of pitch. This is not surprising and it is evidence of the development of the composer's approach who – in his own words – started to work systematically on the expansion of serial principles to the time parameter only with *Sestina,* for soprano and ten musicians (1957).

MODEL *VS* PRODUCTION

The strict model constructed by Krenek, based on a division of the octave into thirteen notes and on the millesimal control of times, presupposes a specific approach to the electronic medium which is perfectly framed both with the author's research work regarding the possibilities of serial writing, and the place and time when he actually worked on the piece: Cologne, 1955-1956, at the WDR which he shared with Stockhausen who, exactly during those days, was composing his *Gesang der Jünglinge*. By exceeding the human performance limits, the precision of electronic media thus seemed able to fulfil the utopia of perfection in the multi-parameter control of sound and structures, the production of crystalline perfection of serial combinatoriality.[19] The history of electronic music then took other directions, in the same

19 This approach to the electronic medium is clearly expressed by the author already in his paper published in the first issue of *Die Reihe* (Krenek 1955), then confirmed and expanded in Krenek 1956.

way as Krenek himself did.[20] The first experiments[21] failed to open up the expected horizons: serialism was gradually abandoned by the world of electronics on tape, which mainly followed the pathways of acoustic research geared instead towards concepts inspired by Varèse such as 'organized sound' and 'sound masses'. The possibility of listening to the acoustic result of any music exactly at the time it is being composed, and of intervening 'live' on its sound, very soon reversed the relationships between model and production for many composers, shifting the balance from codified abstraction in writing towards a pragmatic and systemic approach. In 1955, however, Krenek still lived in that utopia and formalized a model which he would then have to adjust to the media he had available.

Designing the electronic canon was easy: the author transcribed on a sort of production score only the frequency series with their original durations; for the others he indicated the starting point, the ratio between the nominal speed of the tape recorded and the tape segment to be reproduced (for example «9:5 A bis B» or «5:9 A bis C»). The canon imitations had to

20 After *Spiritus Intelligentiæ Sanctus*, Krenek did not write any electronic music until 1963, when – in the small laboratory at the San Fernando Valley State College (now California State University, Northridge) – he produced a *San Fernando Sequence*. The composer's notes lead us to conclude that the procedures inspired by mensural canons are relegated here to just one sequence, out of the six which make up the work; in the others, Krenek paves the way for indetermination introduced by improvising and noise. Moreover, as opposed to the linear and narrative *Spiritus intelligentiæ Sanctus*, what can be noticed here is an afterthought organization of meso-formal elements which comprises, as is the case in many other composers, the discontinuity of time organization implicit in editing procedures for the magnetic tape. In later years, Krenek devoted himself to experimenting with the Buchla synthesizer. He would thus develop, with the new medium a completely opposite language compared to the one he used in Cologne; moreover, faced with an instrument with which music goes back to be performed again, he finally opted for a more performative vision of the creative action. He thus paid special attention also to the live interaction between electronic and traditional instruments. In pieces such as *Tape and Double* (1969/1970), even though there seems to be a clear and comprehensive project to structure the form in its preliminary composition phases, with regard to timbre Krenek empirically experimented with various notes and configurations of the device.

21 Which are due to Stockhausen himself, most notably with *Studie I* (1953) and *Studie II* (1954), and to a certain extent also to *Gesang der Jünglinge*.

be produced through laboratory practice, which in this case precedes and makes writing superfluous and difficult to formalize.

The pathway leading to the production of the vocal part, on the other hand, was more tortuous because the presence of the performer forced Krenek to move to traditional musical writing. The performance indications for *Spiritus intelligentiæ Sanctus* are clear: two singing voices, chorus, narrator and electronic sounds. Even though the result is then uniformed through the magnetic tape *medium*, his Oratorio can be seen as an example of what will then be called 'mixed music'. Just by listening to the piece it appears that the voice is electronically processed, but also that the latter procedure seldom hinders the intelligibility of the (religious) text. More specifically, the voice is treated with filtering techniques and, if necessary, transposed. There is no trace here, nor will there ever be in Krenek's production, of the attempt at unifying voice with electronics by studying the acoustic characters of phonemes as Stockhausen was experimenting when he composed *Gesang der Jünglinge*.

In order to understand how Krenek first interprets, then treats in a studio, the vocal part of the work, it is essential to consider the separate parts written by the composer for the singers, which were the basis for the studio recording which was then used during editing.

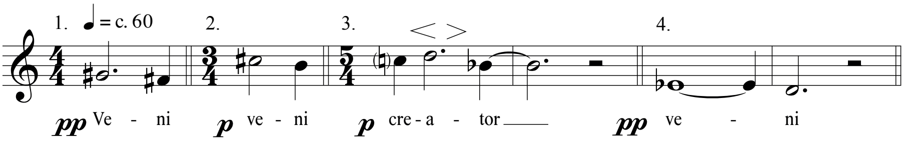

Figure 6. Abstract from the soprano part of Spiritus intelligentiæ Sanctus *(transcription of the manuscript kept at the Krenek Archive, Krems an der Donau).*

Figure 6 shows the part of the initial invocation. The first apparent element is that in traditional notation the division of the octave into thirteen equal parts is obviously lost. Moreover, the rhythm and the number of notes are dictated by the text's metric structure. The approximation of the model to notated writing in order to allow for human performance is a need which Krenek expressly stated in the case of *Sestina*. Clearly it had already been considered for *Spiritus intelligentiæ Sanctus*. How is this approximation expressed?

The set of frequencies, expressed in Hz and approximated to the closest unit in Figure 5 is as follows: 415 - 370 - 554 - 495 - 523 - 587 - 466 - 311 - 294. In the production score of the tape, instead, another set is used, which is also expressed in Hz: 409 - 368 - 534 - 455 - 480 - 594 - 431 - 1726 - 1393. These frequency values are all listed in the equal temperament table with thirteen semitones, also shown in Figure 2. There is thus an underlying model which undergoes the necessary approximation in traditional notation writing. In the electronic part production process, Krenek sometimes apparently tries to restore the model using the tools made available by technology and, more specifically, by controlling the tape's running speed. This is clear in the higher transposition of the two final notes, where the processing, given its incisiveness, becomes apparent also when listening.

Something similar can be said with regard to controlling the temporality of sound events. If you take the same notes in the part for the voice and calculate their duration in seconds with a metronome timed on ♩ = 60 (the indication is actually «about» 60) the result is: 3 - 1 - 2 - 1 - 1 - 3 - 4 - 5 - 3. In the production score, following the concept of time measurement in lengths of tape, expressed on several occasions by Krenek with regard to the electronic medium, the durations are written in centimeters. In order to return to notation in seconds, it is sufficient to divide this length by the running speed on the tape, 76 cm/s (30 ips), as was in use in the studio at Cologne. The result, not counting the rests, is as follows: 2.84 - 0.95 - 1.89 - 0.95 - 0.95 - 2.84 - 3.79 - 4.74 - 2.84. After subtracting any calculation approximations, the time series shows a highest common denominator: 0.95 s, that is to say 72 cm/s (28.3 inches). This sort of *tactus* is present throughout the work and its value varies from one section to the other; it corresponds to the minimum time unit in the model and is developed across several temporalities in the macro-form. There are two noticeable elements: a) it is always slightly faster than the metronome assigned to the separate parts of the singers, in order to materially leave room for physical processing on the tape, as a working margin; b) the duration of the notes in the detached parts is often an approximation of their duration in the production score. Whenever this is not the case, or if there appears to be a difference in frequencies, we are in the presence of electronic processing which is expressly indicated, or of a rest indicated by round symbols which also include an indication of their duration.

Not all notes are thus electronically 'adjusted' in terms of height and duration to fit this model. The reason can be found in the pervasive feature of the technology used: by changing the running speed on the tape, there are indeed changes in terms of duration and pitch introduced, but this operation leads to losing the natural features in the voice timbre, due to the shifting of formants (which becomes strikingly apparent from the processing of the penultimate sound in the example given here). Krenek was thus at a crossroads: striving towards mathematical and combinatory perfection to represent the model, or saving the voice timbre and thus the expressiveness of performance? He finally opted for the second approach.

ORDER AND CHAOS

At this point the following question might arise: how does the acoustic production of such a highly formalized model sound? It is extremely difficult, indeed at times impossible, to follow the movement of the voices while listening: «with the strange and wonderful dialectic that run through this, as though as all human endeavours, this knife-edged accuracy often sounds like the triumph of the aleatorical» (Krenek 1966, 220). This difficulty is not due exclusively to the complexity of the (long) isorhythmic treatment underlying the construction of the electronic canon. The sounds are all obtained by additive synthesis of sinusoid waves; they are thus devoid of any distinctive timbre profile, of a *Gestalt* which would make it possible to categorize them as different 'instruments'. Time values and especially frequency ranges provide valid clues for perception, especially when in these parameters the voices diverge substantially; however, during moments when the sound is denser, the impression is indeed chaotic.

Chaos is actually not in contrast with the topic of the Oratorio; the introductory function of the electronic canon to the story of the Tower of Babel and the confusion of tongues is undoubtedly a factor. In this regard it is important to bear in mind that Krenek, as highlighted on several occasions, believed in the relationship between integral serialism and chaos: already in 1954 – before *Spiritus intelligentiæ Sanctus* – in a short paper published in Germany in the journal *Melos* (Krenek 1954), he wrote that serial music is chaotic because of its complexity; this concept was then repeated in the famous paper *Den Jüngeren über die Schulter geschaut*, which appeared in the first issue of *Die Reihe* (Krenek 1955), and consistently reviewed in *Extents and limits of Serial Techniques* and in *Horizons circled* (Krenek 1974). In these essays it immediately follows the description of the multi-parameter formalizing of *Sestina*:

> If the succession of tones is determined by serial regulation […] and, in addition to this, the timing of the entrance into the musical process of these tones is also predetermined by serial calculation […], it is no longer possible to decide freely (that is, by "inspiration") which tones should sound simultaneously at any given point. In other words, the so called harmonic aspect of the piece will be entirely the result of operations performed on premises that have nothing to do with concepts of 'harmony', be it on the assumption of tonality or atonality or anything else. Whatever happens at any given point is a product of the preconceived serial organization, but by the same token it is a chance occurrence because it is as such not anticipated by the mind that invented the mechanism and set it in motion (Krenek 1960, 228).

Chaos in this case, far from being regarded as a statistical-mathematical concept, is an expression of the inability of the human mind to predict the result of devices it had invented and implemented, even in a deterministic system if the latter is too complex.[22] Krenek uses the philosophically and theologically meaningful analogy of the watchmaker who constructs a mechanism whose result cannot be predicted: in his opinion the freedom of the composer, as opposed to what is known as freedom of inspiration – which is thus nothing other than the chaos produced by phantoms of our culture – consists in the choice of a mechanism. Krenek does not choose the listener's perspective, but rather that of the author, warning that the confusion of language affects

22 In *Horizons Circled*, in 1974, Krenek points out: «except perhaps if the relevant information were fed into a computer» (Krenek 1974, 86), reference to computer assisted composition which in 1960 – the year he published *Extents and Limits of Serial Technique* – he did not know yet.

not only the receiving side but also the poietic end, thus leading to the incommunicability with which any artist is confronted.

The first electronic production by Krenek was significantly suspended at the point of the biblical episode of the Tower of Babel with the confusion of the original common language; it is thus inevitable to think about what was happening during the years following World War II in the world of musical research. The Oratorio *Spiritus intelligentiæ Sanctus*, however, in its original design was expected to end with the visitation by the Holy Spirit on Whitsunday: God thus finds a solution, at least in the case of the Apostles, for the confusion of tongues. The outcome was actually different: not even the first part of the work was completed, and in the following years the research on musical language would be following increasingly complex and diversified pathways.

Krenek belongs to a generation that cultivated the utopia of logically formalizing music and was forced to deal with the failure of the ambitious ethical-scientific project. The paper *Den Jüngeren über die Schulter geschaut* significantly underscores the difficulty in combining the past with the driving force from new technologies and original musical concepts. Krenek pursued his research in California, isolated from European avant-garde movements. In compositions such as *Tape and Double* (1970), *Orga-Nastro* (1971) or *They Knew What They Wanted* (1977) he surveyed the possibilities offered by synthesizers and mixed music, pathways which will lead him to a more pragmatic approach to composition and to give up the hope of unifying language and of overcoming the Babel confusion of tongues.

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Tracks in the deserts

Studying the electronic music by Edgard Varèse

Luca Cossettini

Edgard Varèse is universally regarded as a pioneer in electronic music. A systematic review of the sources of his studio production, however, was never completed. The reasons for this gap in literature are mainly due to the difficulty in accessing audio sources. Varèse worked in several European and American studios, at a time that can be considered to all intents and purposes the dawn on electronic music (from the mid-1950s to the mid-1960s); the audio documents of his work are scattered all over the world today.

The scenario is indeed very complex, but this is no cause for concern to a critic. The most difficult problem to resolve is that most of the audio documents are actually stored in the archives that own them and never made available to researchers, other than in their digitized version which can usually only be listened to through headphones. As I have already mentioned elsewhere,[1] these conditions make any review impossible: with no possibility, on the one hand, of using the original carrier to access all the information outside the signal transferred by the latter (presence of physical processing, writing on the casings, attachments, brands and models of the tape which allow for its dating, etc) and, on the other side, of comparing the digitized signals using software which allows for its visualization and analysis in various domains, misunderstandings are inevitable. In the same way as a philology of photocopies – where it is impossible to distinguish inks, stratifications, watermarks – is unthinkable, so is any review of audio sources based on copies whose underlying production system specifications and parameters are unknown.

1 See “The quest for *Ages*, the radio-drama by Bruno Maderna and Giorgio Pressburger”, in this book.

Another complication is due to the absence in many archives of equipped laboratories to reproduce these documents using professional systems. The reproduction of an audio document is not an acritical procedure and raises the question of the influence of interfaces on the characteristics of the item under examination. The observation and analysis tools used, the same as audio equipment and sound editing and analysis software, have an impact on the item being studied: different tape recorders, even if perfectly calibrated, will extract the audio signal in a slightly differing manner; different software and different analysis algorithms will highlight different aspects in the sound fabric, sometimes even contradictory although mutually complementary (for instance time/frequency indetermination); different diffusion systems will guide our listening towards different aspects of sound. These are always partial investigations, all of them insufficient to respond to the complexity of the world of sound recording, all of them essential to 'circle' the item under examination and provide a representation of it which is bound to be always incomplete. As a matter of fact, science has now abandoned the ideal of a unified mathematical description of the world, choosing to embrace multiplicity, circularity and the refusal of any 'meta-vantage point'. To complete a review, any critic needs to be able to access original audio documents and their copies from several perspectives, through a variety of systems and interfaces.

In our contemporary situation, where most analog sources are inaccessible, it is therefore unthinkable to achieve comprehensive critical outcomes. Nevertheless there is the need of a critical edition of electronic music by Varèse, especially for orchestra conductors and sound directors who have to do their job based on audio documents of doubtful provenance and very poor quality, and thus often give up the idea.[2] Critical edition, moreover,

2 As Jean-Claude Risset stated out in 2004: «the works of Varèse calling for electronic sounds on tape – *Déserts* and *Poème électronique* – are frequently heard in disastrous conditions, detrimental to their potential impact» (Risset 2004, 35). This problem has existed for many years; as far back as 1960 Swedish Radio wrote to Varèse to cancel a performance of *Déserts* scheduled for 22 April because it had been unable to get from Ricordi the revised version of the tapes (letter dated 6 April 1960, kept at the Paul Sacher Stiftung in Basel). Moreover, due not only to aesthetic choices but also to the quality of the audio copies, *Déserts* is often performed without electronic interpolations.

cannot be delayed for another reason: the time available for scholars is inevitably constrained by the natural physical and chemical decaying of carriers, which is already becoming apparent to an often destructive extent in many documents.

We are, however, just in the early stages of a critical-scientific culture which acknowledges the historical-documentary value of audio sources and turns to them based on the wealth of knowledge which over the past few years has made it possible to develop proven theoretical-practical models for the critical edition of notated musical works. This culture is expected to bring together in a mutual relationship the publisher, the archives, the recording studios, the researchers and also the performers to whom the musical edition is finally delivered so that they can make the work live again, always renewed within new times and new spaces.

THE TRIUMPH OF VARIANTS: *DÉSERTS*

> Louise dear,
> Deserts are done. Ovations of the music loving Paris. Stupid noise by the others, the general and dull Paris public. More and more ovations for Varèse. Storm and tempest at Champs Elysées filled to the capacity. A breathtaking masterpiece. The applause was terrific killing off the noises of the stupids. The young are with Varèse. [...] We went to several cafés after the concert. When Varèse entered and left there was applause and this contagious happiness to whom witnessed this musical event of our time. Varèse had his pockets full with telegrams.
> Now it is past 1 [a]m [...] December 3rd 1954 and I am writing these lines at the Studio d'Essay of Radiodiffusion Television Française where I accompanied Varèse. He his in the best of spirit, knowing that the world from now on will be his. He speaks of new on more work. It is thrilling to hear him this way. The world which counts – this world loves him and nothing before tonight's event must have made this known to him. Now, he is preparing to leave Paris. At 12.00 he is leaving by plane to Hamburg where on Dec 8th the conductor Bruno Maderna will play it.[3]

3 Letter by Al Copley to Louise Varèse, 3 December 1955 (Paul Sacher Stiftung – Basel).

These are the words used by Al Copley, the friend telling Louise Varèse – Edgard's wife – about the night after the premiere of *Déserts*, on 2 December 1954 at the Champs-Élysées theatre in Paris. The events are well known: also due to the daring choice of placing *Déserts* on the program between the *Overture in B-flat major* by Wolfgang Amadeus Mozart and the *Symphonie Pathétique* by Pëtr Il'ič Čajkovskij, its performance created a memorable scandal (see Mathieu 2004). On the audio recording of the concert (Scherchen 2006), apart from the encouraging applause from supporters, Copley's 'youngsters', shouts and catcalls are clearly audible from the rest of the audience, which was apparently particularly upset by the electronic interpolations. The music is drowned by them. Any attempt of playing louder than the shouts by increasing up to distortion level the volume of electronic parts – which were being diffused by Pierre Henry – merely caused an outbreak of laughter and clearly annoyed disapproval. Nevertheless, according to Copley, after the concert Varèse was «in the best of spirits»; his mind was full of ideas for new work. Such a 'loud' reaction by the audience was probably one of the reasons leading Varèse – that same night – to visit the Radio France Club d'Essai studios to work on the electronic interpolations, with a view to changing them, thus embarking on revision work which would last for the rest of his life. The day after the premiere Varèse left for Hamburg with some tapes under his arm. That was where he met Bruno Maderna who conducted *Déserts* for the first time on the 8th of December.[4] This was the first chapter in a human and artistic set of events which led to a tradition of audio sources which is probably one of the most complex in electronic music history.

4 Varèse took part in the rehearsals of *Déserts* with Maderna. On that occasion he also met Stockhausen, whose *Kontra-Punkte* was part of the concert program. It is possible that Stockhausen himself might have worked on the sound direction for electronic interpolations. Maderna performed *Déserts* for the second time in Stockholm, on 13 December. Varèse had already returned to Paris, though, to record his famous interviews with Georges Charbonnier (published on CD by INA – Institut national de l'audiovisuel di Radio France – with the recording of world the premiere of Déserts. See Varèse 2007).

A modern quest for the Holy Grail: the 'original' version of Déserts *interpolations*

To date, during the research which I have been conducting for several years on *Déserts*, I have found more than thirty audio documents of electronic interpolations, 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. It is also worth mentioning the resources from private archives of all the *ensembles*, such as for example the Asko Ensemble in Amsterdam, which present this work as part of their repertoire. These musical institutions, often not especially used to complying with regulations on copyright – not to mention the review of sources – in most cases perform the electronic part of the composition using documents saved 'on their hard disks' instead of asking the publisher Ricordi for an authorized copy to rent. It is also true that, if they chose to do this, they would receive a poor quality document, without clear indications as to the version of the work reproduced therein. At the moment, in actual fact, there is no 'official' versions of the *Déserts* interpolations. The number of such copies, with audio sometimes processed also according to its performer's tastes, is huge and continuously increasing. Alongside this myriad documents there are also editions on record. In this regard it is worth mentioning, apart from the recording of the premiere referred to at the beginning of the paper, the *opera omnia* by Varèse published by DECCA (Varèse 1998); *The Varèse album,* a milestone published in 1960 by Columbia, which the author produced to promote his work conducted by Robert Craft; *The Varèse record* of 1977 by Finnadar as reprint of the famous EMS 401 record, quoted even by Frank Zappa (Zappa, Occhiogrosso 1990), to which the *Déserts* interpolations were added (Varèse 1977).[5] This record has become legendary because

5 The cover notes on the record «'Interpolations' are 'organized sound' compositions on magnetic tape, realized in 1954 in the studios of the Groupe de Musique Concrète, Club d'Essai, RTF, Paris, France. This original version is previously unreleased on recordings». I will return later to this point, also to dispel by discussing the concept of original part of the myth which has been created around this work.

of advertising by Zappa (and thus a sure source of commercial revenues); it was then reprinted first by Cherry Red Records on vinyl (now on sale also in its digital version through iTunes Store, *Complete Works of Edgard Varèse, Vol. 1*), then by Ventures Inc., which sells digital copies on Google Play Store. There are also many unauthorized concert recordings, often also improperly made, which can easily be found and downloaded from the Internet.

Much has been written about the different versions of the *Déserts* interpolations,[6] regrettably though the sole certainty is that today no agreement has been found even as regards their number. Plenty of legends, indeed, have circulated around an alleged 'original version' whose tracks are now lost, a sort of 'Holy Grail', about which a clear answer needs to be given: there is no such thing as an 'original version'.[7] Indeed, what do we mean by 'original version'?

Critical editing has for a long time considered the tradition of musical work as a process which inexorably corrupts the integrity of the original; this trend has forced researchers to conduct collation activities based on the concept of 'clearly wrong lesson' (see Caraci Vela 2005, 215) as discriminating factor between deteriorated and correct lesson, the latter being thus original. Already D'Arco Silvio Avalle warned against the idea of 'original':

> Il concetto di originale, nel senso di testo autentico esprimente la volontà dell'autore, è uno dei concetti più sfuggenti ed ambigui della critica del testo. […] L'impressione è che l'originale, così come lo intendiamo generalmente, non sia mai esistito. In effetti il concetto di originale deriva da una visione statica, modellistica, dell'opera letteraria, mentre le singole opere di uno scrittore costituiscono a rigore una sezione a volte casuale e provvisoria […] di quel flusso continuo di adattamenti e di spostamenti successivi attraverso cui si esprimono le tendenze fondamentali di un sistema letterario (Avalle 2002, 33-34).

Similar conclusions can be drawn with regard to the interpolations of *Déserts*. We considered here, on a journey which we shall probably realize does not have any specific destination, some of the most significant versions which I

6 See for example Ouellette 1973, MacDonald 2003, Gertich 1992, or Clayson 2002.

7 And the careful readers will probably have seen a clue to this fact between the lines in Copley's letters mentioned above.

have studied over the years.[8] Their number is continuously increasing; therefore I shall not attempt to provide any more lists; the only certain piece of data in such lists, as a matter of fact, is the number of documents used as reference by the critic who has drafted them.

In Europe

Among Varèse's correspondence kept at the Paul Sacher Stiftung in Basel, there is a letter by Pierre Schaeffer dated 22 January 1959 which says:

> Nous avons retrouvé quelques éléments seulement de votre composition 'Désert' dans notre phonothèque et nous serions heureux de voir figurer votre œuvre. Vous serait-il possible de nous en faire parvenir une copie ?[9]

And in a later letter, also by Schaeffer, without a date:

> Le service des Échanges Internationaux de la RTF nous saisit fréquemment, comme nous vous l'avions déjà écrit, de demandes qui lui sont faites concernant votre œuvre 'DESERTS', or nous continuons à ne posséder que la version concert du théâtre des Champs Elysées de 1954.[10]

The question arises of whether by «version concert du théâtre des Champs Elysées» reference is made to the recording of the concert premiere, separate from the tape with just the interpolations, or to a different version of the interpolations.

8 I started a review and comparison of the versions of *Déserts* interpolations in 2007, as preliminary survey on the possibilities of its publishing, following the interest shown by the publisher Ricordi and as part of research activities by MIRAGE.

9 Letter by Pierre Schaeffer to Edgard Varèse, 22 January 1959 (Paul Sacher Stiftung, Basel).

10 Letter by Pierre Schaeffer to Edgard Varèse, [s.a.] (Paul Sacher Stiftung, Basel).

A comparison between the recordings of the Paris concert (published and kept also at the INA in Paris)[11] and of the Hamburg concert (kept in the archives of Norddeutscher Rundfunk – NDR –, at Paul Sacher Stiftung in Basel[12] and which are also easily available online) helps answer this question. Especially in the second of the three interpolations[13] the differences are macroscopic and apparent also when listening. In the Hamburg version this is nearly one minute longer and, in the middle, some audio material of percussion origin is added (Figure 1).

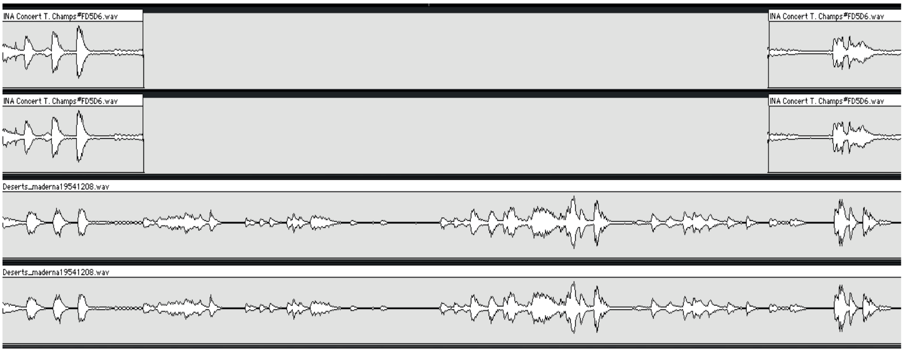

Figure 1. Comparison between the recoding of the concert in Paris (above, tape 32 LUR C) and that of the concert in Hamburg (below, copy courtesy of NDR). Detail of the second interpolation.

11 3 December 1954. Tape 32LUR C. On the case the catalog number was corrected from 32LUR B to 32LUR C.

12 8 December 1954. TS36 and TS48 tapes. Listening to these documents it seems as if the recordings kept at Paul Sacher Stiftung in Basel contain a sound recording which was made using microphones placed in points which are different than in the recording which is kept at the NDR archives.

13 In this essay I will merely be presenting a few macroscopic cases limited to some interpolations, more specifically: to the second one for the paragraph *In Europe*, and to the third one for the paragraph *Overseas*. Being also aware of the fact that Varèse might – and is indeed fairly likely to – have worked separately on the three interpolations, I have chosen to leave any other details to the more suitable space of a possible critical edition, if in the future the conditions should be appropriate for more systematic work on the sources.

The letters do not reveal whether Schaeffer was aware of this. It seems, however, that already in 1954 there were two different versions of the electronic part of this work.

Listening to the recording of the Paris concert there seems to be no clear break in the point where the two versions diverge because the previous material actually shares the sound source of the following one.[14] It is possible that the tape might have been cut at that point to add new material, or also that some material might have been removed from it. There are four possibilities, all of them consistent with the technologies and practices used at the Studio d'Essai in Paris (the 'system' within which *Déserts* was produced):

1. The tape[15] used in Paris could be an abridged copy of the Hamburg one;
2. the tape in Hamburg could be a copy of the Paris one with an addition;
3. both tapes might come from a common source;
4. the two tapes could have been two different editing stages of the same document.

Let us consider the INA sources.[16]

The tape filed with marking 32LUR contains a version of the interpolations which is the same as that in Hamburg. The signal, though, is monophonic. Since both the performance in Paris and the one in Hamburg included stereophonic diffusion of the audio[17] it can be immediately ruled out that it might be an antigraph of the tapes used for the concert. It is probably an 'archival copy' of the extended version of the interpolations.

14 In actual fact the poor quality of the live recording hides a slight discontinuity in rhythm which can be easily detected using the copies where electronic music alone is saved. More about this later on.

15 Or the tapes. It is worth mentioning that Varèse worked on separate monophonic tracks at least until *Poème électronique* was produced.

16 Digital copy given to MIRAGE courtesy of research director Daniel Teruggi, whom I wish to thank.

17 As is well known, the concert in Paris was even broadcast by radio on two different channels in order to uphold the idea of spatialization (though minimal) which underlies the composition.

In the tape with 32SUR D marking the signal is stereophonic, but the sound fabric does not coincide either with the recording of the premiere in Paris, or with that of the concert in Hamburg. Also in the second interpolation there are at least two variants (cuts) which make it the document with less material among those examined so far (Figure 2).[18] It thus seems that not even this one could be the common antigraph for the tapes used in Paris and Hamburg.[19]

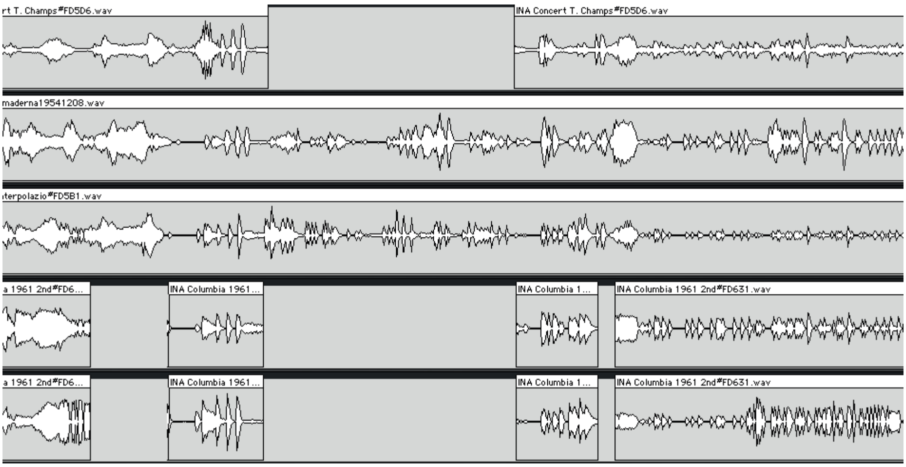

Figure 2. From the top, the recording of the concert in Paris (32 LUR C), the one of the concert in Hamburg (NDR) and the tapes 32 LUR and 32 SUR D. Detail of the second interpolation.

18 The misalignments in the waveforms represented are due to the different running speeds of the tapes. Since I was not personally in charge of the transfers, and with the limited information in my possession about the remediation dia-systems used, I am unable to say anything about the attribution of these deviations, which often exceed the tolerances, to the machinery used to produce the tape or to play it back. The differences in waveforms of tape 32LUR C are due, on the other hand, to the presence in the signal of shouting and applause from the audience.

19 There always remains a possibility that the tape might have been handled again after the copies were created by physically removing a segment from the tape. This assumption can be analyzed exclusively by means of the physical carrier in search of cuts and splices. The audio quality is not excellent, in any case (SNR of about 59 dB) it leads to conclude that this option is unlikely.

In the INA archives there is another tape (32 SUR), on whose casing the following is written: «copie 2 pistes adressée à F.B au Octobre 79. par I. Mimaroglu». It could be the famous 'original' 1954 version which Varèse supposedly delivered to İlhan Mimaroğlu for publishing and often, therefore, regarded as the definitive version of *Déserts* approved by Varèse.[20] Unfortunately, though, it has never been possible to view a copy of it.

A tape has been found in the Ricordi archive[21] kept in an INA-GRM casing where the following words are written «Copie de 32 SUR». A label placed on the core of the document contains these indications: «32 SUR (MASTER)». Those who work in audio recording libraries know very well, however, that the degree of reliability of casings, reels and cores is close to zero. The casings might be exchanged, replaced, lost; the same applies to cores and reels around which different tapes can be wound. It is often the case that the content of the tape is totally different from what has been written on other parts of the document. This is why signal analysis becomes paramount: it is stereophonic and its content is identical to that of 32SUR D. The indications on the casing could be correct because a sound fabric similar to these two sources can be found also in the Finnadar and Cherry Red editions on record – although the latter strangely only contains the left channel.[22] Also 32 SUR D could therefor be a copy of 32 SUR.

It is thus safe to assume that, even though since the time that Schaeffer complained about the lack of a copy of *Déserts* at INA a few other tapes have arrived, the institute apparently does not own either the interpolation versions from the Paris or from the Hamburg concert.

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20 We know that Mimaroğlu worked on the publishing of the Finnagarr record mentioned above, for which he also shot the cover photograph. Writes Mimaroğlu on the back sleeve: «in 1961 Varèse extensively revised the *Interpolations* at the Columbia-Princeton Electronic Music Center in New York, and from then on this final version was employed in all concert performances an commercial recordings of *Déserts*. But Varèse never disowned the 1954 version. Several months before his death (November 6, 1965) he gave me his copy of it and expressed his desire for its performance and recording» (Varèse 1977).

21 With marking 157. I was able to produce a preservative copy of this tape myself, which made it possible to analyze its digitized signal.

22 It is possible to listen to a similar sound fabric on tape TS16 kept at the Paul Sacher Stiftung in Basel.

At Paul Sacher Stiftung, by statute, audio documents are treated in the same way as manuscripts: they can neither leave the Foundation nor be imported – and therefore copied/reproduced – using a computer to be studied with the help of dedicated software; it is possible to listen to them only through headphones from copies on CD. The 'original' audio documents – the sources of the CDs – can be viewed. The Foundation keeps more than twenty tapes, containing interpolations, recordings of instrumental parts, complete versions produced in a studio, recordings of concerts, preparatory materials for both *Déserts* and *Poème électronique*, plus much more. Listening to all these documents is a superhuman feat, and essentially not particularly useful in terms of critical edition, due to the impossibility of comparisons between the sources based on 'aural memory' only.

It should be noted, though, that some tapes stand out merely after browsing the catalogue. Apart from the ones already mentioned which contain a recording of the Hamburg concert,[23] there are two other noteworthy pairs of monophonic tapes, which include respectively the right channel and the left channel of the interpolations: the pair TS14 and TS15 and the pair TS34 and TS35. Their content seems identical, but listening shows that the quality of TS34 and TS35 is remarkably higher; moreover they include a short segment of ambient noise at the beginning of the second interpolation which appears also in other sources, but is absent in the other pair of tapes.

The pair TS34 and TS35 is interesting for a series of reasons: a) the running speed of 30 ips, higher than all other tapes found, is evidence of a highly professional and quality format which leads to conclude that these documents were produced in a well-equipped studio from a technical perspective, and managed by staff with specific qualifications in the area of analog audio materials; b) the presence of splices and leader tapes, which are sometimes long, added within the interpolations is evidence of deliberate and direct work on the carrier, aimed at changing the shape of the sound fabric; c) the musical content seems consistent with that of the Hamburg version; d) in the audio section which has been added to the Paris version, there appears to be an extreme spatialization of percussion sounds, which alternate between right and left channel; as a consequence when there is audio in one, there is silence on

23 TS36 and TS48 tapes.

the other; e) these documents are part of the fund where tapes belonging to the composer are collected.

In a letter to Louise Varèse dated 3 December 1954[24] Copley wrote that «it was 3:10 this AM when Varèse took the recordings along and I wished him bon voyage. [...] He is flying to Hamburg». The idea that these were the tapes which Varèse was carrying to Hamburg is plausible. What might have actually happened?

On the night of 2 December 1954, after the concert at the Champs-Élysées Theatre, Varèse and Copley went to Studio d'Essai, where they stayed at least from 1 o-clock in the morning (when Copley wrote to Varèse's wife) to 3:10 am. Varèse had just about two hours, during which he supposedly changed the interpolations, producing the second version. Anyone who ever worked in a musical production studio will know that it is not very much, especially considering that one is dealing with analog tapes, recorders, scissors and adhesive tape: you have to listen, find the exact point where to cut, decide what to edit; in two hours it is possibly to take only a few concrete actions.[25] The two versions differ in terms of the addition – in the second interpolation – of monophonic material, distributed alternatively onto the right-hand and left channel. Supposing that Varèse had set the interpolations used for the concert not on one stereophonic tape but rather on two monophonic ones with separate channels, such as TS34 and TS35, it is possible that, working two hours on a ready-made preparatory monophonic tape containing the percussion sections, he might have edited it, taken out some sections then divided them between two tapes and placed them in different points. To compensate for the differences in length between the two tapes, he might have added to each of the tapes pieces of leader tape in correspondence to the percussion sections in the other. This assumption is supported by what Fernand Ouellette wrote in his Varèse biography about the French tapes:

24 Paul Sacher Stiftung, Basel.

25 Especially considering that, according to Ann McMillan, Varèse in fact «never felt completely at home» when using the magnetic tape technology (from the typewritten paper entitled "Varèse chose to compose with tape, 30 years ago – A reminiscence" which was sent in 1984 by Ann McMillan to Nigel Osborne for publication in the magazine *Contemporary music* and which was never published. Copy kept at the Department of Special Collections of the Green Library at Stanford University).

> As for the tapes, the R.T.F. [Radio Television Française, ed.] studio has provided them in three different forms. The first consisted of "two superimposed tracks recorded at 38 centimeters a second"; the second of "two separate and appropriately marked tapes each corresponding to one of the playback channels and recorded at 76 centimeters per second"; and the third of "a single 76 cms.p.s. tape with the signals from both channels already mixed" (Ouellette 1973, 185).

TS34 and TS35 could be the second 'form' of the tapes mentioned by Ouellette, taken by Varèse on the night between 2 and 3 December, 1954 from the studios at Club d'Essai and used in Hamburg for the concert on 8 December with Maderna. They were not used for the concert of 13 December in Stockholm because, according to Maderna, «le bande magnetiche che mi hanno dato alla NWDR […] erano sbagliate. Erano due copie della stessa banda».[26] It is likely that Varèse, when he returned to Paris after the concert in Hamburg, might not have returned the tapes to Studio d'Essai but kept them with him and then taken them to New York, where he continued to work on the new versions of the interpolations.

If this reconstruction were confirmed, the fourth of the four possibilities listed above would be true: the tape – or indeed the tapes – from Hamburg are the same which were used in Paris, edited during the night after the concert. In this case we would be dealing with what in terms of textual philology could be described as document in motion.[27]

Some questions arise. What is the relationship between these tapes and the much vaunted 'original'? The authorial variants are apparently evidence that the first copy – the original version in terms of chronology of the creative process – was edited later on, and today could possibly be reconstructed only through a comparison with the concert recording. And, finally, what is the difference in terms of value between the original version and the many other tapes produced by Varèse himself?

26 Letter by Bruno Maderna to Edgard Varèse, 24 December 1954 (Paul Sacher Stiftung, Basel).

27 The document in motion is a document from which two or more lines of textural tradition depart, because it has been copied before and after authorial variants and reprocessing were added to it, or interpolations, changes, innovations, or before and after faults, dropping of sheets, gaps (see Caraci Vela 2005, 228).

The concept of 'original' is duplicated in the distinction between carrier and contained work and is lost in the multiplicity of sources and the vitality of work in motion.

Overseas

In Stratford (Canada), on 18 August 1960, as part of the International Conference of Composers, some music by Edgard Varèse was played for the first time, including *Déserts*, conducted by Frederik Prausnitz, with a new version of the interpolations,[28] announced by Varèse in December 1959 to Michiko Toyama;[29] it was produced at the Columbia-Princeton Electronic Music Center.

The Library and Archives Canada in Ottawa has a recording of this concert,[30] but the comparison with previous performances is particularly difficult due to marked misalignment between the two interpolation channels, caused during the performance and then flattened in the monophonic recording; it is possible that two monophonic tapes reproduced 'out of sync', might have been used.[31]

28 Ouellette identifies this version as number two (see Ouellette 1979, 208). In view of the fact that, so far, three European versions of the interpolations have already been identified, it is impossible to follow his numbering.

29 «I am soon going to start revising the two tapes for *Déserts*. They will be ready in the spring». Letter by Varèse to Michiko Toyama (quoted in Ouellette 1979, 208), 31 December 1959. We know that Varèse started working on this version at the Columbia-Princeton Electronic Music Center no earlier than April 1960.

30 Digital copy of WO 43856 tape.

31 The problems related to the perfect synchronization of two stereophonic tapes – deriving from the tolerance in running speed on tape recorders and from the objective difficulty in the absence of automated sync systems in perfectly aligning the tapes on the reading head and reproduce them simultaneously – have caused misalignments not only in this documents but in almost all stereo documents. This problem has been known for a long time: Pril Smiley (Associate Director at the Electronic Music Center of Columbia University) in a memo dated 15 September 1992 regarding the digitizing of the *Déserts* tapes at Columbia University wrote as follows: «tape #3 = an attempt to synchronize the two (separate reels) origina[l] master (one channel on each reel)» (memo kept in the archives of the Computer Music Center at Columbia University in New York). The question is: what is the exact

At the Library of Congress in Washington D.C. there are two tapes[32] which contain electronic interpolations markedly corresponding to the ones used for the concert in Canada. A comparison between these tapes and the Paris and Hamburg versions immediately reveals the disparity of the numerous interventions on the global dynamics of the sound fabric, conducted independently on two channels, as well as some material replacements; the most macroscopic variant, however, appears at the end of the third interpolation: here the organ part originally included in the Paris and Hamburg versions, is substantially downsized and replaced by new synthesis sounds[33] (in Stratford this caused laughter among the audience, as can be heard in the recording). The final crescendo of the interpolation is subsequently much longer.[34]

Between the versions for Paris and Hamburg and the Stratford elaborations I have verified that there are documents related to variants which could be called 'intermediate'. For example, the tape from the Institute of Sonology in The Hague marked 516BC,[35] although it already contains some replacements of audio sections with new synthesis sounds, does not contain any macro-variant at the end of the third interpolation. This is absent also in the group of documents TS22-TS23, TS12-TS13,[36] TS24 and TS25, preserved at the

overlapping of sound events between the two tracks? A similar question was posed by Kees Tazelaar about reconstructing the mix of *Poème électronique* (see Dobson, ffitch 2005 and "The performance edition of *Poème électronique* by Edgard Varèse", in this book).

32 Digital copies of RXB 2330 and RXB 2331 tapes.

33 This continuous revision work shows the gradual elimination of the organ parts, which are often replaced by pure electronic sounds or by other materials, consistently with the choices made for the re-orchestration of the instrumental part of the work while it is being produced (see Vernooij 2013).

34 The tapes TS18 and TS19, from Paul Sacher Stiftung, seem to contain the same variants.

35 The analysis was conducted on a digital copy.

36 On the reel of this pairs of monophonic tapes there is the following indication «remontée Eindhoven». A label on the casing of TS 22 also provides a date «Dec 1959». We know that Varèse, in 1958, visited the Philips studios in Eindhoven in The Netherlands to work on *Poème électronique*. It seems reasonable to assume, also in the light of the continuous cross-references between the audio in the two works, that Varèse, on that occasion, might have started the revision of interpolations, which he would then continue to work on at the Columbia-Princeton Electronic Music Center and of which these tapes are an intermediate document, because they contain sound events in common to both the Paris and New York versions.

Paul Sacher Stiftung, onto which synthesis audio materials not found in the European versions were added.

Finally, Ouellette makes a distinction between the Stratford version and other two versions produced at Columbia-Princeton Electronic Music Center: the first one dates back to 1960-1961 and was used for a broadcast on 19 April 1961 during the program *Les Pôles de l'esprit* on Canadian radio, of which there is apparently no trace in the Ottawa archives,[37] the second to July-August 1961.[38] The latter is the copy which is currently given for reference to scholars by the Computer Music Center at Columbia University and made available for record editions and concerts. The management of the Center, though aware of the existence of other versions, does not seem to regard them as particularly relevant, dismissing them as preparatory phases for the final version. Today reference can only be made to the digital copy on DAT – but considering how perishable this carrier is there is no telling for how much longer this will be possible – because the original tapes are no longer available.[39]

This belief, which is not philologically supported, apparently dates back to a statement by Varèse himself, also reported by Ouellette: the 1961 copy is supposedly the «fourth and final version» (Ouellette 1973, 211). Should we think of it as the final version produced by the author, which as such becomes the original?

As already mentioned, in this case tracing the original is a debatable, outdated and incorrect undertaking according to modern philology principles, which attribute the right importance to all documents attesting the creative process, without overestimating either the most recent – that is to say the

37 I cautiously added 'apparently' because during my visit to the Library and Archives Canada in August 2011 I encountered numerous cataloging issued. The re-collocation of audio sources, with a view to introducing better filing methods, seems to have jeopardized the matching between catalogue placements and those appearing on the document, which means that often the information in catalogue about the content of the documents is wrong.

38 See also the memo by Pril Smiley quoted above, where mention is made of: «a master performance tape prepared by Bülent Arel in 1961». Currently the management of the Computer Music Center at Columbia University (formerly Columbia-Princeton Electronic Music Center), dates this version to 1961-1962.

39 Personal experience at the Columbia Music Center of the Columbia University in New York.

author's final intent, and point of arrival of continuous fine-tuning aimed at achieving perfection which can only be achieved by a genius (the approach followed at Columbia) –, or the oldest, which is expected to be closer to the purity of the first intuition (the approach chosen by Mimaroğlu for the Finnadar edition).

Varèse's deserts are as many and multifaceted outcomes of an open system made up of different technologies, people and places, and of a constantly developing composition ideal. Given that the interpolations are actually never entirely recomposed, they gradually become more abstract: the synthesis sounds tends to increasingly replace – even physically on the tapes – the concrete sound which was typical of the first versions.[40] Finally the organ was almost completely eliminated in 1961-1962 versions and it was replaced by the sidereal sounds which seem to anticipate new musical horizons which are light years away from the terrestrial gravity in the original sound of saws, drills, sledge-hammers of the 1954 version: new deserts.

Open work vs *work in motion: more deserts*

The continuous changes in this work, the montage and reuse of materials could lead to regarding *Déserts* as a sort of open work which is not closed in a final form. This is a result of the terminological confusion derived from the overlapping of philological and philosophical topics by Umberto Eco.[41] As a matter of fact, the latter expressly defines open work (*opera aperta*) also as work in motion to move from music to other art forms (Eco 1995). In philology, as already mentioned, a document in motion is a document that changes over time and is copied in various stages of its historical progression. It is clear that, when the document changes, its form and content also vary. This is all the more reason to say that the work does not have any form which has been fixed once and for all. But this does not mean that *Déserts* can be defined as open work. Its continuous reprocessing is due to rethinking and

40 The differences in approach to electronic composition become clearer by listening to sound materials separated from final mix of the preparatory tapes, mostly kept in the Library of Congress in Washington D.C.

41 I am referring here to *Opera aperta* and not to Umberto Eco's semiotic theories.

to interest in new electronic production media of which the author became aware. Varèse never allowed the artists who performed *Déserts* to rearrange its 'structure'. The work being thus closed, however, never prevented (and even today does not prevent) its performers from taking a few liberties in terms of execution, also as regards magnetic tape reproduction. This can be seen as natural and intrinsic to the performance status of the musical work.

With regard to *Déserts* there are two significant cases in point: the version by Maderna and the one by Valdimir Ussachevsky. The former, as already mentioned, was due to the circumstance that the tapes which Maderna received from Nordwestdeutscher Rundfunk for the concert in Stockholm were two copies of the same tape.

> Allora io ho fatto un montaggio. Ho preso la banda nella prima parte ed ho copiato la stessa mettendola in contrappunto con gli stessi suoi elementi, due dei quali reversé.[42]

Four loudspeakers placed around the audience were used for sound diffusion. Maderna asked Swedish radio to send Varèse a copy of the tapes rearranged in this way. We are not sure whether Varèse ever received them; there have not been found among his tapes kept at the Paul Sacher Stiftung in Basel.

The events involving the Ussachevsky version are more complex. According to Risset:

> In the late 1960s, after Varèse's death, Vladimir Ussachevsky proposed to replicate Varèse's tape pieces in better technical conditions: he could get hold of the mixing elements and notes or instructions about putting them together again in order to obtain a much cleaner version. However, Louise Varèse was not sure that Varèse would have approved of it, so Ussachevsky, who died in 1989, never realized that project, which is unfortunate (Risset 2004, 36).

There is no certainty that Ussachevsky might not have been at least partly responsible for this version. In a 1992 memo by Pril Smiley, listing a set of digital copies of analog documents related to *Déserts* at the Computer Music

42 Letter by Bruno Maderna to Edgard Varèse, 24 December 1954 (Paul Sacher Stiftung, Basel). See also Meyer, Zimmermann 2006.

Center of Columbia University which she made, mention is indeed made of a «Tape #2: a new master tape prepared by Vladimir Ussachevsi [sic] for a Jan. 9, 1967 concert - group for contemporary music».[43] Unfortunately no audio documents have been found so far in this regard.

The interpolations of *Déserts* are probably the most famous electronic composition in the history of music. The complexity of its document scenario probably also mirrors its huge amount of success.

VARÈSE AND CINEMA: *LA PROCESSION DE VERGES*

In the mid-1950s Varèse wrote the music for the documentary *Around and About Joan Miró* (1955) by Thomas Bouchard, mentioned in the Varèse catalogs as *La procession de Verges*. This work is almost unknown because the heirs of its director prohibit its diffusion. I was able to view a copy at the Library of Congress in Washington D.C. and listen to a version of just the soundtrack (very poor in terms of quality, obviously recorded with a microphone placed in front of a loudspeaker) at the Library and Archive Canada in Ottawa.[44]

The events which led the two artists to work together are narrated by Diane Bouchard in her contribution *Varèse und Bouchard* (Bouchard 2006). Bouchard asked Varèse to compose a soundtrack with excerpts from his works *Octandre, Ionisation, Intégrales* and *Hyperprism*, for his documentary film about Fernand Léger, *Fernand Léger in America. His New Realism* (1945-46), then in 1947 to select some Baroque music fragments for the film *Naissance d'un tableau* dedicated to Kurt Seligmann, which was completed in 1950; finally, in the early 1950s, he asked him to write some original music with organized recorded sounds for the documentary about Miró.

In this documentary the sequence with Varèse's music is the only one in black and white and it is about halfway through the film. It shows the procession which is held in Verges, in Catalunya, on the night between Maundy

43 Note preserved at the Computer Music Center of the Columbia University, New York.

44 Fernand Ouellette collection.

Thursday and Good Friday, also known as the 'dance of death'. Images and music clearly stand out from all the rest: before this sequence there is footage of the churches which inspired Miró; the following part, on the other hand, is dedicated to his studio in the countryside; the remaining music was written by Antonio de Cabezón, Isaac Albéniz and Enrique Granados.

The sequence starts with a narrated introduction, then by its silence and a musical background. Table 1 contains its schematic description, based on the Library of Congress copy; it is an attempt to highlight the relationships between music and image which emerge just by watching the documentary.[45]

The music closely follows the film narration, to a certain extent adjusting itself to conventional descriptions and musical comment with regard to the action, for example in the Gregorian-style chanting, in the rhythm of the procession marked by percussion sounds, in the electronically processed sound to underscore the supernatural and aspiration to grasp it, in the silence of the figure of Christ, in the sound-image gaps which often anticipate the procession, etc. It is clear that Bouchard and Varèse worked on its editing together. According to Diane Bouchard:

> Rief ich Varèse an und sagte zu ihm: «Du mußt unbedingt herkommen und dir das anschauen». Und Varèse [...] sich nicht zweimal bitten: «Ich bin gleich da». Sorgfältig spielte ich den Originalfilm [...] ab. Als es vorbei war, sagte Varèse: «Großartig. [...] Ich werde den 'organized sound' für den Soundtrack komponieren». [...] Dann sagte Varèse zu mir: «Ich brauche ein Verlaufsschema des Films, mit Angaben zu allen Szenenwechseln und genauen Timings». Als ich dies gemacht hatte, stellte sich heraus, daß die Sequenz eine Dauer von 2 Minuten und 47 Sekunden hatte. Varèses wunderbares Stück paßte perfekt zur raschen Bewegung der Bilder, zur Stimme des Priesters, der das Caligaverunt, singt, zum Seufzer, zum abrupten Ende (Bouchard 2006, 322).

Thanks to this collaboration Edgard Varèse was thus introduced to the world of editing for the cinema industry. This experience had indelible consequences

45 There appears a slight discrepancy between the duration of the copy viewed (2'39") and the one mentioned in literature (2'47"). The copy kept at the Library of Congress does not include any cuts. It is possible that the duration mentioned for the first time by Ouellette, and which was taken from there, might also include the introduction by the narrator's voice.

on his approach to music, most notably for the definition of the idea of 'organized sound'. In actual fact Varèse worked on the soundtrack for Bouchard's film at the same time as he started collecting audio materials for the *Déserts* interpolations (see Ouellette 1973, 174). These two productions are closely related, and not just in terms of sounds materials which are indeed similar when not identical. Also *Déserts* originated as an idea, presented to Disney, for a sound motion picture (Mattis 1992). Already in the early 1950s Varèse showed that he had a clear independent aesthetic ideal, which included the potential of relationships between sound and images in motion, going far beyond mere synchronization and asynchronization, although suitable for Bouchard's documentary:

> Visual images and music or, as I prefer to say, organized sound will not duplicate each other. Light and sound are different essence, eye and ear do not behave in the same way, their limitations and reactions are not the same. For the most part, light and sound will work in opposition in such a way to give maximum emotional reaction; sometimes they will join for dramatic effect and to create a feeling of unity. For example, well-timed silences might at times be the only accompaniment of visual turbulence or terror, instead of the usual procedure – the noisily imitative crescendo. Or in some calm, contemplative scene, the music might evoke quite a different event taking place far away and unrelated in mood, but which will help create, through contrast, a feeling of space and time and of universality. These contrasts achieved through the synchronization of simultaneous, unrelated elements would create a dissociation of ideas which would excite the imagination and stimulate the emotions. At other times both sound and image would joint in a kind of visual and sonorous counterpoint.[46]

46 Undated paper preserved at the Department of special collections of the Green Library, University of Stanford.

Time	*Images*	*Music*
0'00"	Dark streets, illuminated only by torches.	Starts quietly with noises and soft percussion sounds.
0'07"	Change of scene. The men in the processing become visible, the priests walking towards the camera wearing death masks.	Singing which reminds us of Gregorian chant.
0'09	Change of scene. In the center of the procession a statue of the Virgin Mary is carried, wearing a crown of candles.	Electronically processed sound.
0'15"	Change of scene. Zoom in on the procession.	=
0'20"	Overview of the procession: its head, middle, tail end. Women and penitents in chains surround and follow the statue of the Virgin Mary.	Singing resumes.
0'29"	=	The voice disappears and the electronically processed sounds and percussions are highlighted.
0'32"	=	Percussion solo.
0'35"	=	The percussions seem to mark the rhythm of the procession.
0'43"	Change of scene. View of the torches.	Electronically processed sounds.
0'47"	Change of scene. View of the procession.	The percussion sounds resume and, once again, they seem to mark the rhythm of the procession.
There follows a section with frenetic editing, as regards both images and sound, without correlations, specific correspondences or syncs.		
0'59"	Change of scene. Close-up of a hooded man carrying a torch.	Enter the flute.

Time	*Images*	*Music*
1'05"	Change of scene. Full shot on the procession.	Long flute note connecting the two scenes.
1'07"	Change of scene. Full shot showing only the light from the torches.	Enter a 'whistle' almost in sync with the change of scene.
1'16"	Change of scene fading to black. You can just see the soldiers wearing Roman-style armors surrounding a statue of Christ.	The music matches the fading and continues with electronically processed sounds.
1'19"	=	Re-enter percussions which this time clearly mark the marching rhythm of the soldiers.
Very dark images follow, accompanied by electronic sounds which seem independent.		
1'31"	Change of scene. The image of Christ drawn on a sheet is visible. Slow zoom on the figure.	Silence. Fade in to diffused sounds processed electronically accompanies the zoom.
1'44"	Change of scene. Same subject.	Enter percussion sounds (slightly in advance of the change of scene).
A more frenetic montage section follows. The music is unrelated.		
1'56"	The camera moves up from the procession to the sky, creating a sort of fade to black.	The voice is heard again, alone against a black backdrop.
2'00"	Imperceptible change of scene. Very dark image, where a face looking into the camera can be barely seen. The effect is very unsettling.	With an abrupt dynamic leap, the processed noises are back in ***ff***.
2'04"	Change of scene. Back to the procession.	Re-enter percussions (slightly in advance of the video editing).
Many changes follow, both as regards images and music; they are independent one of the other, but in any case the result is a sort of frantic finale.		
2'39"	Fading end.	Fading end.

Table 1. Analysis of the sequence called La procession de Verge.

It is on the practical level of electronic composition that Varèse's experience with Bouchard had the most evident impact. It is a well-known fact that magnetic tape audio montage techniques are similar to those used in cinema. In the revisions of the *Déserts* tapes, after the first production in Paris, Varèse worked almost exclusively by addition, removal and replacement of tape segments and local interventions on volume. The analogies with editing in cinema are clear. The reconstruction of technical-composition processes in electronic music by Varèse, therefore, necessarily needs to take into consideration the concept of 'organized sound' in all its density, which is not limited to tape composition, but also encompasses cinematography experiments and, last but not least, the sound-architectural experience of *Poème électronique*.[47]

THE LESSON FROM VARÈSE

As is often the case in the history of media, also in the 1950s there was a natural tendency to accept a new medium with excessive enthusiasm. Electronic equipment had encouraged an idea already present in the debate raging during that period about New Music and facilitated its implementation: the utopia of the perfect structure, frozen once and for all within the physical space of the magnetic tape: no need for a performer to implement at a later stage the musical concept and turn it into 'music', no disconnection between creation and practice, no coding and decoding, and most of all the possibility of fixing events and defeating time forever. The magnetic tape, in the early days of electronic music, was seen as a ploy to capture the musical creation directly as it becomes music, thereby escaping the entropic process of performance tradition. Something changed in the course of that journey, though, and the initial enthusiasm as regards the crystallizing of 'perfect' musical structures dwindled: the static fixing of the composition concept probably led to creating work which was already 'mummified' as soon as it originated, removed from time, because it denied to music the possibility

47 See "The performance edition of Poème électronique by Edgard Varèse", in this book.

of re-contextualizing itself through the live action of the performer. All this changed radically with the advent of live electronics. The times and especially the media were now ready for the use of electronics and computers as live control systems of sound, exactly in real time, to go beyond deferred generation and static fixation practices. A new technology had clearly shown the limits of what had been done until then and generated new enthusiasms. In live electronics the structure is created and recreated every time in the live gesture of the performer, which is basically the same that happens with instrumental music. The interaction with audio outboards and later with digital systems became an extension of the performance action, not aimed at inventing unheard of sounds and situations, but rather at defining and developing conceptual entities which could generate new musical processes, possibly signaled exactly by new sounds (see Berio 2013, 233).

Varèse was unfortunately not able to experience the age of live electronics, but the study of his electronic production on tape shows us how this great composer, born nearly two generations before the 'enthusiasts' of the possibilities implicit in structuring which could presumably be achieved through sound recording technologies, could successfully survive the utopia of crystallizing the musical action. Exactly as Maderna did after him,[48] especially with *Déserts* Varèse seems to be continuously restating that also in the case of electronic music, Busoni's concept of the ideal identity composition = performance = interpretation still applies.

48 See "Towards an electronic 'global work'", in this book.

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Bi-dimensional inventions

Naming problems for *Dimensioni II / Invenzione su una voce* by Bruno Maderna

Daniele Badocco

Dimensioni II / Invenzione su una voce is an electronic/mixed composition (or, possibly better, a construction) on which Bruno Maderna begun working between December 1959 and early 1960 at the RAI Studio di Fonologia Musicale in Milan. It is based on a phonetic text with no semantic meaning, drafted by Hans G. Helms, and it was designed to allow for a dialogue between the live voice of Cathy Berberian and its recorded counterpart (modified and edited by Maderna himself).[1]

Even though, for the text, Helms had decided to use serial rules as regards choice and positioning of phonemes,[2] Maderna conceptually took apart the work by the German scholar, going beyond it in search of the expressive aspect of the voice. Cathy Berberian, while recording, did not just read out the phonemes, she interpreted them, thus enormously expanding their sound possibilities. Maderna recorded these performances many times and on several occasions (which would actually become part of his

1 In actual fact, less than half of the times that *Dimensioni II / Invenzione su una voce* was performed in concert while Maderna was alive, involved the interaction between taped and live voice; this was probably due to the fact that it was impossible to always have Cathy Berberian on hand to sing live, and she could not be replaced by other singers. Today the few public performances of this composition include the electronic part alone. In this case, however, there are new complications because – given that there are several different versions available – it is difficult to make a final choice about which one to use (see Cossettini, Orcalli 2015 and Badocco 2016).

2 See T*ext for Bruno Maderna*, text dated May 1960 sent by Hans G. Helms to Bruno Maderna (Rognoni Fund, University of Palermo, Department of Human Sciences, Folder 20 “Fonologia”).

compositional practice),[3] then segmented and reassembled them, until they overlapped with pure electronic sections and other electronically modified vocal elements; this resulted in the text being unpredictable and unexpected.

DIMENSIONS

Dimensioni II / Invenzione su una voce is a continuation of the research, which started with *Musica su due dimensioni* (1952-1958), as regards the interaction between electronic music and instrumental music. This interest in the electronic medium started after the meeting with Werner Meyer-Eppler in Darmstadt in 1951; as a consequence, in 1952, Maderna decided to contact the German professor in order to suggest to him a new idea about the use of electronics: «ich habe gedacht, dass es möglich sein könnte, ein Stück für Klavier, Flöte und diese neuen elektronischen Klangmittel zu komponieren, ungefähr eine Musik über zwei verschiedene Dimensionen».[4] In spite of the questions raised by Meyer-Eppler in his written answer,[5] Maderna visited the research laboratory at the Phonetics and Communication Institute of Bonn University (whose head was Meyer-Eppler himself) where, in June 1952, he recorded the first version of *Musica su due dimensioni*.

3 Just by listening to some preparatory materials by Maderna kept at the Paul Sacher Stiftung in Basel it becomes clear how many rehearsals, recordings and attempts were required by the composer before the works were finalized; it should also be noted that often, due to the constant travelling and incessant orchestral conduction work, the time available to work on the recording was reduced to a bare minimum. This is what Bruno Maderna said in an interview with Jean-Yves Bosseur in 1966: «je voudrais travailler avec l'électronique, mais je ne le peux pas, faute d'opportunité, de temps. Les studios sont trop bureaucratisés. Et puis, c'est délicat à dire, mais en raison d'un minimun de possibilités, une œuvre électronique représente trois mois de travail, et je ne les ai pas» (Bosseur 2010, 17).

4 Letter by Bruno Maderna to Werner Meyer-Eppler, 13 May 1952, kept by the Internationale Musikinstitut in Darmstadt.

5 Letter by Werner Meyer-Eppler to Bruno Maderna, 14 May 1952 (see Baroni, Dalmonte 1985, 62-63).

The difficulties encountered during the composition phase[6] and its result not being totally satisfactory, led the Venetian composer to abandon the electronic practice of *Dimensioni* (live recordings and instruments) and focus on electronic music compositions *tout court*. It was only in 1958, after learning about electro-acoustic laboratory practices, that he recorded at the Studio di Fonologia in Milan the second and better known version[7] of *Musica su due dimensioni*. After the success of this new version, the director of the Internationales Musikinstitut in Darmstadt (IMD), Wolfgang Steinecke, organized – on 4 September 1959 – one evening of the Ferienkurse entirely devoted to the interactions between traditional and electronic music (see *Darmstädter Beiträgen zur Neuen Musik* 1960, 110), asking Bruno Maderna to give a talk on this topic as introduction to the concert.

It was thus during the presentation of the concert on 4 September 1959 in Darmstadt that Maderna himself clarified his idea of *Dimensioni*:

> Con dimensioni intendo forme della comunicazione musicale: primo con i mezzi tradizionali, cioè con interpreti che suonano strumenti o cantano in presenza del pubblico, e secondo con i mezzi della registrazione e riproduzione elettroacustica, nella quale sono impiegati o soltanto processi sonori elettronici o suoni strumentali registrati (ed eventualmente trasformati) oppure materiali sonori elettronici e strumenti fissati su nastro che vengono poi riprodotti attraverso altoparlante. Mentre all'inizio si poteva notare una

6 «Non ho ancora incominciato a scrivere il mio pezzo – ossia sono andato avanti per 80 battute circa e poi mi sono accorto che tutto è falso. Devo trovare una nuova serie e rifare tutto. Ma mi limiterò al puro necessario. Cioè ripeterò lo schema dei soli quadrati ponendo tutta l'attenzione solamente ai mezzi elettronici. Questi come unico problema. Non si può contemporaneamente usare un nuovo mezzo e cercare un tentativo di sintesi di tutte le nostre trovate e ricerche. E poi sono certamente al limite di un mondo. Bisogna andare molto più in là, ma prima ho bisogno di un lavoro che solo noi due possiamo fare: con calma riesaminare tutti i risultati e tutte le ricerche lasciate in sospeso dal '48 in poi». Letter to Luigi Nono, 30 May 1952, Luigi Nono Archvie in Venice. A French translation is published in Feneyrou 2007, 492.

7 For a long time there remained merely an echo of the 1952 version in the letters and concert hall program of 21 May 1952: «la composizione fu stampata […] dalle edizioni Ars Viva di Mainz, ma nessun esemplare del testo sembra più rintracciabile. D'altra parte non si ha notizia neppure di ulteriori esecuzioni avvenute dopo la prima» (Baroni, Dalmonte 1989, 205).

> chiara divisione fra musica elettronica e strumentale, negli ultimi due anni circa sono state prodotte opere nelle quali vengono combinate la riproduzione attraverso altoparlante di musica registrata e musica eseguita al momento della rappresentazione […]. Una sintesi di entrambe le possibilità esistenti che io chiamo "dimensioni" mi sembra particolarmente fruttuosa, dal momento che l'interprete – nell'incontro con le realizzazioni sonore fissate sul nastro, fatte dallo stesso compositore o da lui controllate – raggiunge un contatto molto più stretto con l'autore (infatti egli non legge soltanto la partitura, ma ode anche contemporaneamente quello che il compositore vuole). D'altra parte però l'autore deve compiere in se stesso questa sintesi, se vuole creare una forma musicale così complessa, nella quale s'incontrano l'interpretazione immediata e ciò che egli stesso ha fissato. Io ho avvertito per la prima volta nel 1952 la necessità di questa sintesi, e ne fui molto felice, poiché ho sempre desiderato collegare il più strettamente possibile la composizione e l'interpretazione (Baroni, Dalmonte 1985, 85-86).[8]

The reflections in preparation of the Darmstadt speech then encouraged Maderna to compose *Dimensioni II / Invenzione su una voce*.

DIMENSIONI II OR *INVENZIONE SU UNA VOCE*?

But what is the actual title of the composition? *Dimensioni II* or *Invenzione su una voce*? And why name this composition separating, with a slash, *Dimensioni II* from *Invenzione su una voce*? Today, following a fairly widespread practice but which is still far from becoming a unified canon, the name of the composition simply includes a full stop or a dash between the two parts of its title. This practice, which is encountered only once in concert programs for performances while the composer was still alive – more specifically in Florence in 1963 – tends to diminish the complexity which this double naming entails.

Tiziano Popoli, when compiling the summary sheets for Bruno Maderna's *opus* was well aware of this issue and explained it all with the chronological

8 It should be noted that this is the translation of a German manuscript kept by Maderna's widow.

gap between the production of *Dimensioni II* and *Invenzione su una voce*. Listing the various concerts during which the composition was performed he describes the development of the title as follows:

> Da un punto di vista cronologico il titolo *Dimensioni II* precede *Invenzione su una voce*; il nastro magnetico utilizzato a Darmstadt il 16.7.1960 porta il seguente titolo: *Invenzioni su una voce. Dimensioni II* ed è provvisto del seguente sottotitolo: musica elettronica e voce femminile su fonemi di H. G. Helms. I due titoli da noi proposti sono dunque entrambi legittimi e possono essere usati singolarmente oppure accoppiati; in quest'ultimo caso il secondo funge da sottotitolo del primo. L'ulteriore sottotitolo esplicativo "musica elettronica e voce femminile (…)" viene talvolta usato assieme all'uno o all'altro dei due titoli principali. Per quanto concerne la scelta del termine *Dimensioni*, che appare come una sorta di precisazione dell'idea già proposta in *Musica su due dimensioni* […]. In questo senso *Dimensioni II* acquista il suo titolo in quanto sviluppo e approfondimento della "dimensione elettronica" (Popoli in Baroni, Dalmonte 1985, 230).

Following up on Popoli's work, below is a list of the performances which were held while Bruno Maderna was alive, in chronological order, with the place, title and instrument list featured on each concert program. Unfortunately, the only recording available to us is the concert in Warsaw (1961), the only instance when it has been possible to verify the presence of the live voice. In all other cases, wherever possible, an attempt was made to find references in secondary literature.

> 9 April 1960, Milan, *Incontri Musicali*, Sala piccola del conservatorio "Giuseppe Verdi". Title: *Dimensione 2, per nastro magnetico e voce dal vivo* (Cathy Berberian).

> 2 May 1960, San Francisco, *Berio. A lecture-concert*, Main Auditorium – San Francisco State College. Title: *Dimension, II, per nastro magnetico e voce dal vivo* (Cathy Berberian).

> 13 June 1960, Paris, *Festival de la Recherche 1960*, Salle Gaveau. Title: *Invenzioni su una voce, per nastro magnetico*.

16 July 1960, Darmstadt, I*nternationale Ferienkurse für Neue Musik*, Kongreßsaal Mathildenhöhe. Title: *Dimensioni II, per nastro magnetico*.[9]

21 September 1961, Warsaw, *Warszawska Jesień / Automne Varsovien*, Salle des concerts de la Philarmonie Nationale. Title: *Invenzione su una voce, per nastro magnetico e voce dal vivo* (Cathy Berberian).

10 April 1963, Florence, *Vita musicale contemporanea*, Sala del consevatorio "Luigi Cherubini". Title: *Dimensione n°2 invenzione su una voce (elettronica), per nastro magnetico*.

1 June 1963, Rome, *Nuova consonanza*, Teatro delle arti. Title: *Invenzioni su una voce, per nastro magnetico*.

13 December 1966, Milan, *Concerto di musiche elettroniche – Primo salone internazionale della musica di Milano*, Sala del Grechetto – Palazzo Sormani. Title: *Invenzione per una voce sola, per nastro magnetico*.

9 It is a widespread opinion in literature that the composition was performed on 16 July, 1960 in Darmstadt with the live voice of Annemarie Jung (see for example Borio, Danuser 1997, 606 and Rodà 2009, 87). The current state of research, however, does not make it possible to confirm this information. On the contrary, the concert reviews (kept at the IMD Archive) never mention a live part and the composition is always regarded as 'electronic'. Annemarie Jung does indeed feature on the concert program among performers that night, but – as confirmed by the Jung-Steinecke correspondence kept in Darmstadt – on that occasion the singer had been engaged to sing *Herzgewächse* (op. 20) by Arnold Schönberg. Also from this correspondence we learn that Annemarie Jung arrived in Darmstadt on the evening of 14 July. Even assuming that Maderna had been willing to revolutionize the composition by replacing the singer and thus renouncing the dialogue between Berberian's voice live and on tape, it is difficult to believe that a performer whose repertoire was actually so distant from Maderna's work could have been able to rehearse for one day and perform also *Dimesioni II / Invenzione su una voce*. The theory that Jung performed this composition could probably be due to the presence at the IMD Archive of a tape, erroneously catalogued as concert recording which in actual fact contains only the electronic part (19' version, see "Towards an electronic 'global work'", in this book). It is well known that the part on tape includes the electronically processed voice as well as the untreated recording. It is thus likely that the staff in charge of drafting the performance catalogue for the Ferienkurse (in Borio, Danuser 1997), where Annemarie Jung is for the first time associated with the performance of *Dimensioni II / Invenzione su una voce* of 1960, could have mistaken Berberian's unprocessed voice on tape as a live voice.

11 June 1968, Florence, *Convegno internazionale centri di musica sperimentale – XXXI Maggio musicale fiorentino*, Teatro della Pergola. Title: *Invenzione su una voce, per nastro magnetico e voce dal vivo* (Cathy Berberian).

11 March [1969?] [Erfstadt?]-Liblar, *Konzert*, Aula der Realschule. Title: *Dimensioni II* [no other information].[10]

As can be seen from this short listing there is no homogeneousness in the choice of called the composition *Dimensioni II* and/or *Invenzione su una voce* (with all possible variations).[11]

There is less heterogeneity as regards naming in the information found on the casings of the magnetic tapes, where in most cases the title is *Invenzione* (or *Invenzioni su una voce*).[12] There are some exceptions, though: the tapes A30 and A28 in the Archivio Grossi in Florence include the titles *Invenzioni per una voce sola*[13] and *Improvvisazioni per una voce sola*; some tapes in the Maderna Archive in Bologna, namely B34 and B43 include the wording

10 In the absence of more certain data, we have added also this concert to the list. Unfortunately it has not been possible to find further details to support this information. Looking at the concert program (found at the Maderna Archive in Bologna) it is indeed possible to assume that the title *Dimensioni II* could be a typing mistake and actually refer to *Musica su due dimensioni*. As a matter of fact, apart from not featuring in other lists of concerts with *Dimensioni II / Invenzione su una voce*, its instrument list includes Angelika Sweekhorst on flute and the pianist Peter Michael Braun.

11 Including typing mistakes as in the case of *Dimenzioni II* in "Neue Musik in Darmstadt 1959-1961", in *Darmstädter Beiträgen zur Neuen Musik*, n. IV (1961), pp. 121-128, or *Invencione su una voce*, in the CD *Klangstudie and komposition*, Cherry Red Records, London, Other2, 2011; or *Invenzione a una voce* in Leonardo Pinzauti, *La Nazione* 16 June 1968.

12 In all of the correspondence found where mention is made to the magnetic tape of this composition being sent, the reference is always to *Invenzione su una voce* and never to *Dimensioni II*.

13 Tape A30 which corresponds, with the usual difference in number (*Invenzioni* instead of *Invenzione*), to the electronic music concert of 13.12.1966 at the *Primo salone internazionale della musica* in Milan. The concert program lists Pietro Grossi as host of the event, and as curator the Studio di Fonologia Musicale in Florence, also directed by Grossi. It is thus possible to find a common origin for this denomination.

Dimensione/i,[14] while on B23 and B55 the title *Dimensioni II* follows *Invenzione su una voce;*[15] finally, on the casing of tape M-6944 at IMD the words *Dimensioni II* have been written by hand after the typewritten title *Invenzione su una voce*.

At this point, in order to understand how the name of this composition actually originated, it might be useful to extend the research scope to include secondary sources. Due to the scarcity of information left by Maderna directly, it becomes fundamentally important to analyze the documents from the Studio di Fonologia Musicale in Milan, as well as the correspondence between the organizations and those who worked with the Venetian composer.

There is no definite information as to the premises which led Maderna to produce *Dimensioni II / Invenzione su una voce*. The first hints in respect of the composition project can be found in a letter by Cathy Berberian to the musicologist Leonard Stein dated 13 December 1959: «Bruno Maderna is currently preparing another *Musica su 2 dimensioni* for recorded voice and live voice (mine)».[16] This is also confirmed by the summary sheet of activities at Studio di Fonologia Musicale dated March 7th, 1960 where the heading *Produzione musica elettronica nel periodo I° luglio 1959 I° Marzo 1960* is

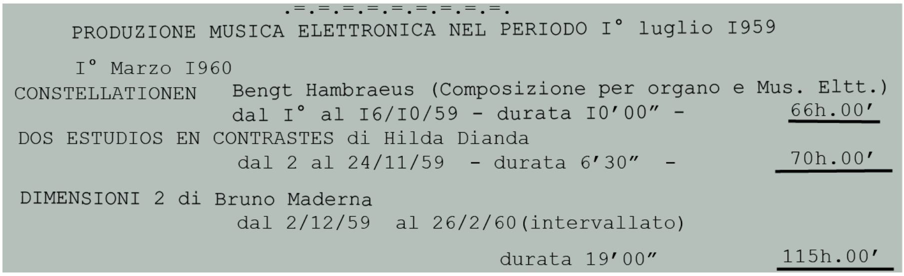
14 The casings include the words *Dimensione I*, *Dimensione II* for B34 and *Dimensioni I*, *Dimensioni II* for B43, where only *Dimensione/i I* is actually a version of *Invenzione su una voce*). On the other hand, *Dimensione/i II* is a montage of the electronic part of the 1958 version of *Musica su due dimensioni*. The catalogue sheets for these tapes found at the Maderna Archive in Bologna report as their origin the publisher Suvini Zerboni in Milan.

15 Casing B23 also includes the subtitle «Musica elettronica e voce femminile su fonemi di H. G. Helms».

16 Letter by Cathy Berberian to Leonard Stein, 13 December 1959 (Paul Sacher Stiftung, microfilm 163.1). Furthermore, Berio told Leonard Stein: «I will ask the technician of the Studio to send you some two-track tapes by air mail; I'm sorry that I won't have time to take care of it myself. To date, there are no discs of our electronic music available but, when the two new pieces by Maderna and myself are completed, we will prepare an album with Philips which we hope will be released next year [...]. This year, there are several works planned at the Studio besides the two new pieces mentioned above. In this case, there is an excellent chance that for the concert in May you can present some first performances». Letter by Luciano Berio to Leonard Stein, 30 September 1959 (Paul Sacher Stiftung, microfilm 163.1, n. 00017). We do not know what compositions he was referring to, but it might be *Dimensioni II / Invenzione su una voce* itself.

followed by this wording «DIMENSIONI 2 di Bruno Maderna // dal 2/12/59 al 26/2/60 // durata 19'00" 115h.00'» (Figure 1).

At the Rognoni Fund in Palermo there is a tape with shelf mark P22. The casing is marked «Maderna: Invenzioni su una voce (1960) // (Katy) [sic]». There is a very interesting sheet attached which reads «Bruno (1960 - marzo - aprile) // Intenzionalità 3 // oder // Urgesang als Ursprache // Fonologia // [other ink] Phonicanto (H.G. Helms)» (Figure 2).



.=.=.=.=.=.=.=.=.=.=.

PRODUZIONE MUSICA ELETTRONICA NEL PERIODO I° luglio I959

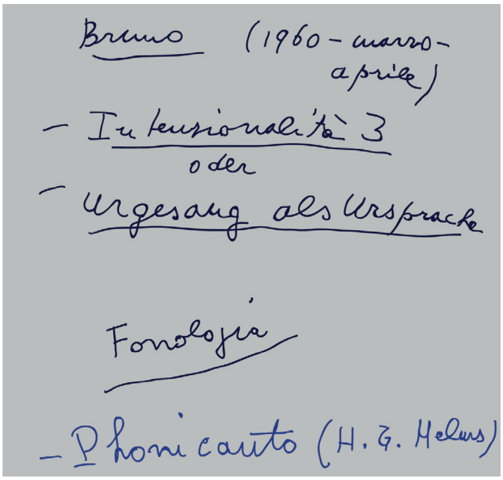
I° Marzo I960

CONSTELLATIONEN Bengt Hambraeus (Composizione per organo e Mus. Eltt.)
dal I° al I6/I0/59 - durata I0'00" - 66h.00'

DOS ESTUDIOS EN CONTRASTES di Hilda Dianda
dal 2 al 24/11/59 - durata 6'30" - 70h.00'

DIMENSIONI 2 di Bruno Maderna
dal 2/12/59 al 26/2/60(intervallato)
durata 19'00" 115h.00'

Figure 1. Transcription of the summary sheet of activities at the Studio di Fonologia Musicale dated 7 March 1960 (RAI, Milan).



Bruno (1960 - marzo - aprile)

- Intenzionalità 3
oder
- Urgesang als Ursprache

Fonologia

- Phonicanto (H. G. Helms)

Figure 2. Transcription of the sheet attached to the P22 tape (Rognoni Fund – Palermo).

Unfortunately there is no precise date on this tape; it is possible, however, to assume that it is very old; this is because the attached sheet, apart from the indication March-April 1960 as the date on which the tape was produced or, more likely, received by Rognoni, does not include the title *Invenzione su una voce*, which had probably not yet been chosen by Maderna at the time the tape was sent. Moreover, using a different pen, the title *Phonicanto* was added. The name was suggested for the composition by Helms to Maderna in a letter written in May 1960.[17] It seems clear that Maderna, at the time, did not inform Rognoni about his choice of calling the composition *Invenzione su una voce*, a name which was added later on the casing and on the reel but not on the accompanying sheet.

The title *Invenzione su una voce* appeared for the first time on 21 April 1960 in a RAI document for internal use (Figure 3), which includes a list of the 25 reels which Berio took with him for the American tour,[18] most notably the lecture-concerto in San Francisco on 2 May 1960.[19]

17 «Auch einen Titel für das Stück habe ich mir einfalle lassen: ich würde vorschlagen: // Phonicanto// eine Kombination also von griechisch /*phonē*/ (die Stimme) und italienisch /*canto*/». Letter by Hans G. Helms to Bruno Maderna, 15 May 1960, kept by the Rognoni Fund, University of Palermo. The same title *Phonicanto* also appears in some typewritten pages by Rognoni dated 1960 (research led to finding three different versions of the same typewritten text: two at the Rognoni Fund in Palermo and one at the RAI Archivio dello Studio di Fonologia musicale in Milan).

18 In actual fact the list includes as many as three reels for *Invenzione su una voce*: BD MI/15-44098, BU MI/15-44099 e BU MI/7½-44100. The shelf mark indicate that one copy is stereo (BD = *banda doppia*), while the others are monophonic (BU = *banda unica*); moreover the running speed of the first two is 15 ips, while the third has a running speed of 7.5 ips. It can be assumed that Berio did not know what tape recorders and reproduction systems would be available during his stay in the United States, therefore he opted for having several copies on hand with different technical characteristics.

19 Berio was accompanied by Cathy Berberian on the whole of his American tour.

Unita alla presente lettera alleghiamo l'elenco delle venticinque bobine (formato piccolo), contenenti i riversamenti di musiche elettroniche e frammenti di musiche strumentali, richiesi dal Maestro Berio e che gli serviranno per le conferenze che terrà nei prossimi mesi presso le Università degli Stati Uniti d'America:

1)	B.Maderna		Invenzioni	su una	voce	BD-	MI/I5=44099
2)	"	"	"	" "	"	BU-	" =44099
3)	"	"	"	" "	"	BU-	MI/$7\frac{1}{2}$=44I00

Il ricevente Luciano Berio

Milano,21/4/60.

Figure 3. Transcription of the RAI document with the list of the tapes which Berio took with him for the American tour, 1960 (RAI, Milan, internal use).

From this perspective it becomes possible to reinterpret the assumption made by Popoli about the later appearance of the title *Invenzione su una voce* compared to *Dimensioni II*, shortening the distance between their first appearance almost to the extent of overlapping: the title *Dimensioni II* was actually used for the first time on 9 April 1960, while the first documented version of *Invenzione su una voce* appeared just 12 days later. It almost seems as if these two titles were contemporaneous; what could the reason be for having two different titles for the same composition?

One possible assumption in response to that comes from the performance notes which the composer wrote for *Juilliard Serenade* (1971).[20] Maderna stated here the margins of action for the construction-performance of the composition left to the conductor (almost a composer on stage, who can arrange the order of the sections in the score): the work is divided into a series of sequences and structures using the letters of the alphabet. The *Serenade* can also be performed with the 'collage' *Tempo Libero I* – recorded on magnetic tape which contains audio fragments of *Dimensioni II / Invenzione su una voce*.[21]

20 Kept by Paul Sacher Stiftung in Basel.

21 See also "Towards an electronic 'global work'", in this book.

In agreement with the sound engineers, the recording may be added with the timing and intensity levels required. The live performance of *Juilliard Serenade* together with the magnetic tape for *Tempo Libero I* – once again a combination of instrumental and electronic dimensions – was called by Maderna *Tempo Libero II*.[22] The title changes according to the performance conditions: with or without a dialogue between the two dimensions. Hence the idea that, in the composer's intentions, the electronic part of *Dimensioni II / Invenzione su una voce* was actually just *Invenzione su una voce* – also bearing in mind that he continued to use the title *Invenzione su una voce* (or simply *Invenzione*) with reference to this electronic material also in later compositions, such as *Hyperion, Ages, Tempo Libero* (see Cossettini, Orcalli 2015; Badocco 2016),[23] in spite of its transformations; on the other hand, the production with live voice could actually be *Dimensioni II*, that is to say the true implementation of what Maderna called *Dimensioni*.

The evidence is still insufficient for a final resolution of this naming issue, which therefore remains a mere assumption. The element preventing a definite conclusion is exactly the use in concert settings of these two titles in a way which does not always match this idea: in the case of the first three concerts, our assumption is indeed confirmed (*Dimensioni II* with live voice, *Invenzione su una voce* tape along); but starting with the Darmstadt concert it seems no longer to apply. It is possible that the program for the evening performance entitled *Dimensioni II* might have been drafted several months before the actual concert, planning to have Cathy Berberian sing live on stage; given that she could not be there – either because of the extension of Berio's due or due to other commitments – the electronic part of the composition alone was performed. We are not yet fully aware of all the occurrences behind these events, but it seems clear that just after the performance in

22 This was also confirmed by Tiziano Popoli who says that the title results in a «nastro magnetico in abbinamento ad esecuzioni dal vivo: secondo l'indicazione del compositore l'unione di *Tempo libero* (prima versione) con la *Juilliard Serenade* dà origine a *Tempo libero II* e non è inopportuno sottolineare (per evitare un altro dei frequenti equivoci maderniani) che questo *Tempo libero II* è cosa ben diversa dal nastro elettronico *Tempo libero* (seconda versione)» (Popoli in Baroni, Dalmonte 1985, 293).

23 See also "Towards an electronic 'global work'" and "The quest for *Ages*, the radio-drama by Bruno Maderna and Giorgio Pressburger", in this book.

Darmstadt the composition started no longer to be called *Dimensioni II* also in those instances when Cathy Berberian was there to sing live – for example the performance in Warsaw in 1961 or Florence in 1968. The only case when *Dimensioni II* was used again (alongside *Invenzione su una voce*) was a concert in Florence in 1963, on the occasion of the event *Vita musicale contemporanea*; in this instance, however, the composition was once again performed in its electronic part alone – even though Cathy Berberian herself was on stage for the performance of *Circles* by Luciano Berio.

The reason for this change in approach is still unknown; in any case it is impossible not to notice the harshness of the German reviews on the Darmstadt (see Lèwinski 1960, Razumovsky 1960, Ochlman 1960, Knessl 1960). Below is just a sample from the most caustic one:

> Madernas "Dimensioni" (1960, Uraufführung) setzen den Versuch fort. Elektronische und instrumentale Klangmittel einander gegenüber zu stellen, zu denen noch die Stimme als Steigerungseffekt benutzt wird. Die Komposition ist für stereophone Wiedergabe angelegt und stammt aus Madernas Mailänder Studio. Dieses Kauderwelsch, das im Vogelhaus eines Zoos spielen könnte, mit Papageinegekreisch, glucksenden Lauten, Katzenmiauen, Gekicher, Gegacker, Pfeifen, Gelächter, Gequieke und Gedonner verstärkt durch Großstadtlärn, kann nur als Volksbelustigung und Clownerie gewertet werden; denn es ist das Ende dessen, was wir noch unter Musik verstehen (Wehagen 1960).

As a consequence of the strong criticisms made to the electronic version entitled *Dimensioni II*, it would be no surprise if Maderna had then decided to avoid using that title for subsequent productions of the work, also with the live voice. One year later the composition was staged in Warsaw with the title *Invenzione su una voce*[24] in the version with Cathy Berberian's live voice; this

24 The concert took place on September 21st, 1961 – as confirmed by the lists in the Historical Archives of the Autumn Festival in Warsaw (also in this case the list of contents includes the title *Dimensioni II / Invenzione su una voce* as opposed to just *Invenzione su una voce* which appears on the concert program) and by letters from Cathy Berberian – and not, as mentioned in Rodà 2009, on 21 September 1960. The mistake is definitely due to a typing error in the concert program kept at the Maderna Archive in Bologna, which actually reads 1960. The Warsaw version is shorter than the concert in Darmstadt. We do not know the

is also confirmed by the letter sent by Cathy Berberian to Leonard Stein on September the 10th, 1961: «this is probably my last letter to you in the next month or so. I'm leaving within three days for Warsaw and when I come back, I have 10 days before leaving for Paris to record "Circles" for Philips records and then on October 9th I begin my labor pains for Donaueschingen».[25] And also, on October 17th: «Warsaw was an interesting experience; although probably nothing in comparison to the exotic life in Brasil […]. I myself was not too happy at how I did the Maderna, although Cage and the Bussotti *Torso* with orchestra went splendidly. I think I had a personal success in Warsaw but they are still non sophisticated enough for the kind of music I performed».[26]

CONCLUSIONS

The indefiniteness in the title *Dimensioni II / Invenzioni su una voce* is a reflection of Maderna's approach to considering his compositions not as something complete in itself, but rather as continuously developing open systems, subject to being integrated, amended or reused. The words by Maderna himself, in an interview with Christoph Bitter in 1973, provide an insight as to the specific writing practices of the Venetian composer:

> Divento sempre più consapevole che nella vita non bisogna essere conseguenti, specialmente se si è compositori, artisti. Credo che si debba odiare la consequenzialità. Bisogna invece cercare di essere così naturali e vivi da poter seguire ed esprimere i diversi momenti del nostro organismo sia fisico che psicologico. Credo che la famosa consequenzialità seriale sia stata una

reason for such a drastic cut in duration (from nearly 19' to just over 11'); Maderna might have been affected by the strong criticism from Darmstadt which in some cases criticized this composition for being excessively long (see Knessel 1960, 303).

25 Letter by Cathy Berberian to Leonard Stein, 10 September 1961, Paul Sacher Stiftung (microfilm 163.1).

26 Letter by Cathy Berberian to Leonard Stein, 17 October 1961, Paul Sacher Stiftung (microfilm 163.1).

> delle più brutte malattie. [...] Allora era necessario essere unilaterali, anzi fanatici perché si doveva creare un nuovo inventario di possibilità da tenere a disposizione (Bitter e Maderna in Baroni, Dalmonte 1985, 117-118).

The issues concerning Maderna's composition are of course not merely limited to naming because they cover all aspects of the production process, to the extent that any analysis process becomes complicated (see Baroni, Dalmonte 1985).

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Towards an electronic 'global work'

Author's transcriptions of *Dimensioni II / Invenzione su una voce* by Bruno Maderna

Luca Cossettini

POSSIBILITIES AND CONSTRAINTS OF ELECTRONIC MUSIC ON TAPE

In 1955, at the dawn of the reflection about new electronic music, in the first issue of the journal *Die Reihe*, Karlheinz Stockhausen wrote that electronic sound becomes relevant only within the structural context for which it has been created (Stockhausen 1955; see also Koenig 1995, 99). Once an electronic composition has been completed, therefore, all 'preparatory audio materials' would thus need to be destroyed, because musical compositions and their materials are unique. In the 1960s, however, the 'philosophy' of *alea* and the information theory started to break into the European strongholds of musical structuralism. As a consequence, in Italy, also the composition symbolizing 'pre-designed' electronic experimentation in Milan, *Thema (Omaggio a Joyce)* (1958), ended up becoming a *unicum* in Berio's electronic production, as well as possibly also for the production at the RAI Studio di Fonologia Musicale in Milan. To understand the specificity of *Thema* it is interesting to read what Berio wrote in 1967 for a conference held at Harvard University whose title reflects a marked change in his musical approach, *Del gesto vocale*:

> Nessuno [...] può difendere una concezione dualistica del linguaggio. Nel linguaggio non abbiamo da una parte i concetti e la loro realizzazione acustica dall'altra. Nello stesso modo, non possiamo affermare che le convenzioni della comunicazione verbale (parole, grammatica, sintassi) costituiscono un dominio separato rispetto alle caratteristiche, rese ugualmente convenzionali o spontanee e non verbali, del linguaggio parlato (Berio 2013, 65).

The elements lost in the signifier/significance duality are: the implicit expressiveness of the gesture inextricably linked with an already acquired sense, the immediacy of para-linguistic elements of the human voice, and most importantly the context within which communication process takes place. A gesture, writes Berio, can exist only within a context, given or implicit, within which it acquires significance. When the context changes, so does significance because «ogni atto può avere una rilevanza differente a seconda che a scrutare il cielo sia un contadino o un villeggiante, o se a maneggiare l'ago sia un dottore o una spia» (Berio 2013, 61).

Thema (Omaggio a Joyce) is actually one of the rare experiments on phonetics at the Studio di Fonologia Musicale. Its subsequent production appears to be more focused on the immediately communicative aspects of the voice. Berio himself started to look for a first way out in the gesture, the re-introduction of corporeality, the intelligibility of words – or, on the contrary, intentionally making them unintelligible. For example in *Visage*, for electronic sounds and the voice of Cathy Berberian on magnetic tape (1961), his last composition produced in the Milan Studio, a sort of farewell and tribute to radio music, he added expressive components such as laughter, singing and crying as accompaniment to phonetic articulation. In 1961 the interest for linguistics underlying *Thema (Omaggio a Joyce)* had now shifted to phonetic structures, to the «carica simbolica e rappresentativa dei gesti e delle inflessioni vocali, con le 'ombre di significato' e le associazioni mentali che li accompagnano».[1] First Maderna in *Dimensioni II / Invenzione su una voce* (1960), then also Berio in *Visage*, tried to retrieve a communication element, without any post-Romantic *pathos*.

Other limitations soon became apparent: the fixing of the composition idea in an aural form on tape made it impossible to re-contextualize music as it was being played. The only context variation was thus the architectonic space in which the recording was reproduced; attempts were made to dominate even this variability through the control of multi-channel diffusion. This aspect was dealt with by Stockhausen in Cologne starting from *Gesang der Jünglinge*, then led Luigi Nono onto the path of *live electronics* in Freiburg in

1 From the presentation text of this work:
<http://www.temporeale.it/index.php?option=com_content&view=article&id=219%3A-visage&catid=35%3Aproduzione&Itemid=62&lang=it>, accessed 15 January 2015.

the 1970s: it was, as a matter of fact, the end of the electronic experimentation in Milan.[2] In the case of work where the sound director was left with the marginal task of ensuring the (impossible) transparency of the medium, reproduction became mechanical, which meant that an irreparable divide soon emerged between composition and listening.[3] Over time this hiatus became so large that even authors keen on the idea of unity in their work reviewed their compositions after many years, in order to restore or revisit them. Also Berio, on his part, felt the need to reprocess 'closed' work such as *Thema (Omaggio a Joyce)*. The restoration of *Thema* completed in the early 1990s, for example, was defined by Paolo Zavagna as an «updated version» (Zavagna 1992). The reasons for such a definition are certainly not of a philological nature, and they are possibly associated with the 'early aging' phenomenon which affected electronic music on tape. The audio carrier on which the work has been recorded resists direct access – in other words, its content

2 For an history of the RAI Studio di Fonologia in Milan see Santi 1984; Scaldaferri 1997, Donati, Pacetti 2002, Novati 2009.

3 Regarding the issue of obsolescence of electronic work, this is what Maderna told Aldo Maranca in 1965: «quanta percentuale di gusto dell'epoca, di abitudini, di allenata sensibilità auditiva, potrà rimanere attraverso il tempo? Questo è il problema nostro. […] La parola nel suo significato semantico è un elemento ben più preciso e valutabile della musica. La musica si riferisce a dei sentimenti, a degli stati d'animo, a dei momenti di natura psicologica, quasi "temperamentale" se si può dire così. E noi sappiamo proprio dalla letteratura che attraverso i secoli ci sono dei mutamenti a volte piuttosto rapidi; quindi alcune cose che sono drammatiche, possono risultare ben poco tempo dopo, assolutamente insigni canti e viceversa. […] Non credo che l'avvento del nastro magnetico possa portare un grande cambiamento di rapporti fra musica e storia, fra musica e patrimonio culturale di una civiltà. […] Mi sembra che la musica proceda con una rapidità piuttosto impressionante verso una evoluzione nel gusto, nel costume e nel modo di ascoltare prima di tu o e anche nel significato dei suoni, che impedisce una formulazione circa un giudizio sulla durata di un'opera, che […] attraverso il nastro magnetico potrebbe prolungarsi. […] Soltanto il tempo ci darà la ragione, ma ci sono già oggi alcune cose; basti pensare a certi particolari effetti di rumori scenici che non più di trenta, quaranta anni fa avevano un enorme significato e che oggi ci fanno semplicemente ridere, non per colpa della musica elettronica, ma perché per esempio è intervenuto il fenomeno della sonorizzazione nel cinema […]. Oppure perché è avvenuto che alcuni rombi per noi non significano più nulla. Il rumore dell'automobile era lacerante, spaventoso, per i primi che lo ascoltavano; oggi chiunque è abituato, è diventata una questione di costume, per cui per far paura alla gente, ci vuole ben altro che un rumore di automobile» (Sani 1995, 67).

is not visible nor audible for the 'naked eye/ear'; the audio document is silent without a technological interface. The interfaces, however, change with the typical speed of technology, and so does the acoustic sensitivity of the listener. For us, who are daily immersed in reproduced music, it is unthinkable and impossible to recover for example the surprise and impact which audio technologies, when they first began to be used, might have had both in the composers and in an unaccustomed audience. It is therefore understandable that composers, first and foremost, would feel the need to 'update' their electronic work – also in those cases where performance difficulties caused by the obsolescence of the reproduction media which produced them were not an issue – in order to make allowance for changed forms of perception. Berio seems to have become aware of this already in 1958; not only did he hope that the development of media would soon lead to overcome the antinomy of the 'two dimensions', he also postulated a new type of listener, who in the future would no longer need to close his or her eyes and follow musical dreams (Berio 2013, 264), but could rather become an active, conscious and involved observer of the action to become part of the creation process in the musical 'sense'. For Berio the solution was Tempo Reale in Florence. On the contrary, it was perhaps the fear that the multiplicity of materials produced by the work done in electronic music studios could be interpreted as a lack of authorial intentionality that convinced Stockhausen to independently establish a canon for his work, through a huge editing effort he conducted in person at the Stockhausen Foundation.[4]

4 See <http://www.karlheinzstockhausen.org/pdf/CD_order_form_2015_english.pdf>, accessed 15 January 2017.

Bruno Maderna's path. *Dimensioni II / Invenzione su una voce*.

In 1960, with *Dimensioni II / Invenzione su una voce* Maderna finally confronted the issue of the voice. 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 (Figures 1 and 2).

The idea of giving up on a text with specific meanings – which had instead been used for *Thema (Omaggio a Joyce)* – and therefore the choice of the vocal materials themselves, show that attempts were being made to establish a distance in respect of Berio's experimentation with Joyce's text. The problem of the relationship between text and sound had been dealt with by Berio through forms of regression, to the extent of making language and music converge at a pre-constitutive levels of organized language. On the contrary, Maderna treats the recorded voice like a sound source, controlled by the clearly defined contours of the phonetic symbol sequence which was provided to him by Helms. But the compositional idea of *Dimensioni II / Invenzione su una voce* don't lie 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. This analysis perspective on his music with electronics, perceived by some critics,[5] is concretely supported today on the basis of a systematic study of sources carried out by MIRAGE which shows a surprising number of author's variants (see Cossettini, Orcalli 2015): the audio documents attributable to *Dimensioni II / Invenzione su una voce* show that an unimaginable amount of work has been done on the recordings.

5 Already in 1989 Alvise Vidolin hit the mark when he wrote that is: «più interessante porre l'accento sul metodo del fare musicale di Maderna. La sua tecnica compositiva [...] si sposa in maniera perfetta con i processi di manipolazione e montaggio dell'elettroacustica per diventare un metodo di lavoro assolutamente originale; la possibilità di riprendere i materiali, di "giocarci sopra", di rimontarli e ritrattarli anche in tempi successivi, trasformano i diversi lavori in una sorta di opera globale» (Vidolin 1989, 205).

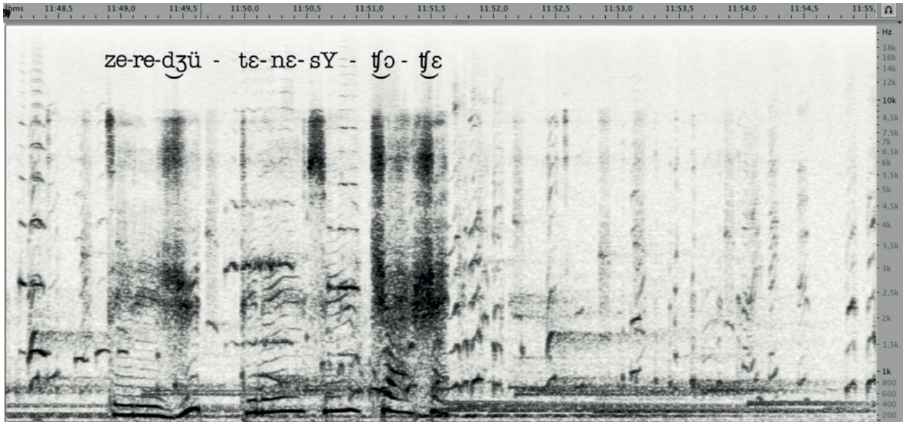

Figure 1. Bruno Maderna, Dimensioni II / Invenzione su una voce *(1960). A segment where the phonemes* ze-re-ʤü-tɛ-nɛ-sY-ʧɔ-ʧɛ *are recorded on tape by Cathy Berberian (Source:* RD1*).*

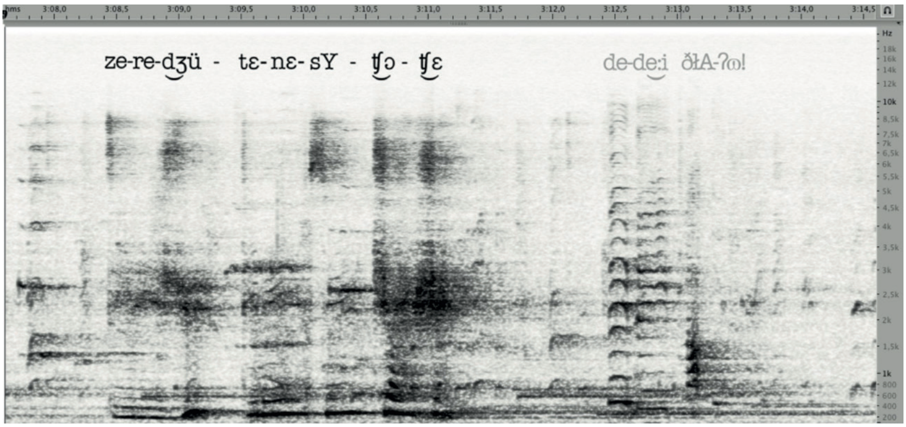

Figure 2. Bruno Maderna, Dimensioni II / Invenzione su una voce *(1960). The same segment where the phonemes* de-de : i ðłA-ʔω! *are sung live by Cathy Berberian (Warsaw Autumn International Festival of Contemporary Music, September 21st, 1961. Source:* RD9*).*

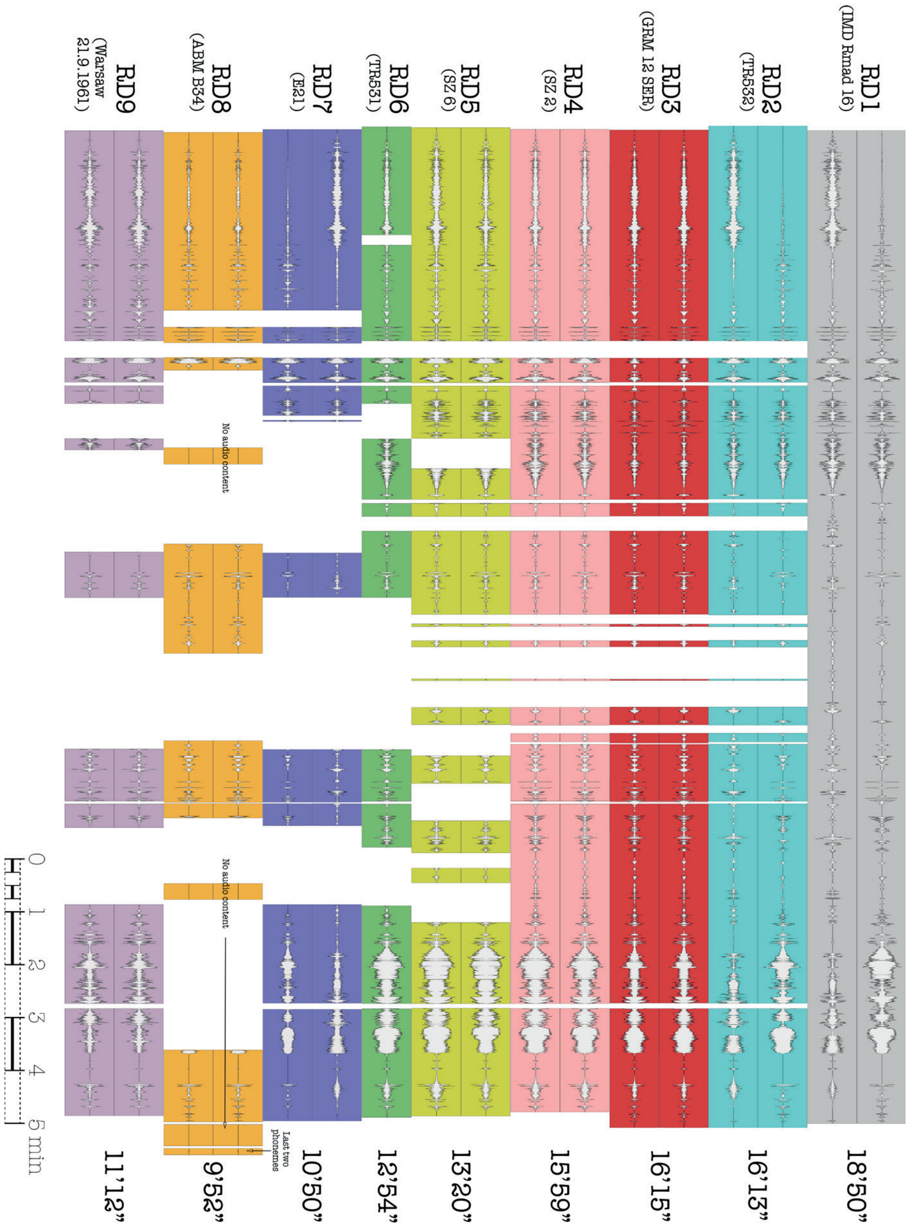

Figure 3. Nine significant sources of Dimensioni II / Invenzione su una voce *(catalogue numbers, waveforms, durations). Audio content comparison. Graphic design by Daniele Badocco.*

Figure 3 shows the comparison among nine significant sources. Audio files, obtained by digitizing the signal contained on the original carriers, have been split at the editing point and then vertically aligned. Gaps show the material removed at any physical revision of the original tapes. The timeline is significant: from 1960 to 1972 Maderna devoted special attention to this work, after it was first performed. He worked on the tapes to adjust their duration to the various concert settings – also affected by the increasingly less assiduous presence of Cathy Berberian – incessantly changing also its name;[6] he finally went back to parts of the composition and added them to his later work: *Hyperion, Ages, Tempo Libero*.

The succession of productions of *Dimensioni II / Invenzione su una voce* is typical for the practice of the Venetian composer; it is not attributable to the aesthetics of *opera aperta*, because the endless variety of production is not a result of involvement on the part of the public or of other composers, as happened for example in *Scambi* by Henri Pousseur (Pousseur 1975), but rather of a repeated action by the author of the tape (supported by his assistant Marino Zuccheri). In *Dimensioni II / Invenzione su una voce* Maderna did not give up full authoriality. This can also be seen by analyzing the types of intervention. A version lasting ~ 19' was gradually shortened by the author through subsequent cuts; a second version lasting ~ 16' (presumably created at the same time as the 19' one and designed to be performed without live voice) was transferred almost unaltered to the 'Italian'[7] versions of *Hyperion* along and then mixed with the final part of *Le Rire* (Figure 4); mixing and recombination procedures, on the other hand, can be found in *Hyperion en het geweld*, in *Ages* and most notably in *Tempo Libero* where the sound materials undergo an extreme fragmentation process (see Cossettini, Orcalli 2015).

6 See "Bi-dimensional inventions", in this book.

7 La Biennale in Venice 1964 (RH1 and RH2), Feste musicali in Bologna 1968 and 1972 (RH3).

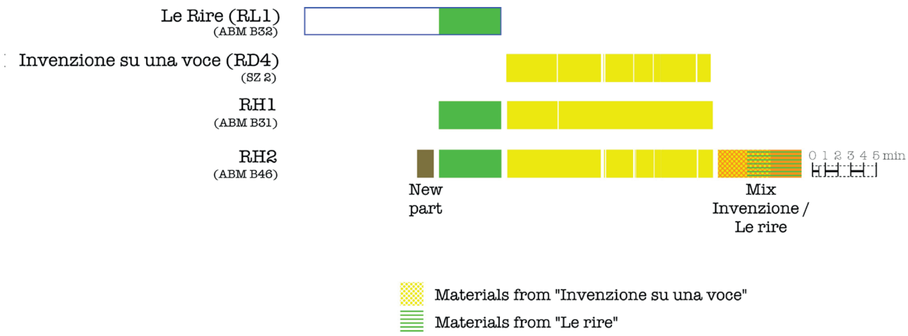

Figure 4. Analysis of the electronic parts of Hyperion *(RH1: 18-19 July 1968, Feste Musicali in Bologna; and RD2: 6 September 1964, La Biennale in Venice 1964). Comparison with the 16' version of* Dimensioni II / Invenzione su una voce *(RD4) and* Le Rire *(RL1).*

The fact that the reprocessing work lasted more than a decade is related to the specificities of the medium used by the composer. Electronics allow for the addition of a new voice, which however does not have the same immediate variability as live voice; nevertheless the electronic medium makes it possible to act on the communication process: Maderna fully understood the significance of the possibility of getting rid of the performers and their mediation role between music and audience. Through electronics he fixed the interpretation of the work, that is to say sound itself. Once recorded on tape, however, sound – using the technological methods available at that time – cannot be instantaneously changed. Therefore if the composer also wishes to be the performer, in order to renew the interpretation act with each performance, it is possible to use studio manipulation, editing, copying processes, mixing and to produce new recordings. This is Maderna's approach to electronics: restating, also within the new media context, that the ultimate purpose of music, its essence, consists in the possibility of recreating it by performing. From this perspective it is thus possible to review the dramaturgy of the 'Italian' versions of *Hyperion*: the mechanical order impersonated by the segment of *Dimensioni II / Invenzione su una voce*, closed, unchangeable, renews the conflict with live improvisation by a human performer (Severino Gazzelloni), provided that it is part of the interplay between acoustic and electronic dimension.

DIMENSIONI II / INVENZIONE SU UNA VOCE AND *HYPERION* TODAY

The expectation of defining *Dimensioni II / Invenzione su una voce* and *Hyperion*, more specifically their electronic parts, based on the set of their versions clashes with the complexity of the tradition: this work cannot be seen as a series of independent items, but rather as part of a more general composition process, which covers a substantial part of Maderna's production. Our work was therefore focused on reconstructing the innumerable transformations introduced by the Venetian composer to the sound fabric of the audio documents. Reviewing the history of *Dimensioni II / Invenzione su una voce* following the audio evidences has allowed us to discover the distinctive traits of Maderna's electronic music production at Fonologia. 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 a new connectivity among different Works. Berio looked to the future with a view to technological developments; Maderna's attention, on the other hand, as a great orchestra conductor, was fully focused on the present, on musical expressiveness here and now. This is why, for *Dimensioni II / Invenzione su una voce*, he was not satisfied – as Berio had done in 1958 for *Thema (Omaggio a Joyce)* –, with a single production of the work: he wanted to 'interpret' and 'perform' the tape again, after the creation of the master. To do that he had to change the input of his system: no longer Cathy Berberian performing Helms' phonemes, but the master tape itself – or other preparatory materials – had to be manipulated. What previously was an output of the system had to become its input. Thus, the system became 're-injective', a feedback was instituted and it created variance and multiplicity. *Dimensioni II / Invenzione su una voce* consists in its creation process within a complex system. The distance from Stockhausen's view of electronic music which is 'unmoving' and set forever in the material frame of the magnetic tape becomes clear and explicit in Maderna's approach. It is reaffirmed in the composer's documented legacy.

Transcribing is a manifestation of writing, an artifice which gives illusory freedom but works by reduction. In order to escape the determining power of writing, Bruno Maderna's generation saw a way out in *alea* – in all its meaning, most notably that of controlled *alea* – which the author did not hesitate to embrace during those same years. An example of this are the performance notes provided by the composer for the *Juilliard Serenade* (1971):

> La *Juilliard Serenade* (*TEMPO LIBERO II*) – è commissionata dalla Juilliard School of Music di New York – è articolata in una serie di sequenze e strutture indicata dalla successione di le ere dell'alfabeto. Le sezioni (sequenze e strutture) sono di due tipi: a MASSIMO CONTROLLO – da eseguire rigorosamente, così come stanno scritte –; a CONTROLLO RELATIVO – da eseguire con una certa libertà ('a fantasia' come avviene nelle 'cadenze' o nei 'soli').
> La successione delle sezioni è lasciata alla interpretazione del dire ore d'orchestra che potrà, inoltre, decidere se sovrapporle o meno: per esempio A1+B oppure B+C, A1+B+C ecc. […]. Questa Serenata, dunque, viene non solo interpretata ma quasi 'ricomposta' dal dire ore d'orchestra il quale, durante il periodo di prova, dovrà 'sentire' il desiderio e la necessità formale di accostare, sovrapporre, articolare il materiale sonoro a sua disposizione.
> La *Serenata* può anche venire eseguita insieme al 'collage' *TEMPO LIBERO I* – registrazione su nastro magnetico – […]. Previo accordo con i tecnici, egli potrà far intervenire la registrazione nei momenti e con le intensità desiderati. L'autore raccomanda di misurare ed equilibrare esattamente il volume sonoro della registrazione e del gruppo strumentale. È preferibile avere una preminenza del gruppo strumentale, il quale dovrà sempre essere presente e condurre il giuoco di questo *TEMPO LIBERO II*.[8]

In *Juilliard Serenade*, which played with electronic parts is transformed into *Tempo Libero II*, we finally find the almost unrecognizable traces of the phonemes by Helms originally used for *Dimensioni II / Invenzione su una voce* and then added to the tapes of *Tempo Libero I*.

The variety of sources and the specificity of Maderna's composition raises one fundamental question for his music: how can this work be reproduced today in concert or on recorded editions?

For compositions passed on via multiple versions such as *Dimensioni II / Invenzione su una voce* and *Hyperion* the simplest and most careful solution would be the documentary approach: in the light of the study of the tradition, taking on the responsibility of choosing one version, explaining the reasons (see Orcalli Cossettini 2015). There is also another way, however.

8 Note kept at the Paul Sacher Stiftung in Basel.

In an interview with Aldo Maranca in 1965, Maderna outlined the general characters of the production process of electronic music in a studio. The composition element is expressly regarded here in the same way an interpretation act:

> Va sottolineata un'unica qualità del lavoro sia del poeta, sia del compositore, sia del pittore e cioè anche se il rapporto è dire o tra pensiero dell'opera d'arte e sua realizzazione, vista oppure ascoltata, questo rapporto ha sempre un passaggio in tutti e tre i casi. Un passaggio che è, diciamo così, di interpretazione. Da quel che mi è parso di capire nella pittura e nella letteratura mi sembra di poter dire che avvenga anche in queste due forme diverse di interpretazione artistica lo stesso passaggio che avviene più o meno nel rapporto tra compositore e musica elettronica. C'è un primo stadio di vera e propria realizzazione dei contenuti e del materiale, poi c'è una sistemazione del materiale, una forma che viene data a questo materiale, di cui una percentuale si potrebbe proprio quasi ascrivere all'atto interpretativo di essa forma. Cioè sembra quasi che a un certo punto del lavoro, il compositore, il poeta o il pittore, passino, e questa sarebbe la forma finale, a una interpretazione, a una rappresentazione interpretativa del proprio pensiero (Sani 1995, 68).

These words bring to mind what Ferruccio Busoni wrote in 1910 in *Abbozzo di una nuova estetica della musica* where he stated that:

> Anche l'esecuzione di un pezzo è una trascrizione, e anche questa non potrà mai far sì che l'originale non esista – per quanto libera ne sia l'esecuzione. Giacché l'opera d'arte musicale sussiste intera e indenne prima di risuonare e dopo che ha finito di risuonare. È insieme dentro e fuori del tempo, e la sua essenza è quella che ci può dare una tangibile rappresentazione del concetto dell'idealità del tempo, altrimenti inafferrabile (Busoni 1977, 52).

And also:

> Perché vedete, i milioni di melodie che un giorno risuoneranno esistono sin dall'inizio, sono pronte, aleggiano nell'etere, e con loro altri milioni di melodie che non saranno udite mai. Basta tendere la mano ed eccovi un fiore, un soffio d'aria marina, un raggio di sole: evitate la routine perché essa arriva solo a ciò che riempie la vostra stanza, e sempre alle stesse cose: diverrete

> così pigri che non vi alzerete quasi più dalla vostra poltrona e prenderete solo ciò che vi sta a portata di mano. Mentre milioni di melodie esistono sin dal primo principio e aspettano di manifestarsi! (Busoni 1977, 59)

Maderna has showed us these new 'melodies', he adapted them to the technological system in which he was working at the time, he has given us innumerable interpretations/transcriptions of them. The study of sources gives us information about his *modus operandi* in the electro-acoustic music laboratory. Having abandoned the idea of 'unified' and 'standardized' work, and embraced the vision of a wonderful multiplicity to which Maderna himself had hinted, would it then not be possible think of 'restarting' the system also without its author? Or better to start new technological systems and create new 'transcriptions' of the work based on the materials which the composer has left us? 'Getting up from the couch' and being sufficiently brave to make one's own authoriality overlap with that of the Maestro, in the same way as Busoni masterfully did with Bach? In actual fact something similar has been done, with awareness and undeniably valuable artistic results, also by Peter Eötvös for his reproduction of *Hyperion* without electronics, now published by Suvini Zerboni (Maderna, Eötvös, 1990.).

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SOURCES[9]

Audio sources of Dimensioni II / Invenzione su una voce *cited in the paper*

RD1: Darmstadt, Internationale Musikinstitut Darmstadt Rmad 16, [s.a.]. Magnetic tape, ¼", [?, unknown speed], 2-track, stereophonic.

RD2: Florence, Tempo Reale Archive TR532, [s.a.]. Magnetic tape, ¼", 15 ips, 2-track, stereophonic.

RD3: Paris, GRM Archive 12 SER, [s.a.]. Magnetic tape, ¼", [?], 2-track, monophonic.

RD4: Milan, Suvini Zerboni Archvie SZ2, [s.a.]. Magnetic tape, ¼", 15 ips, 2-track, pseudo-monophonic.

RD5: Milan, Suvini Zerboni Archive SZ6, [s.a.]. Magnetic tape, ¼", 15 ips, 2-track, monophonic.

RD6: Florence, Tempo Reale Archive TR531, [s.a.]. Magnetic tape, ¼", 15 ips, full track, monophonic.

RD7: Milan, RAI Archive E21, [s.a.]. Magnetic tape, ¼", 38 cm/s, 2- track, stereophonic.

9 For a full review see Cossettini, Orcalli 2015.

RD8: Bologna, Bruno Maderna Archive B34, [s.a.]. Magnetic tape, ¼", 7.5 ips, 2-track, stereophonic.

RD9: Warsaw, Polish Composers' Union Archive, [s.a.]. Compact Cassette. Recording of the concert of 21 September 1961, Warsaw Autumn International Festival of Contemporary Music.

Audio sources of Hyperion *cited in the paper*

RH1: Bologna, Bruno Maderna Archive B31, [s.a.]. Magnetic tape, ¼", 7.5 ips, [?], monophonic.

RH2: Bologna, Bruno Maderna Archive B46, [s.a.]. Magnetic tape, ¼", 7.5 ips, 2-track, monophonic.

RH3: Bologna, Bruno Maderna Archive B67, [s.a.]. Magnetic tape, ¼", 3.75 ips, [?], monophonic.

Audio sources of Le Rire *cited in the paper*

RL1: Bologna, Bruno Maderna Archive B32, [s.a.]. Magnetic tape, ¼", 7.5 ips, 2- track, stereophonic.

Y entonces comprendió by Luigi Nono: spatialization of sound and theatrical practice

Nicola Buso

Luigi Nono designed and produced *Y entonces comprendió* between October 1969 and January 1970. The author described his composition as follows:

> Il materiale di questa composizione è basato unicamente sulla voce umana usata con testo, suoni puri in varie elaborazioni elettroniche in modo da formare l'asse continuo formante della composizione. Solo nella seconda parte ho adoperato anche materiale metallico ed elettronico e nel quinto episodio ho inserito tre citazioni da *Non consumiamo Marx* e la voce di Fidel mentre legge l'ultima lettera a lui indirizzata dal 'Che' Guevara. Nell'esecuzione si sovrappongono tre piani acustici: voci dal vivo (le sei voci e parte del coro) – parte del coro, unitamente a frequenze del generatore, elaborata direttamente con filtri e modulatore a anello – voci su nastri magnetici. Il lavoro di sperimentazione, di ricerca, di registrazione iniziale delle voci, è avvenuto sempre in vera collaborazione e partecipazione attiva con le sei interpreti e con il tecnico Marino Zuccheri (tecnica varia nell'uso dei microfoni). È seguito il lavoro di sperimentazione, di scelta, di elaborazione, di composizione presso lo Studio di Fonologia della Rai di Milano. L'uso di direzionatori acustici, appositamente costruiti dal tecnico Giovan Battista Merighi, permette il superamento della staticità meccanica delle fonti di riproduzione (altoparlanti), applicazione attuale della tecnica spaziale dei 'cori spezzati' e un movimento, nella riproduzione dei nastri, continuamente libero spazialmente ma scelto e deciso tecnicamente, espressivamente in base alle esigenze tecniche espressive delle cinque parti della composizione, cui concorre in modo significante (Nono 2001a, 471).

The author's description highlights the dominant role of the human voice, the stratification of different acoustic levels, the working method based on collective collaboration, the use of the magnetic tape. The spatialization of different acoustic levels is underscored and clarified by sound spatialization.

Designing a composition as collective experience means that the author is faced with the specific characteristic of each performer and may work directly in contact with the specificity of sound materials, as opposed to starting from an abstract project: this is the working method which Nono had already come across when he entered the RAI Studio di Fonologia Musicale in Milan, and with *live electronics* practice in Freiburg:

> Notammo allora, Zuccheri e io, un fatto abbastanza singolare (che sarebbe poi risultato anche durante il lavoro allo Studio di Friburgo con Peter Haller e Rudi Strauss), cioè che il materiale conteneva, esprimeva, proponeva da sé alcuni principi compositivi. Sono i materiali, i segnali stessi a proporre, a richiedere vari tempi di durate di ascolto e diverse possibilità di combinazione e di spazialità (Nono 2001B, 527).

As a consequence, approaching *Y entonces comprendió* means encountering a working method based on listening, which involves not only the use of technological equipment, but also (most importantly) the practice revolving around such equipment.

The prevalence given to listening and to each performer's specific characteristics, with the focus being shifted towards concrete practice and the individuality of sound materials, makes it difficult to hand over experimentation to writing and to commit the results of teamwork to paper.

Nono drafted the score for the chorus part (Nono 1970) on squared paper; on the *x* axis each small square is considered to last one second, the *y* axis – on the other hand – shows the frequency regions, modulated as high (a), central (c), low (b), which are then connected by arrows and segments; dynamic notation is in standard form. The chorus section, which is in fact limited to the final episode, may be sung live or recorded on tape: the magnetic tape of the final episode actually includes two variants: with or without chorus.[1] Nono thus drafted a score for the chorus but did not get as far as drafting a score either for solo voices or for sound direction. There is actually no score for solo voice, nevertheless there are some 'separate parts': these are notebooks put together by the female singers and actresses during

1 See "The critical edition of the electronic part of *Y entonces comprendió* by Luigi Nono" in this book.

the work done at Studio di Fonologia Musicale with the composer and sound engineer, now kept at the Luigi Nono Archive in Venice.

The writing that characterizes these 'part notebooks' is neither autonomous nor complete in itself: they are notes jotted down by osmosis with the live practice of concert performance; their signs draw life from practice, they are testament to the mutual interaction between composer and performer. Looking at the covers of the 'part notebooks' used by Liliana Poli, Mary Lindsay, Gabriella Ravazzi, Kadigia Bove, Elena Vicini and Myriam Acevedo no indication is given as to the voice (soprano, …, actress, …), but rather the names of the performers because Nono does not work on the voice of an abstract soprano but on the specific characteristics of Elena Vicini, etc. By not working on abstract vocality, but on the actual specificity of a voice, the composer does not 'pre-scribe' a part, but rather produces with the performer notes and instructions following common practice. Listening proliferates: the composer listens to the specific characteristics of each individual voice, and each performer listens to the instructions suggested by the composer based on listening to the performer's characteristics; a mechanism is thus established between composer and performer based on retroaction; composer and performer, however, also interact through the electroacoustic medium – i.e. the environment – varying microphone use technique, so that often the sung-spoken texts were filtered in their harmonic spectrum.

Let's leaf through Poli's notebook (Figure 1). The running of the magnetic tape is represented by a horizontal line: the performer has to 'get' the tone from the tape, then sing at the pitch offered by the tape, as confirmed by a comparison between the spectrogram of the master tape for the record edition and the spectrogram of the magnetic tape (Figure 2).

The osmosis between live voices and tape is underlined by the recurring presence of arrows which connect the two dimensions and by verbal indications («prendi suono dal nastro»): not only does the magnetic tape mark the start of live sections, it also suggests the pitches at which to sing: listening to the tape is the basis for concert production. In summary, Liliana Poli does not see the note to be sung written on the score, she hears it on tape: there is a shift from reading to listening.

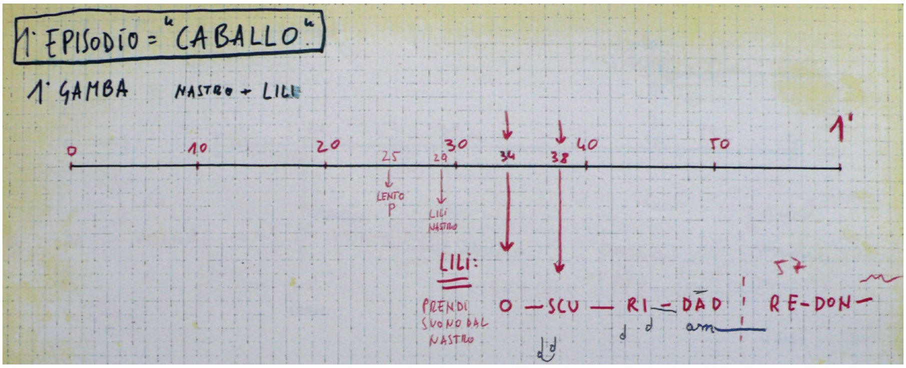

Figure 1. Page one of Poli's notebook. Source: ALN (Luigi Nono Archive) 35.09.01/01-22.

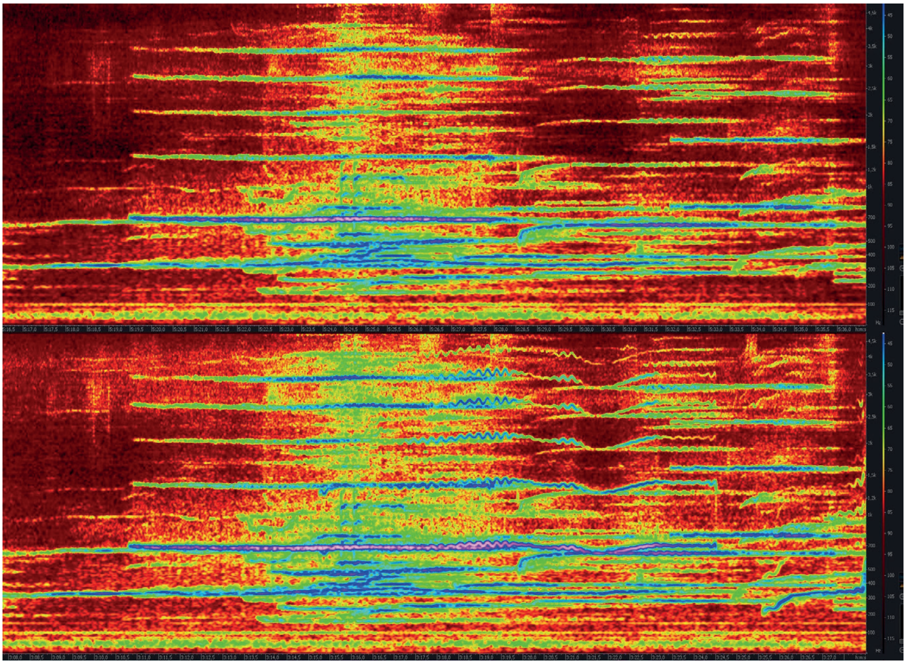

Figure 2. Above: spectrogram of the quadraphonic magnetic tape (mono mixdown) alone (MI RAI Q33); below: mix of live voices and the electronic part (mono mixdown of MI RAI Q34). The element not in common between the two spectrograms is the live voice of Liliana Poli, 28 seconds after the beginning of the composition.

The constant comparison with the material, always open to new listening possibilities is confirmed, for example, also by the choice of microphones: on the back of a composer's sketch (ALN 35.11/01-05-07) a diagram of the audio system designed for *Y entonces comprendió* is drawn, as well as a black felt-tip pen draft of the list of audio materials to be used: «ALT. ALTEC 50 [wts] / AMPLI. MC.INTOSH / MICRO: NEUMANN U67».

Neumann U 67 is a variable polarity pattern microphone (omni-directional, cardioid, bi-directional, Figure 3); looking at the frequency response patterns, and at the microphone polar diagrams, it appears that it is very well suited to returning the vocal gesture and the movements of the female performers in front of the membrane, which is appropriately described by Nono when he talks about varying microphone use technique.

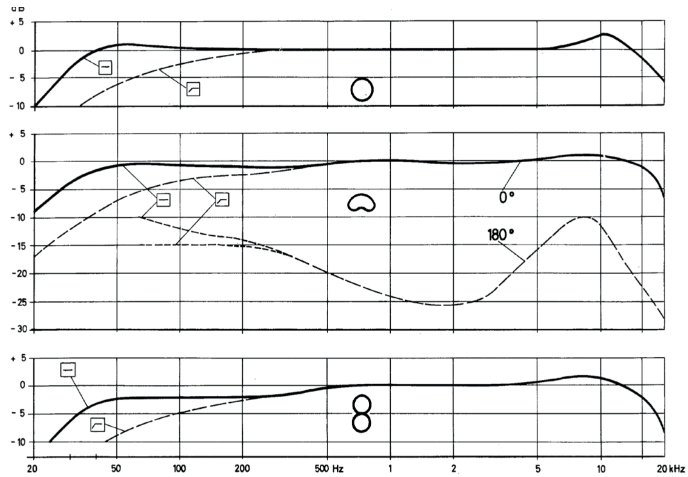

Figure 3. Frequency response of the Neumann U 67 *microphone (Brochure U 67 1966)*

Changing the polar configuration of the microphone and/or the incidence angle of the signal (voice) on the membrane, the frequency response of the microphone itself varies: a live performer can control through motion (standing closer, further away, at different angles in respect of the membrane itself) the individual timber, interacting with the microphone; a symbiotic relationship is thus established between voice and microphone, very similar to the one between a musician and the instrument being played.

THE SPATIALIZATION OF SOUND IN *Y ENTONCES COMPRENDIÓ*

On more than one occasion Nono underscored the importance of the spatiality of sound in composing *Y entonces comprendió*, also with regard to his subsequent research work. Says Nono to Enzo Restagno:

> [E.R.] *In questo lavoro come erano trattate le voci rispetto al nastro?*
>
> [L.N.] Continuavo nella tecnica del confondere le voci dal vivo con quelle elaborate e trasformate su nastro e avendo disposto altoparlanti in tutta la sala riuscivo a ottenere passaggi e trasformazioni continue tra le fonti sonore dal vivo e quelle elaborate. Come vedi si tratta di una tecnica che allora mi occupò molto nello Studio di Milano e che avrebbe trovato una piena attuazione solo molto più tardi, grazie alle attrezzature del live electronics dello Studio di Friburgo (Nono 2001B, 531).

Looking at the position of microphones and loudspeakers in a diagram included among the sketches it appears that the microphones are to be positioned between the loudspeakers used for magnetic tape amplification and those used for live voice amplification; a further diagram then shows the following positions:

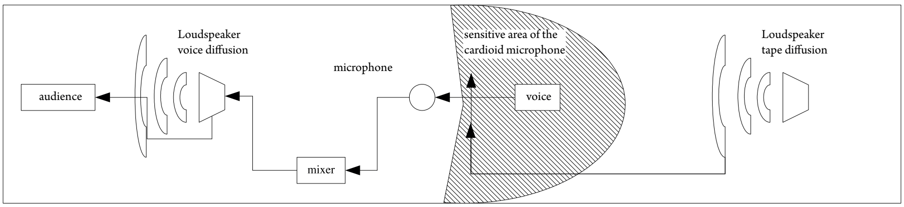

Figure 4. Diagram of the microphone/loudspeaker position in Y entonces comprendió. *Source: ALN 35.11/01-05-07 (transcription).*

This position leads to conclude that the microphone is used selecting a polar configuration of the cardioid type, in other words it is only sensitive to the semi-sphere placed 'before' it, on the other hand it appears to be essentially insensitive to the tones which reach it 'from behind'; Figure 4 is a diagram of the sensitivity area of the cardioid in the crescent drawn with dashed oblique lines; the loudspeaker that amplifies the microphone signal directs the sound towards the audience, while at the back the cardioid microphone directs its sensitivity in the opposite direction: because of the loudspeaker-microphone position and of the cardioid polarity of the microphone the two electroacoustic transducers look in opposite directions, minimizing the risk of feedback. If the microphone looks in the opposite direction compared to the loudspeaker which amplified the voice live, at the same time it looks straight in the direction of the loudspeaker sending out the magnetic tape. The microphone will thus pick up both the live voice signal and the magnetic tape signal: the loudspeaker that amplifies the microphone signal will therefore send out both the voice and the electronic part; this means that the magnetic tape is amplified twice, because it is sent out by the loudspeaker to which the tape track is assigned, as well as by the loudspeaker amplifying the microphone signal. With this amplification of the live voice together with the tape on the microphone, voice and tape overlap: the result is a technique based on confusing live voices with those processed and transformed on tape which Nono pursued both in Milan and in Freiburg.

Let us now move on to the example of voice and tape interaction mentioned above, and look at how the signal is distributed in a different way on the four tracks (Figure 5).

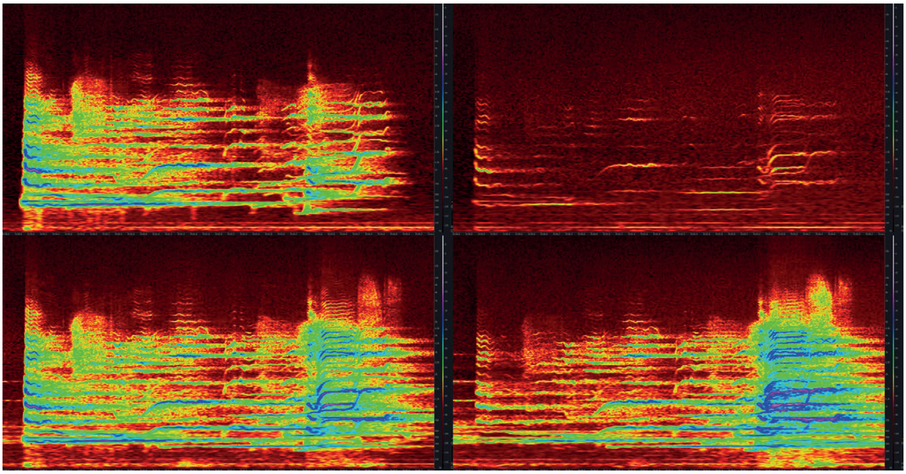

Figure 5. Distribution of signal energy between the four tracks on tape MI RAI Q33.

The four tracks should be assigned to four different loudspeakers placed in the room around the audience. The different signal energy distribution between the four tracks translates into the energy distribution from the signal across space. The tape is distributed through space, it is sent out in the room, and the voices are guided by the tape in their live interventions; the latter rely on listening to the tape, and listening to the tape depends on the sound distribution across space (a loudspeaker is heard clearly if it is close, with more difficulty if it is further away); a fundamental factor is the voice-loudspeaker relative position.

> La diffusione in sala con altoparlanti variamente piazzati, in rapporto alle sei voci (ciascuna con microfono diretto), considera lo spazio, ancora 'uniforme-rettangolare', con vari percorsi itineranti e 'componenti' la diversità dei segnali-suoni. La percezione attiva si complica, certo, ma viene 'provocata' dalla pluralità delle fonti e dalla pluridimensionalità della diffusione acustica (Nono 2001a, 390).

Space is a decisive element in terms of performance as well as of composition:

> Occorre poi sviluppare, come ancora non è stato fatto se non in minima parte, l'elemento della spazializzazione. Al concerto si piazzano gli altoparlanti in un modo particolare, ma questo riguarda la diffusione, non il processo compositivo; è quest'ultimo, invece, che deve tener conto dello spazio come elemento essenziale. Oggi è necessario pensare alla composizione *nello spazio* (Nono 2001b, 364).

The spatial parameter comes into play in the mutual collaboration between composer and performer, not only when music is played, but also while it is being composed: when Alessandro Tamburini expressly asked him about the role of space in his approach to poetics, Nono significantly hinted to the world of theater:

> [A.T.] *L'interesse per lo spazio, del resto, non è una novità per lei, che utilizzava spazializzazioni, oltreché l'idea di comporre 'per' uno spazio preciso, fin da* A floresta é jovem e cheja de vida*, del 1966 e con* Y entonces comprendió *del 1970. Come è nato in lei questo spiccato interesse per lo spazio?*

> [L.N.] Ci sono stati molti motivi e molte esperienze che mi hanno stimolato in questa direzione: il teatro di Mejerchol'd e quello di Gropius, lo spazio e il modo in cui veniva utilizzato nel teatro barocco, poi naturalmente San Marco e la scuola veneziana, e gli studi che Bruno Maderna mi fece fare in proposito (Nono 2001b, 366).

The choice of working on the specific features of individual voices itself could lead to writing issues as regards the final draft of a score; the result of the choice of focusing on the individual specificity of each voice and especially on its listening relationship with other voices, with the electro-acoustic system and with space, in the specific case[2] of *Y entonces comprendió* is the absence of a core: the notebooks ('part notebooks') guarantee the margin of freedom required by the inevitable (and, from Nono's perspective, beneficial) change in listening conditions; these notebooks are more similar to an actor's script and to a theater director's notebook then to a musical score: the reference to theater is relevant not (only) in poetic but – most importantly – in practical terms.

THE THEATRICAL ELEMENT

Nono's attention to theatrical practice already shows in the Darmstadt experience, in respect of the *vexata quaestio* of improvisation; this is where Nono finds an interpretation patters for actors' improvisation, as it was practiced in the Italian *Commedia dell'arte*:

> Ma queste giustificazioni, come sono state presentate qui a Darmstadt, ricevono la loro principale attrattiva da una fraseologia infarcita di aggettivi come 'libero' e 'spontaneo'. In verità il concetto tecnico che può giustificare questo frasario è il concetto antichissimo di 'improvvisazione'. [...] Un genere di improvvisazione tecnicamente affine lo si trova nella commedia dell'arte: le azioni delle commedie erano allora ridotte a poche indicazioni

2 Textuality in Nono actually takes many different forms, see for example Morelli 2003.

> sceniche riferite a situazioni caratteristiche dei rapporti tra i personaggi, e determinavano lo spazio entro il quale l'attore poteva liberamente improvvisare il dialogo e l'azione (Nono 2001A, 51-52).

Improvisation, though guided, is one of the underlying elements in the collective experimentation work, both at Studio di Fonologia Musicale and in the Freiburg studio.

The points of reference for Nono, at that time as well in the future, were Vsevolod Ėmil'evič Mejerchol'd and Erwin Piscator:

> Piscator lo avevo conosciuto, subito dopo il suo rientro in Germania, al termine di un concerto alla Radio di Amburgo, nel 1954, nel quale Bruno aveva eseguito anche musiche mie. Mi trovai improvvisamente davanti uno dei personaggi che maggiormente avevano ispirato la mia immaginazione. Gli chiesi, tra l'altro, di poter finalmente leggere il suo libro *Das politische Theater* che era stato pubblicamente bruciato dai nazisti, ed era quindi introvabile. Piscator me lo fece avere (Nono 2001B, 518).[3]

At page 71 (chapter eight, *Das dokumentarische Drama*) of the German 1963 edition of Piscator's book, with regard to *Trotz alledem!*, the author writes the following:

> Die Aufführung entstand kollektiv: die einzelnen Arbeitsprozesse von Verfasser, Regisseur, Musiker, Bühnenmaler und Schauspieler griffen unaufhörlich ineinander. Mit dem Manuskript zugleich entstanden die szenischen Aufbauten und die Musik, mit der Regie gemeinsam entstand wiederum das Manuskript. Szenen wurden arrangiert, an vielen Stellen des Theaters gleichzeitig, noch ehe der Text dazu feststand (Piscator 1963, 71).

Here again we find the practice of collective experimentation which, from the very beginning, characterized the work around *Y entonces comprendió.*

3 The Luigi Nono Archive in Venice includes a copy of *Das politische Theater* (Schultz 1929), from the Luigi Nono fund, which is listed in the catalogue *Biblioteca* with shelf mark B 3019; the same fund also includes the German edition, dated 1963, which was published by Rowohlt (catalogue *Biblioteca*, with shelf mark B 439), and the Italian edition published in 1960 by Einaudi (catalogue *Biblioteca*, with shelf mark B 1356).

Apart from collective collaboration, Nono was interest in how Piscator used space for musical purposes:

> Il teatro di Piscator in Berlino ha un impianto acustico direi eccezionale. Altoparlanti dappertutto, collegati con i magnetofoni nella regia, cioè la stanza in cui son situati i vari apparecchi per il controllo delle luci, per le proiezioni di diapositive e di inserti filmati ecc. Altoparlanti sulla scena sul proscenio, a destra e a sinistra sulle parti, sul soffitto, e sotto il pavimento in sala. Una vera festa per l'uso di tutto lo spazio acustico del teatro, con ricchissima varietà di movimento dell'elemento sonoro (Nono 2001A, 212-213).

The search for an 'immersive' listening dimension entails going beyond passively 'sitting before' the performance as structurally imposed by the Italian theater layout; the structuring and organization of theatrical space are seen by Nono as a reflection of social 'space': «il centro focale unico, la dislocazione su due piani del pubblico e della scena e la staticità della scena stessa avevano allora una giustificazione teologica e pratica, in rispondenza cioè a struttura sociale precisa» (Nono 2001A, 122-123). The idea of actively involving the audience in the web of interrelations and retroactions established by the artists in the renewed scenic (acoustic) space blossoms with the Living Theatre experience, as suggested by Nono himself:

> L'esigenza di stabilire un più stretto rapporto col pubblico, di comunicare intimamente con esso, di integrarlo nello spettacolo e di imporgli di partecipare non più come semplice spettatore; e la nostalgia, il richiamarsi alla vita quotidiana onde costruire un teatro "che non sia di imitazione della vita, ma la vita stessa" (come si legge anche nelle dichiarazioni programmatiche di Judith Malina e Julian Beck relative al Living Theatre di New York) danno adito a varie possibili concezioni spettacolari, valide anche per chi affronti oggi il teatro musicale (Nono 2001A, 138).

By the way, Judith Malina trained at the *Dramatic Workshop* in New York, under Piscator's supervision.

Nono actually involved Living Theatre in the production of *A floresta é jovem e cheja de vida* (1965-66). It is interesting to note that: 1) the meeting with Living Theatre took place at Studio di Fonologia Musicale, 2) the reading of drama gestuality was done through microphone mediation, in partnership with Marino Zuccheri, and 3) the microphones should be listening to space. The interaction with the electro-acoustic medium is underscored by Nono himself:

> Per giorni e giorni allo Studio di Fonologia di Milano ho ascoltato da trenta a quaranta attori, e ho annotato tutte le loro reazioni davanti a questi testi. I meravigliosi artisti del Living Theatre hanno registrato otto versioni dell'escalation. Avevo creduto di abbandonare per una volta il microfono, ma, nel corso dell'esperienza, mi sono reso conto della dimensione nuova che esso poteva offrire a certi effetti della voce umana. Poiché, ancor più che nelle mie composizioni precedenti, mi sono sforzato di riunire e utilizzare qui tutti i suoni umani possibili, ma evitando qualsiasi manipolazione di laboratorio *a posteriori* che avrebbe potuto distruggerne la freschezza e la verità (Nono 2001B, 8)

Also with Living Theatre Nono established that process of retroactive interaction which leads him to accept into the composition fabric the inputs from the specific performers' characteristics, developing a sensitivity for sound spatialization through theatrical gestuality:

> Il Living era veramente una violenza esplosiva. Una delle loro espressioni più violente, che io ho usato nella *Floresta*, era la "lettura del dollaro". Si limitavano a leggere i numeri della serie, il nome della banca e le poche altre cose che si possono leggere sulla banconota americana, ma i vari modi di dire i numeri, di gridarli, di sussurrarli, i rumori dei passi, delle corse tra gli studi di registrazione, i canti improvvisi, interrotti costituivano una specie di vari campi magnetici che si allargavano spaziando sempre più (Nono 2001B, 528).

The problematizing of space in establishing a new type of relationship with the audience is present, as already mentioned, in Piscator, in Living Theatre, but also in Mejerchol'd (with whom Nono became acquainted thanks to Angelo Maria Ripellino):

> Nel dar vita all'Ottobre Teatrale, intuisce e propone già nuove soluzioni al problema del rapporto fra spettacolo e pubblico e della partecipazione di questo a quello: non semplice contatto fisico ma entusiasmo inventivo

> e operante, espressione di una nuova struttura sociale. Su questa strada proseguono, da un lato Piscator, dall'altro il teatro epico e la concezione non-aristotelica di Brecht, esperienze, queste, che sono illuminate da un preciso impegno umano (Nono 2001a, 139).

Which is a position Judith Malina also agreed:

> When he [Mejerchol'd] spoke of his theory as "the organization and geometrization of movement, based on deep study of the human body", he knew that something psychophysical was at stake; that the way back to the sensibilities of the spectator must be through referring again to the human body standing there trapped before him (Malina 1965, 85).

The relationship with the audience does not end in mere physical contact: Mejerchol'd sensed that there was something psycho-physical involved, which meant that a new form of sensitivity needed to be developed in the perceptive attitude on the viewer's part, a development which Nono tried to foster by expanding the levels of listening:

> Però con il *live electronics* l'ascoltatore è chiamato secondo me a svolgere un compito ancora più attivo. Il sistema *live electronics* invia segnali acustici nella sala ma questi suoni vagabondi, variati nella qualità, trasformati e composti devono essere anche collegati fra loro dall'ascoltatore, non semplicemente attraversarlo. La composizione non ti viene data, calata da Sirio. Ma tu stesso vieni messo dentro le possibilità compositive, combinatorie spaziali in continuo movimento, spesso artatamente confuso – almeno per me – per cui si innesca un processo che va molto più in là della funzione di un transistor: è infatti chiamata in causa la tua capacità di confondere delle relazioni anche là dove non sono state pensate dal compositore. È lo spazio che suona (Nono 2001b, 534).

In Mejerchol'd the musical element plays a pivotal role for the purpose of the actor's and directors' work. More specifically music helps manage space on stage: an actor's task is to acquire self-awareness in space; the control of space on stage through music is organized in 'drama and direction scores':

> Le partiture drammaturgiche e registiche impostate su base musicale, consentono di ottenere una corretta suddivisione del tempo scenico tanto dell'azione generale quanto di ogni singolo momento, e di pervenire a una corretta scomposizione e a un corretto uso del tempo e dello spazio scenici (Malcovati, Pesocinskij 1993, 97).[4]

The task of the actor directed by Mejerchol'd, therefore, proceeds through noting and listening memories, which is essentially the method used by Nono also for *Y entonces comprendió*; the need to rely on the physical memory of listening through the use of rhythm and music is testament to the impossibility of defining and crystallizing in writing the actor's gestures. The script does not include any independent and self-sufficient written description, just a set of notes which need to be complemented and consolidated through practice: biomechanics = laws consolidated in the course of rehearsals. Memory does not rely (only) on writing but (also) on the body: actors should not 'commit to memory' what they have to say, but rather remember their part on the basis of *memoria loci*, i.e. starting from the place, the position of their body in a specific space at a given moment (see Braun 2016, 225-258).

The theatrical practice of consolidating a composition during rehearsals included, in Nono's experience, approaching electro-acoustic equipment as well as the composition process. Focusing on 'action' means that it is necessary but not sufficient to be familiar with the technology of the time to understand a work because misical composition is an ongoing process, improvised, instinctive, reasoned, measured, *felt*. Technical errors often paved the way for new musical possibilities, in the mysterious inventive 'game' (see Nono 2001a, 411). Technology belongs to the broader context of its use (also including the error), whereby interpreting the magnetic tape presupposes systemic reconstruction of the electronic practice world, i.e. of interactions between composer, sound engineer and the audio technology from which it originates (see Orcalli 2006, 33).

4 From the Italian collection and translation of the texts and performance notes written by N. A. Basilov and V. E. Mejerchol'd between 1923 and 1932 and preserved at the Central'nyj Gosudarstvennyj Archiv Literatury i Iskusstva, Moskow (CGALI f. 2385, op. I, ed. che. 73).

The use by Nono of a theater-based praxis is a result of the issues raised by Mejerchol'd and Piscator, as well as of the meeting with the Living Theatre; nevertheless Nono is also aware of Grotowski's experience, as early as 1962:

> Per chiarire il rapporto col pubblico mi sembra interessante considerare certe realizzazioni raggiunte nel teatro di prosa. Possiamo rifarci al rituale dei popoli primitivi dove è una partecipazione, attiva e omogenea della collettività presente allo spettacolo, e non di una parte che agisce e un'altra che assiste; possiamo citare il teatro psicodinamico di Jerzy Grotowski (Teatr-laboratorium 13 Rzedów, in Opole Polonia) il quale elabora una partecipazione, della collettività allo spettacolo, su base laiche e attuali e non mistiche e religiose: tutta la sala si trasforma in un'unica scena, in cui due gruppi, gli attori e il pubblico, agiscono in reciprocità (Nono 2001a, 138).

In Grotowski all the elements encountered so far become intertwined: attention to the specific vocality of the performer on stage, essential relationship between performer and stage space, involvement of the audience. Each actor is valued because of individual psycho-physical traits: «the elements of the exercises are the same for all, but everyone must perform them in terms of his own personality. An onlooker can easily see the differences according to the individual personalities» (Grotowski 2002, 210). The voice of the performer is always seen in connection with actual acoustic space:

> The words must resound against the ceiling as though the upper part of the skull were talking. The head must not be tilted back as this causes the larynx to close. Through the echo, the ceiling becomes the partner in the dialogue which takes the form of questions and answers. [...] Then begins a conversation with the wall, also improvised. Here it becomes evident that the echo is the answer. The whole body must respond to the echo. The voice originates in and issues from the chest. Next the voice is placed in the belly. In this way a conversation is held with the floor (Grotowski 2002, 176).
>
> During rehearsals, the actor should be aware of the acoustic possibilities of the room in which he is acting in order to discover effects (echoes, sharp or muffled resonances, etc.) that he can put to conscious use, incorporating them into the structure of his role (Grotowski 2002, 169).

Having become aware of spatiality meant that Grotowski, working with Gurawski, started questioning the theater's architectural structure:

> In the period of theatre reform at the beginning of our century, attempts were made (by Meyerhold, Piscator and others) to bring the actors down from time to time among the audience. The stage is still, however, the centre of the action (Grotowski 2002, 157)

> The conquest of space in the Theatre Laboratory, beginning with the Italian stage and ending with the full exploitation of the whole room even among the spectators (Grotowski 2002, 160).

The stage space development suggested by Grotowski is consciously part of the breach opened by Mejerchol'd and by Piscator (with Gropius), of which Nono was well aware. Along this development line the vocal technique in relation to space is developed:

> Tutto quello che è associativo e orientato verso una direzione nello spazio, tutto ciò libera la voce. Soprattutto questo tipo di gioco libera quegli impulsi che non sono freddi, ma che sono cercati nell'ambito della nostra memoria, del nostro "corpo-memoria". È questo che creerà la voce. Allora rimane un solo problema: come liberare gli impulsi del nostro "corpo-memoria"? Non potete lavorare con la voce senza lavorare con il "corpo-memoria" (Flazen, Pollastrelli 1969, 178-179).[5]

The awareness of the voice in space thus raises the question of memory, which can no longer be entrusted to writing but to the 'body-memory' and the memory consolidated during rehearsals is the lynchpin for the type of writing we find in the 'part notebooks' of *Y entonces comprendió*.

> The actor, like the musician, needs a score. The musician's score consists of notes. Theatre is an encounter. The actor's score consists of the elements

5 Italian translation of a Grotowski's speech for foreign students of Wroclaw Teatr Laboratorium (May 1969). A French tranlation can be found in the journal *Le Théâtre Cahiers dirigés par Arrabal* nr. 1 in 1971 (Grotowski 1971). A polish version was then published in *Dialog* nr. 1 in 1980 (Grotowski 1980). An English translation is still unpublished.

> of human contact: 'give and take'. Take other people, confront them with oneself, one's own experiences and thoughts, and give a reply. In these somewhat intimate human encounters there is always this element of 'give and take'. The process is repeated, but always *hic et nunc*: that is to say it is never quite the same (Marljnen in Grotowski 2002, 212).

The issue of the score in *Y entonces comprendió*, is associated with the typical praxis in theater, especially in the theater which expressly focuses on the question of space. The signs (synchronism arrows, etc.) supported by accurate evidence, by a long habit of listening, are deposited on paper as on the magnetic tape: the tape is not only the seat of magnetic memory, it is a memory element involved on several levels of practical interaction between composer-performers-sound engineer-space. Transferring onto another carrier the information contained on tape is only part of the complex re-mediation process.

Composer, performers, sound engineer interact one with the other in relation to space and also to the audience's response ('listeners' reactions'). Another – extremely important – variable comes into play here (namely the audience) in the retroactive listening practice. The theater staff's relation with the audience is expressed by Grotowski in terms of 'contact':

> Contact is one of the most essential things. [...]. Contact is not staring, it is to see. Now I am in contact with you, I see which of you is against me. I see one person who is indifferent, another who listens with some interest and someone who smiles. All this changes my actions; it is con- tact, and it forces me to change my way of acting. The pattern is always fixed. In this case, for instance, it is to give you my final advice. I have here some essential notes on what to say, but how I speak depends on contact. If, for example, I hear someone whispering, I speak more loudly and sternly and this unconsciously because of the contact (Grotowski 2002, 226).

Contact with the audience is also the basis of the actor's training suggested by Mejerchol'd:

> La creazione dell'attore si differenzia nettamente dalla creazione del drammaturgo e del regista per il fatto che l'attore crea in pubblico e ha la possibilità di improvvisare sotto l'influsso che gli spettatori esercitano su di lui; nell'arte

> dell'attore non tutto è previsto (vedi necessità di combattere contro l'ostilità del pubblico oppure di ripianificare, ricomporre, adattarsi, e così via). Il contatto con il pubblico è chiaramente percepibile (attraverso il respiro, i rumori, eccetera). È questo il modo in cui il pubblico "pronuncia la sua battuta" e l'attore deve accoglierla e utilizzarla (Malcovati, Pesocinskij 1993, 71).

It is not by chance that this contact with the audience is also expressed by the metaphor of acoustic space:

> Il lavoro dell'attore è prendere coscienza di sé nello spazio.
> [...] Attento a seguire, con il suo fine udito, la cassa di risonanza (il pubblico), l'attore, dal suo canto, reagisce istantaneamente, per mezzo dell'improvvisazione, a tutti i bisogni che ne emergono (Malcovati, Pesocinskij 1993, 94).

The contact with the audience ('sounding box') prevents the theatrical practice from defining a unified and final prescriptive textuality, as emerges from the following comments by Grotowski:

> Il sottoscritto è d'accordo con coloro che considerano che specificità dello spettacolo come opera d'arte sia:
> a) il contatto vivo, immediato tra lo spettatore e l'attore,
> b) l'atto collettivo; attori e spettatori come una sola collettività, insieme attiva, insieme partecipante e inter-attiva,
> c) l'assenza di una forma fissata (a stampa, su nastro, su altro materiale); il divenire nel contatto tra spettatore e attore (Flazen, Pollastrelli 1969, 51).

The seat of memory is not something written in a fixed form, on paper or magnetic tape, but the body:

> Il nostro intero corpo è una grande memoria e nel nostro "corpo-memoria" si creano vari punti di partenza. [...] Si pensa che la memoria sia qualcosa di indipendente dal resto del corpo. In verità, almeno per gli attori, è un po' diverso. Il corpo non *ha* memoria, esso *è* memoria. Ciò che dovete fare è sbloccare il "corpo-memoria" (Flazen, Pollastrelli 1969, 195-196).

Considering the body and the world as memory sediment, the origin of a composition might abandon the unified prescription of writing and open up to collective experimentation, which is what Julian Beck remarked with regard to his own working method within the Living Theatre:

> Example. At the Cherry Lane we prepared plays by making rather careful directing books. That is, we worked on the staging of the play in advance, considering the movements actors would make, the interpretation of lines. We prepared the set designs, the music, the costume designs ahead of time. We used this mode of preparation less and less as our work progressed, and nowadays neither Judith nor I indulge in the Reinhardt *Regiebuch*. We study the play before rehearsals begin; we talk, mull, discuss, discard, talk some more. I no longer make any designs for a play until I have heard the actors read it, not once but many times. I prefer not to make the costume designs until I have watched the staging and watched the actors move (Beck 1965, 17).

Having set the event in mainly performative terms as part of collective collaboration, the issue arises of the reproducibility of an event and of its 'tradition'. Says Nono to Philippe Albèra:

> [P.A.] *Cosa succederà il giorno in cui lei non ci sarà più?*
>
> [L.N.] Altri musicisti faranno altre musiche! Si tenta nondimeno di fissare graficamente le cose, ma ho più volte ripetuto che non ci tengo al concetto di scrittura! È come la musica di Gabrieli: egli scrive "a sonar e cantar". La dinamica, il tempo, la divisione tra voce e strumenti non sono fissati. La prassi che ne permetteva la realizzazione è scomparsa.
>
> [P.A.] *Ma questi sono parametri secondari nella composizione dell'epoca, e questo è differente dalla sua pratica. In realtà, lei non attribuisce alcuna importanza alla perennità delle sue opere.*
>
> [L.N.] Esattamente (Nono 2001b, 423).

With regard to *Quando stanno morendo. Diario polacco n.2*, Nono says to Paolo Petazzi:

[L.N.] Della musica dei due Gabrieli per San Marco o della grande scuola polifonica spagnola, ci è arrivata la tradizione scritta, che si presenta semplice; ma non ci è arrivata la tradizione della prassi. È un materiale che suonava nello spazio, che lo spazio faceva suonare: la musica scritta è una parte la cui pratica di realizzazione è andata persa. Con il l*ive electronics* c'è qualcosa di simile. Modifichiamo continuamente i programmi. Come è possibile fissare la pratica di realizzazione? Il problema mi affascina molto, perché siamo in un'epoca in cui si fissa tutto, si standardizza tutto, si mira alla massima riproducibilità. Mi affascina che il lavoro con il *live electronics* comporti proprio la impossibilità della riproducibilità ripetitiva.

[P.P.] *Ma c'è anche la necessità che questa 'tradizione' possa continuare a vivere.*

[L.N.] Certo, il problema è questo (Nono 2001b, 465).

Nono is aware of this issue and leaves it open. The accurate description of the technological equipment is undoubtedly an important and essential step in the transmission of a composition. When transmitting the work, however, the technical aspect should be seen from the perspective of its use and as part of cooperation practice (based on a theatrical matrix): dealing with the question of re-mediation, using an approach based on aesthetics – with a view to reproducing a composition such as *Y entonces comprendió* within a contemporary concert setting (which is what happened on the occasion of its first 'modern' re-staging at the Biennale in Venice in 2005) –, will therefore mean not only transferring the magnetic tape from the analog to the digital domain, but first and foremost keeping the theatrical backdrop alive against which the composition originated.

The theater backdrop mentioned above – bearing in mind what has been said by those who, like Piscator, Mejerchol'd, Beck, Malina, Grotowski, who have constituted an important point of reference and comparison all along Nono's creative experience – underscores not so much the *poetics* of drama, but rather the practice of theater. Nono's theater was definitely not *poor*, however both Nono and Grotowski highlight the importance of space in the use of the voice: if poetics diverge, the practice of listening converges in acknowledging that the space factor (the *here and now*) plays a decisive role.

In theater practice a retroactive interaction is created between author, performer, sound engineer, acoustic space and – last but not least – the audience. From this 'systemic' perspective the moment of re-mediation is unlikely to be limited to transferring one technology to another and pursuing any kind of 'standardization' with a view to becoming 'fixated' on 'maximum reproducibility', *if* the intent is to remain true to the fascination of 'impossible repetitive reproducibility'.

That is indeed the question.

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The quest for *Ages*, the radio-drama by Bruno Maderna and Giorgio Pressburger

Luca Cossettini

ENTRANCE

If you were to search for the keywords 'Ages' and 'Maderna' on YouTube, you would get only one pertinent hit,[1] unless it has already been deleted because it infringed some copyright, or the rapid changes on the Web made the link obsolete. Considering that one day this content might no longer be accessible, I attach below the caption of the video:

> I suoni e l'universo immaginifico che si apre ascoltando *Ages* sono difficilmente riconducibili a una visione scenica univoca. È fondamentale riuscire a costruire un'immagine aperta a più letture che sappia espandere al campo visivo quello che Maderna ha realizzato in ambito sonoro. Per questo abbiamo seguito un itinerario ideativo simile a quello che ci immaginiamo Maderna abbia percorso compositivamente. In *As you like* [sic] Shakespeare dice "tutto il mondo è un palcoscenico e tutti, uomini e donne, sono solamente attori: hanno le loro entrate e le loro uscite e ognuno, nel tempo che gli è riservato, rappresenta molte parti e gli atti sono sette età". Sette quinte mobili costituiscono l'essenza scenica, uno spazio astratto che produce e consente un continuo susseguirsi di entrate e uscite, di presenze e assenze, di passaggi. Quattro attori, due donne e due uomini, interpretano una serie di ruoli scambiandoseli in un continuo gioco di trasformazione e travestimento. Ogni attore, quindi, non interpreta una parte, ma segue piuttosto un percorso durante il quale, secondo una rigorosa partitura, assume i panni di più personaggi.

This video is a 1990 processing of a version in representative form of the 'radio invention' *Ages* (from William Shakespeare's *As you like it*) by

1 *Ages – 1990 – Archivio Tam Teatromusica*. <https://www.youtube.com/watch?v=MU-25WLZqQ0Q>, accessed 15 January 2017.

Bruno Maderna and Giorgio Pressburger edited by the Tam Teatromusica group and commissioned by RAI in Milan.[2] I have chosen to use this source as an introduction for three main reasons: 1) because several well-written articles describing *Ages*, its origins, structure and success have already been published (see for example Baroni, Dalmonte 1985, 311 or Vincis 2012); 2) because YouTube and similar websites have now become, for most users, the first point of access to music; and 3) because it is surprising not to find traces of *Ages* by Pressburger and Maderna, considering that the user community on YouTube seems to have set itself the arduous task of uploading on the website also the whole corpus of electronic music by contemporary avant-garde composers. The absence of such important work, which by the way was awarded the Prix Italia in 1972, is surprising, considering that there is no lack of reference bibliography.

HOPELESS TO FIND, YET LOATH TO LEAVE UNSOUGHT OR THAT OR ANY PLACE THAT HARBOURS MEN. A JOURNEY IN SEARCH OF *AGES*

If you refer to the catalogue in the famous book by Massimo Mila, *Maderna musicista europeo* (Mila 1999) – which of course a web surfer is bound to have bought online – you will find out that *Ages* lasts 34 minutes. This has therefore nothing to do with the approximately ten-minute video posted on YouTube. However, today's web surfers are cleverer than that: they know that they are watching an 'upload' edited for advertising purposes, not a 'transparent' (see Manovich 2001) filming of the performance, and are thus not surprised about the cuts. Following a few links from YouTube, they will then reach the page of the director and staging view editor, Michele Sambin. Entering the word 'Ages' in the search engine which the webmaster has made available on the home page, they will find a link to a page where it will be possible to view another version of the same video: footage from rehearsals,

2 See <http://archivio.tamteatromusica.it/archivio_v9_ages.htm>, accessed 15 January 2017. The premiere of this version in representative form was performed at the Conservatory in Milan, as part of the event *Dialogo con Maderna* on 7 October 1989. See also a list of the scheduled performances kept at the Bruno Maderna Archive in Bologna.

lasting 23'06".[3] We are not there yet. Now curious, the web surfers will thus set off in search of the 'original' version of *Ages*.

Up until its very recent publication in a Die Schachtel-RAI Trade box-set (De Benedictis, Novati 2012), it was indeed difficult to find any audio recording of *Ages*. The record company Stradivarius published an edition on CD together with *Satyricon*, also by Maderna, in 1993, which was unfortunately immediately sold out. Today, if you spend some time browsing the Web, you might find and buy it from on-line collectors' stores, paying – as the saying goes – 'its weight in gold': prices range from 39 € to 287.95 $!

The last freeware resource remaining are the official podcasts by RAI, or blogs kept by radio enthusiasts. The web surfer will find two things: 1) an audio reproduction of the work, published online as part of the series *I gioielli del Prix*,[4] and 2) a recording of a radio program hosted by Sandro Cappelletto and broadcast on Radio RAI – no mention is made of which channel –, on 10 October 2010.[5] The audio content of both programs is identical: a version of *Ages* lasting about 31 minutes. During the program mention is made of the CD published by Stradivarius, possibly the source used for broadcasting. Finally, our tireless surfer's attention might be attracted by a website called *Classical music online*: an online platform with an extensive collection of audio and video classical music footage, uploaded directly by a community of registered users, for the purpose of creating an online classical music archive. It is possible to find there a version lasting 49 minutes and 30 seconds.[6]

At this point our web surfers are bound to give up, return to the world of non-virtual documents and purchase the box-set from Die Schachtel: a stylish product, something rare in musical publishing reserved for radio productions in the second half of the twentieth century. It includes *Ages*, plus a valuable collection of work presented at Prix Italia, most of which would

3 <http://www.michelesambin.com/contributo/ages>, accessed 15 January 2017.

4 <http://www.rai.tv/dl/raiTV/programmi/media/ContentItem-32a1f81e-f286-4273-877a-38d1097beb88.html>, accessed 15 January 2017.

5 <http://radiopassioni.lefora.com/topic/3686456/Prix-Italia-1972-Ages-di-Giorgio-Pressburger-e-Bruno-Mader#.V4IpMJOLSu4>, accessed 15 January 2017.

6 <http://classical-music-online.net/en/production/40467>, accessed 15 January 2017.

otherwise be impossible to find;[7] a box with six audio CDs, and a book containing essays in Italian, also translated into English, on the published work, and technical data sheets detailing the archival documents used for editing. They will then feed the CD into the computer – since hi-fi systems and 'desktop' CD players are now used only by audiophiles –, open the volume where the essay by Claudia Vincis starts, on page 69, and read. In the meantime they hear, through in-ear headphones, the words of the monologue by Jaques in Shakespeare's *As you like it* taken apart and rewritten by Pressburger, retaken apart and rewritten electronically by Maderna – of course with help from Marino Zuccheri, sound engineer at the RAI Studio di Fonologia Musicale in Milan. Among the music accompanying the text they might recognize previous work by Maderna, also taken apart and re-edited, rewritten in their re-contextualization: *Ausstrahlung, Dimensioni II / Invenzione su una voce, Biogramma, Dialodia,* in the words of the author of the essay on page 73. After 31 minutes and 17 seconds the audio of *Ages* ends. «Chiude infine l'opera a 30'43". Pochi secondi dopo l'annunciatrice legge i titoli di coda» says Claudia Vincis in her effective reading of the radio-drama, which our web surfers could use as guide to listening. What about the more than three minutes missing to reach the duration given on the catalogue of the book by Mila?

Having exhausted the published and accessible sources, the only way to find out would now be to go in search of the original magnetic tapes. And here our web surfers would be faced with a series of hindrances difficult to overcome: even supposing that the archives grant permission to view the analog audio documents they have, how can their content be accessed? Will there be equipment available to read historic audio formats? And, if so, what about the technical expertise or support to use them? Will it be possible to analyze the re-recorded audio signal? On the other hand, there is only one way to try and shed light on the time discrepancies found by our web surfer between the duration of the recordings and the indications in secondary literature: referring directly to the audio sources. One way of accessing some interesting documents, including the preservative copy of the tape owned by one of the authors, Pressburger, is visiting MIRAGE.

7 The six CDs contain: *Don Perlimplin* (1961), *Ritratto di Erasmo* (1969), *Ages* (1972) by Maderna; *Diario immaginario* (1975) by Berio; *La notte di un Nevrastenico* (1959) by Rota, *Attraverso lo specchio* (1961) by Castiglioni and *La voce dell'Inferno* (1981) by Sciarrino.

ONE MAN IN HIS TIME PLAYS MANY PARTS. ON THE VERSIONS OF *AGES*

Our web surfers, having now decided to use the tools of audio source criticism, learn that the current state of research, conducted by the team at MIRAGE, has led to finding 15 audio documents bearing witness to at least five separate versions of *Ages*.[8] The amount of changes, combined with the difficulty in accessing the original documents for careful analysis of the physical carrier, makes it difficult to suggest well-grounded theories about the origin of the copies/versions. It thus seems more prudent and effective to use a division into families, defined according to the duration of the work and to their musical content.

A	B	C	D	E
R1	R3 R7 R8	R2 R4 R9 CD1 CD2 NET1 NET2 MP1	R5 R6	NET3

Table 1. Ages *families*

Family A

Family A consists of a single document: R1. It is the longest uncorrupted version of the work, lasting 36'43", to which about 23" of final announcements should be added. For this reason, in describing the variants of the other families, time references to this version will be made.

Family B

The sound fabric of the documents in family B has the same duration as R1,[9] except for the final announcements, which are not included here. Also

8 See *Sources*, p. 226.

9 When working with analog audio documents or their copies, it is not surprising to find discrepancies in the duration of sound fabrics belonging to sources which are evidence of

the musical content is identical. A specificity of this family is a variant in the announcements which follow the first part of the work. The female announcer here does not say «*Ages*. Invenzione radiofonica di Giorgio Pressburger, da *As you like it* di William Shakespeare. Musica ed elaborazione elettronica di Bruno Maderna. Realizzazione effettuata presso lo Studio di Fonologia di Milano della Radiotelevisione Italiana», but «*Ages*, testo ideato da Giorgio Pressburger, tratto da *As you like it* di William Shakespeare; musica ed elaborazione elettronica di Bruno Maderna. Realizzato presso lo Studio di Fonologia della Radiotelevisione Italiana». However, the flute part in the background is unchanged (Figures 1 and 2). A similar variant presupposes a different mixing of the preparatory audio materials (presumably a document containing the flute and one containing the announcements), rather than a mere replacement of the magnetic tape following the definition of the sound fabric structure.

Family C

Family C contains the shortest version of the work: 30'53" plus final announcements, according to R2. The sound fabric can be entirely taken from R1, announcements included, by eliminating musical materials (Figure 4). It seems, however, that the possibility can be ruled out of R1 being the direct antigraph of the documents included in this family, because there are minor variants which can be interpreted as disjunctive. More specifically, in the documents from family C, the sound event following the initial announcements (at 7'04") enters in advance by a few tenths of a second compared to R1. The structure of the work remains the same; this discrepancy leads us to think of a different editing (Figure 3).

the same version of the work. It is well known that analog audio technology is characterized by tolerances which affect all format parameters, most notably the running speed of the tape. For the time indications, therefore, I arbitrarily choose a reference document. It is up to the reader to take into account any discrepancies compared to other sources, which may be gathered from the detailed description in the review on page 226.

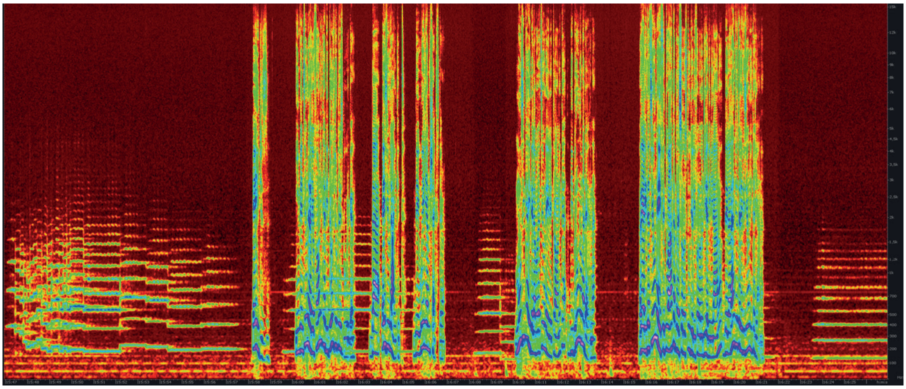

Figure 1. Initial announcements from families A, C and D, spectrogram of the fragment in R1.

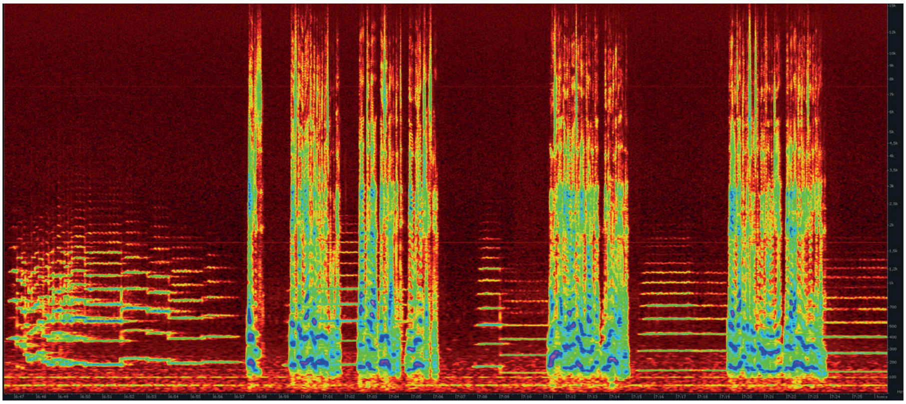

Figure 2. Initial announcements from family B, spectrogram of the fragment in R3.

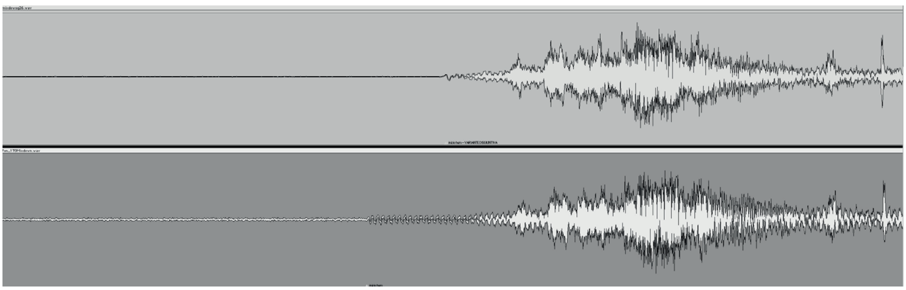

Figure 3. Variant of the sound entrance at 7'04" between R1 *(above) and* R2 *(below).*

Family D

It is especially interesting to analyze the sound fabric in the documents from family D. It is a version, lasting 33'50' plus final announcements, which has reached us exclusively in monophonic format and where cuts and variants are clear as regards mixing and montage of preparatory materials which separate it from the rest of the tradition (Figure 4).

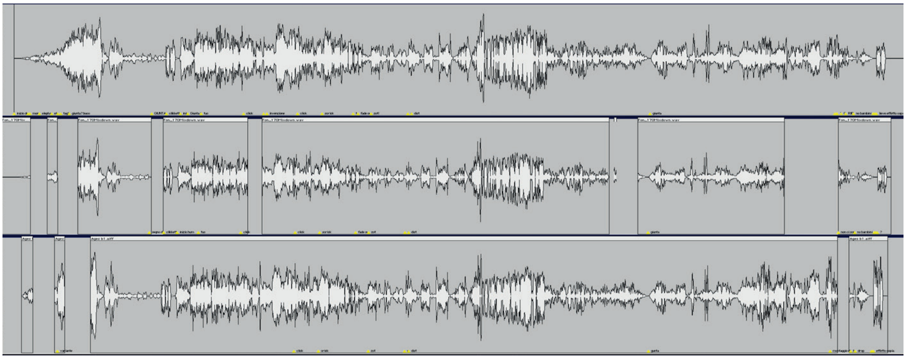

Figure 4. Montage differences between families A and B (R1, above), C (R2, middle) and D (R5, below).

There are three variants on which our web surfers, now more experienced, might decide to focus:

Variant 1. As appears clearly from Figure 5, the version of family D (upper waveform) includes material which is absent in the other versions, because it has been removed (lower waveform – family C), or excluded from mixing of the preparatory materials (middle waveform – families A and B). This sounds like a child's voice uttering the words «the stage»; a spectrogram analysis (Figures 6 and 7), however, can help us here better visualize the variant and focus on the details, often obscured by the poor audio quality of documents in this family.

As shown in Figures 6 and 7, this is an 'additive'[10] variant obtained by mixing, where further sound events overlap with the audio materials also found in families A, B and C by stratification. This applies not only to the already mentioned «the stage», which can be heard clearly at the point where the sound fabric of the other versions is characterized by fade-out, but also to other sounds and voices before it.

Variant 2. An intervention of a different kind characterizes the second variant (Figure 8). In this section, Maderna and Pressburger introduce a part of strings with overlapped reciting voices. In the documents from families A and B, at 34'58", the string part fades out, and an elderly man's voice recites the words «mere oblivion» (Figure 9). The next words, which begin with the evocative «sans everything», remain suspended in silence. The strings come back, with a fade-in at 35'25".

In family D, on the other hand, the string part continues (Figure 10) until the cut at 35'06" and beyond. There is a deletion here, without any audible or visible trace of joining, of about 35" of audio, compared to the documents of families A and B. The audio is re-synchronized as shown in Figure 8, and when the three versions start matching again, at 35'41", the sound fabric is identical.

In family C what is missing is the section at 34'58" where the variant is found. This version is actually characterized by the destitution of audio material which in A goes from 32'57" to 35'03". The sound fabric in common with the other version is thus consistent with that of families A and B.

In this variant, loaded with aesthetic meanings, the common base between the versions is the voice. In one version the latter is alone, in silence, «sans everything»; in the other it is emphasized by the insistent string part in a *loop*.

10 I coined the expression 'additive variant' because the categories used by textual variance and authorial philology studies are insufficient to accurately describe the processes which take place in the world of audio processing: we are facing here a 'mix' variant which – without any physical interventions on the carrier – leaves part of the sound fabric unvaried, as well as its total duration. Other expressions could be: 'destitution variant' for cut operations, 'institution variant' for physical interpolations, and 'substitution variant' for the actual replacement of sections of the tape.

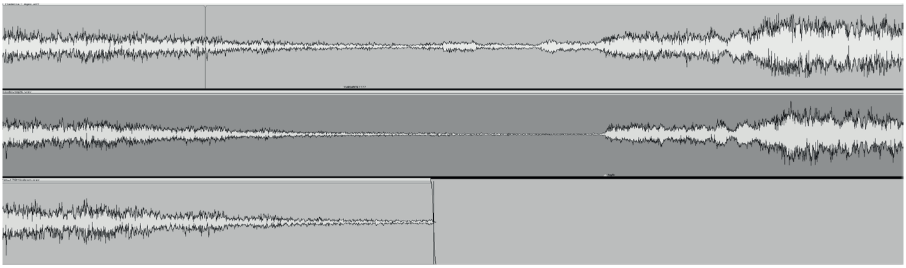

Figure 5. Variant at 1'57" between R5 (above), R1 (middle) and R2 (below).

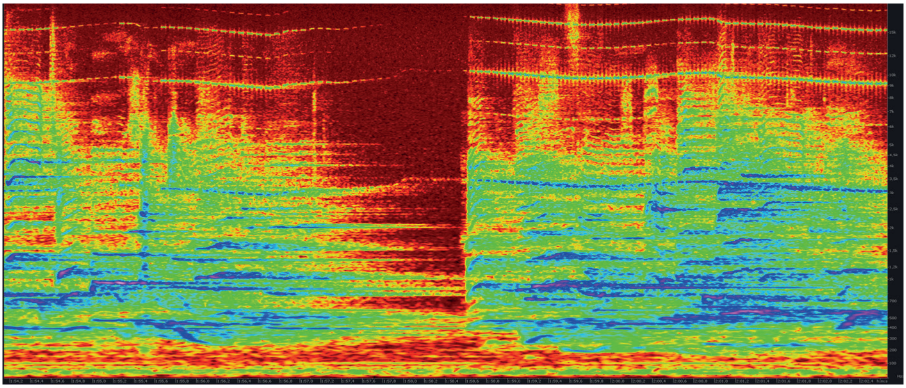

Figure 6. Variant at 1'57". Families A, B and C (spectrogram of the fragment in R1).

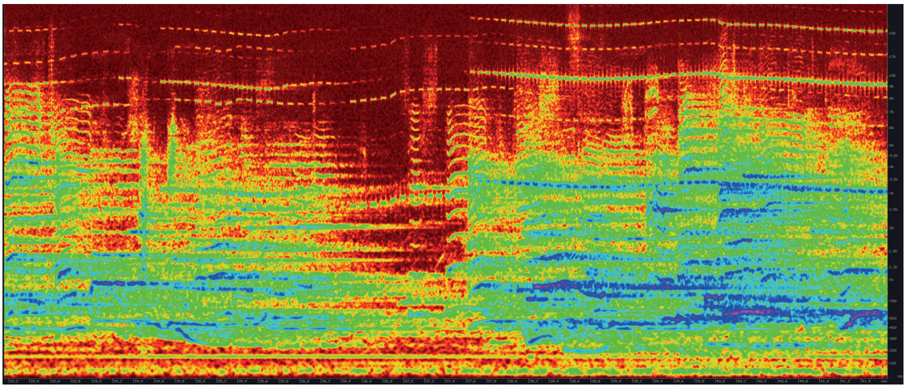

Figure 7. Variant at 1'57". Family D (spectrogram of the fragment in R5).

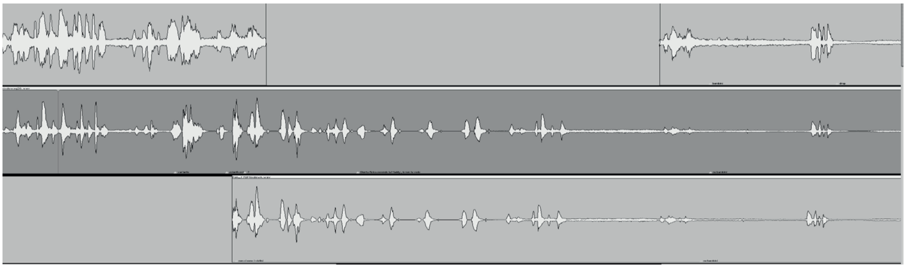

Figure 8. Variant at 34'58" between R5 (above), R1 (middle) and R2 (below).

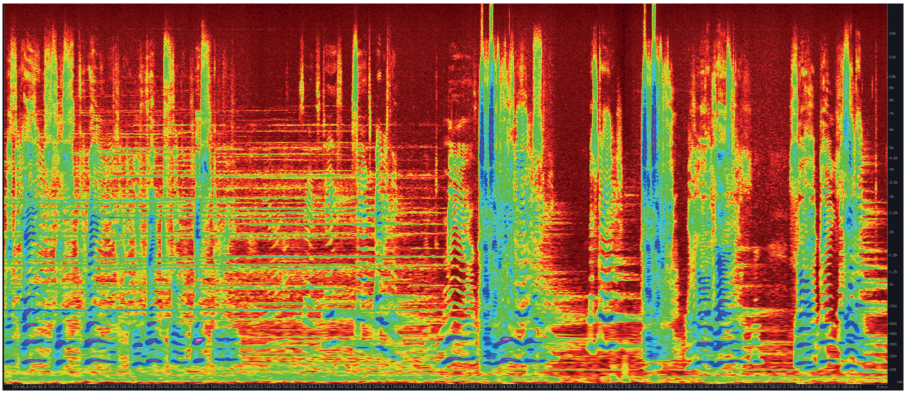

Figure 9. Variant at 34'58". Families A and B (spectrogram of the fragment in R1).

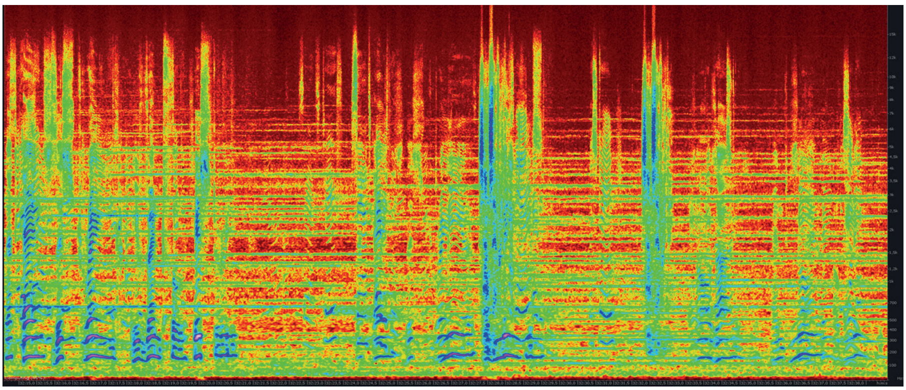

Figure 10. Variant at 34'58". Family D (spectrogram of the fragment in R5).

Variant 3. The last significant variant is found towards the end of the work, at 35'42". Also here, as in the other variants, the montage of preparatory materials is different (Figure 11). In this section, families A, B and C match. In family D, on the other hand, there are some voices absent from the other versions («sans taste» with a senile voice and «a second» with a child's voice – Figures 12 and 13); the common basis remains unvaried. This is another 'additive' variant.

Family E

This family consists in a single document available online: NET3, that is to say the Mp3 file which can be downloaded from the website Classical Music Online. It is the longest version of the work known so far: 49'30". The unreliability of the source, however, immediately becomes apparent when, following a basic analysis of the sound fabric, we discover that the audio section from 11'48" to 30'39" seconds is repeated twice, in exactly the same way.[11] 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'.

11 At this point our reader might have become curious to know where such a rough and unjustifiable variant comes from. My hypothesis is the following: supposing that our web surfers incautiously ventured beyond the borders of the domain of dubious legality which is the world of peer-to-peer. They might then have stumbled upon an almost unknown system for file sharing called *Nakido* and have found there, obviously by chance, a bootleg copy in Mp3 format of the CD published by Stradivarius. Driven by curiosity, they might have downloaded it and, after opening it, discovered a version of the work lasting 49'30". In the CD published by Stradivarius, *Ages* is divided into four tracks: *Prologue* and radio announcement, *Part One*, *Part Two*, *Part Three* and *Final Chorus*. If this division were found in the bootleg copy as well, and if the first, third and fourth track of the copy were identical to those on the CD, while track two did not end where it should, but continued to the end of the work, then the repetition would be easily explained: a mere error in the importing and subsequent Mp3 coding of the original CD. Of course, supposing our web surfers had actually made this comparison, they would have immediately deleted all traces of the bootleg copy from their computer!

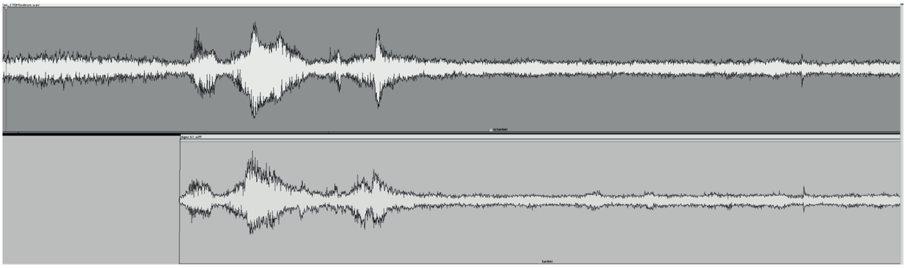

Figure 11. Variant at 35'42" between R1 (above) and R5 (below).

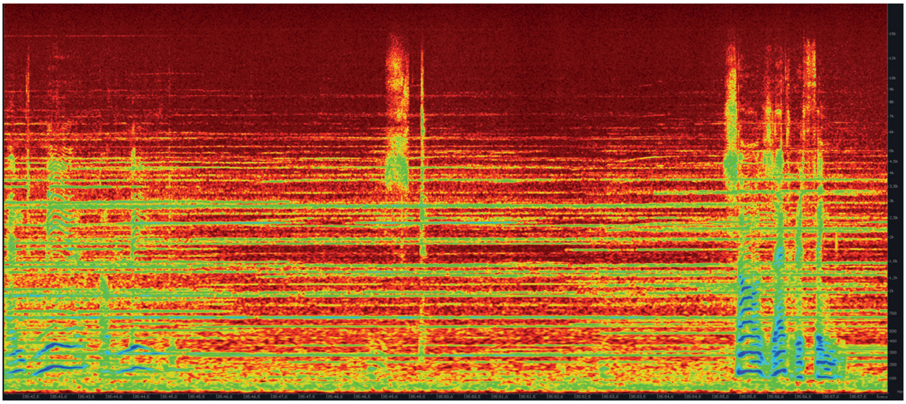

Figure 12. Variant at 35'42". Families A, B, C (spectrogram of the fragment in R1).

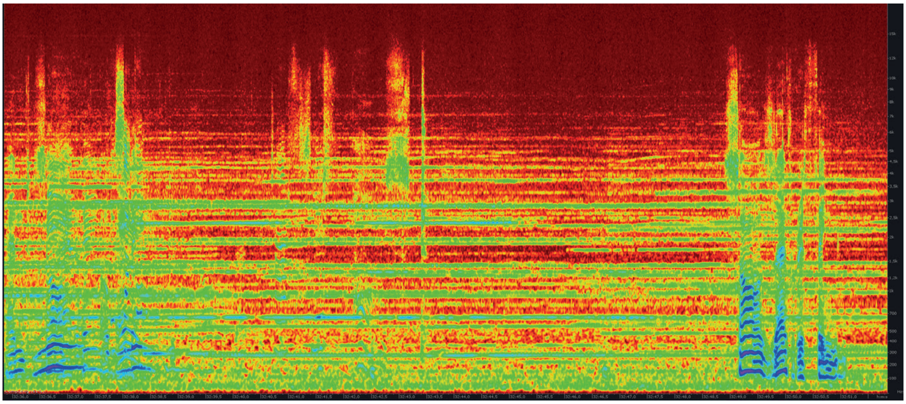

Figure 13. Variant at 35'42". Family D (spectrogram of the fragment in R5).

’TWAS I; BUT ’TIS NOT I. I DO NOT SHAME TO TELL YOU WHAT I WAS. REWRITING AND TRANSFIGURATION OF MUSIC DURING ITS PRODUCTION AND DIFFUSION PROCESSES

The recent developments in research on the production and dissemination processes of electronic music composition lead us to consider the variants of *Ages* as natural moments during the life of the work. Our web surfers, being in close contact with audio technologies and sound engineers, now feel at ease in any recording studio: they have begun to understand its underlying concepts and use its working methods; they understand very well that the electronic medium itself sometimes imposes a very specific composition practice, based on continuous re-writing processes of the audio, carried out as part of concrete laboratory practice, and not of abstract writing. The possibilities, inherent in manipulating existing materials, of listening ‘live’ to the sound result of the processing, of recording each rehearsal and every ‘sound sketch’, of building databases of sounds to be reused at will in different compositions, of thinking about various sound fabrics for different destinations (concert, radio, record, etc.) already lead to thinking about the act of composing electronic work no longer in unified terms, but in the more complex terms of continuous rewriting, of a multiplicity. Within this scenario the variant is the rule, not the exception. And what is even more fitting for Maderna’s production which, as Mila already claimed in 1976, and Mario Baroni and Rossana Dalmonte confirmed ten years later in the volume inaugurating academic research in Italy about the composer’s production:

> È una selva foltissima, da perderci la testa, e richiederà un paziente lavoro di classificazione e di catalogazione per vederci chiaro. In particolare i frequenti rifacimenti d’una medesima opera, le nuove versioni, gli impieghi di materiale precedente in nuovi contesti, pongono problemi che per molti anni daranno del filo da torcere agli studiosi e ai ricercatori (Baroni, Dalmonte 1985, 4).

Indeed Maderna has not left much information about the work leading to the composition of *Ages* (see Vincis 2012) which might help us track down the processes underlying the completion of this work, documented today by several versions. It is actually rare for a composer to leave precise indications as to the writing and re-writing processes of the music, especially when working inside a recording studio, where the artistic idea is often dictated by an instinctive response to the acoustic input and to the manipulation possibilities made available by electronic equipment.

It is therefore interesting to consider the path which has led the documents to reaching us, and focus on the place where they were actually found. Being aware of the fact that the variant of the electro-acoustic work or radio drama is the manifestation of a technological production system, we then always need to hold on firmly to the historical-technological research which allows us to reconstruct the environment and the practices in which the audio documents we analyze today were created and passed on.

At the current stage of research, there is only one source to document version A: R1. The DVD analyzed, according to the publisher, contains a digitization of the tape with marking Q26 by the Archive of the Studio di Fonologia Musicale, the site where the radio drama was produced. It does not seem that this version was publicly circulated, which is why we are led to conclude that it is an archival copy, possibly of a first 'extended' version of the work. The working practice at the Studio di Fonologia Musicale of making preservation copies of the mono and stereo tapes at ¼" on 1" 4-track tapes further confirms this assumption.[12] On the other hand, we know from the catalogue published by Maddalena Novati (Novati 2009, 164) that the carrier contains physical splicing, probably[13] a sign that work was done directly on the tape and with the intent of modifying the form of the sound fabric. Unfortunately, though, finding them in the files contained in R1 is far from easy: with no indications as to 'point zero' from which counting ought to begin, the times given in the catalogue say little about the actual position of the splicing.[14] Consequently, it will only be possible to complete the survey by referring to the original tape.

12 The critical editing work on the corpus of electronic music on tape by Luigi Nono carried out by the team at MIRAGE has brought to light many other similar instances, for example *Ricorda cosa ti hanno fatto in Auschwitz* (Ricordi, Milan, 2008).

13 It was not uncommon for magnetic tapes to be reused and overwritten. In some cases they physical joining might be totally unrelated from the sound fabric found on the tape today.

14 For these reasons, MIRAGE started the practice of recording a video of the running tape during the copying phases which, re-synchronized with the audio, shows us the exact position of joining, writings or any other information on the original tape.

As we have seen, a direct reference to the 'extended' A version is the B version, whose sources have been found in the authors' personal libraries. Pressburger's tape (R3) was provided directly by the author, while the documents belonging to Maderna were listened to at the Paul Sacher Stiftung in Basel – Maderna Fund (R7, R8). The access to the original document R3 has made it possible to deduce a series of important information: Marino Zuccheri's handwriting on the casing leads us to conclude that the copy might have been made by the sound engineer at the Studio di Fonologia Musicale, and the indication, also handwritten on the casing, «copia non tagliata» (unabridged copy) confirms the existence of an 'extended' version (whose content, apart from the announcements, corresponds to family A) and of an 'abridged' version of the work. It seems therefore that the authors preferred the 'extended' to the 'abridged' version, where cuts where probably made for contractual reasons and radio broadcasting constrains.[15] Pressburger, in a recent interview (Casanova 2012), indeed told us that these 'cutting' interventions were the order of the day for radio broadcasts and they were made during post-production, often without asking for the authors' authorization. This leads to a scenario where the broadcast version of the music is different from the one composed by its authors.

Abridged version C is the one which had the largest dissemination. As a matter of fact we find it in all the recorded editions and streaming online. Reconstructing the path of the work from Prix Italia to the other public broadcasts, however, is an arduous task.

In the sources found online there is, as can be expected, a strong compression of audio data, applied to improve the transfer speed. This makes it impossible to conduct accurate tests on the sound fabric: a compression which is not *lossless* may affect, depending on the algorithm used, essential parameters for criticism, such as signal/noise ratio and equalization curve.[16]

15 See the letter by RAI to Bruno Maderna and Giorgio Pressburger (1 August 1974 – Paul Sacher Stiftung PSS MF 307.1 D negativ – n. 002467-2468) and the contract with G. Ricordi (22 December 1972 PSS – MF 306.1 D negativ – n. 000902-911).

16 In NET1 the silence before the final announcements has been reduced from the seven seconds in the other documents of the family to one second. It is possible that this cut might have made during the post-production phase to reduce to a minimum the silences in radio broadcasts and podcasts.

The nameless[17] curators of CD1 did not think it essential to mention the source of the published audio in the booklet, or to provide information about the post-production processes leading to the creation of the audio CD. What we have before us is a sound fabric drowned in background noise, with a dynamic range which does not reach beyond 45.45 dB on channel 2 (compared to 62.10 dB measured on channel 2 for R1) and with a different equalization curve between the two channels which does not reproduce the linearity of the frequency response in the recording. Last but not least, there are global disturbances,[18] probably due to interferences (Figure 14) which have entered the signal during the re-mediation phase from an unknown analog antigraph. It is therefore difficult to make critical assumptions about this source.

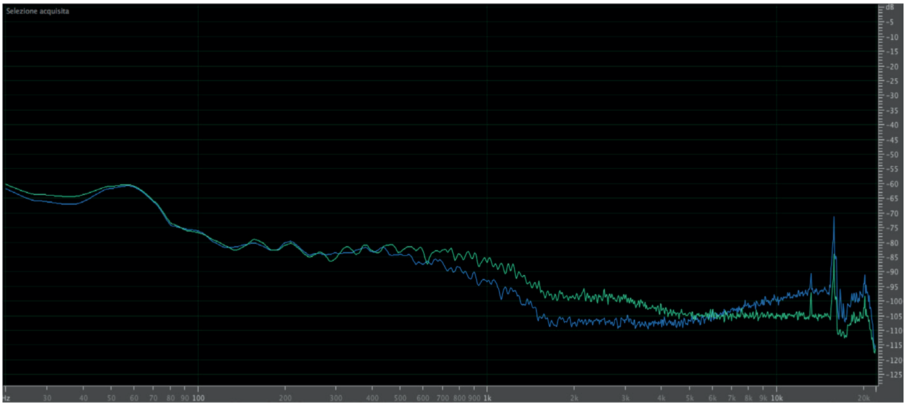

Figure 14. FFT analysis (Blackmann-Harris window 4096 points) of the background noise preceding the beginning of the music on CD1. The left channel is blue and the right channel is green.

17 Giordano Montecchi wrote an introduction to the work for the CD booklet, but no mention is made of the sound engineers who did the audio re-mediation work, or of the actual curators of this edition.

18 On the whole track there are two clearly audible global disturbances on 13.3 kHz and 16 kHz, in the same way as the non-linear distribution of frequencies in the highest frequency regions of the spectrum (as can also be seen from Figure 14). Near the beginning of the recording there is a third global disturbance at 7.4 kHz.

The curators of CD2, instead, seem to have been more careful when filing the analog magnetic tape FON170 in the Archive of the Studio di Fonologia Musicale as source for their edition.[19] Nevertheless there are digital disturbances which were clearly added during the post-production or CD creation phase. The most evident is a stationary and global noise with fundamental frequency at 700 Hz and harmonic partials all across the audio band which disfigures the sound fabric. Figure 15 compares the FFT analysis on three audio sections taken from the beginning of the left channel on the first track: the digital 'silence' (in red), the background noise which precedes the recording (in yellow), and the background noise on the analog tape in a section which precedes the first sound event (in green). The digital 'silence' is obviously not silence; the second background noise is difficult to interpret; the third shows, apart from the digital disturbance, the non-linearity of the equalization of background noise on the tape.[20] The signal-noise ratio of the whole audio file is very low: it reaches a maximum of 48.40 dB on the right channel.[21]

19 See De Benedictis, Novati 2012, 369. It is interesting to note that the website page of the publishing house Die Schachtel advertising this edition, reads: «Bruno Maderna – *Ages* (winner, 1972) – Original edition» (<http://www.dieschachtel.com/editions/prixitalia.html>), while in the same volume Claudia Vincis says, in a note about Q26: «Presso l'archivio dello Studio di Fonologia della RAI di Milano è conservato il nastro originale a 4 piste di *Ages*, catalogato come Q.026» (Vincis 2012, 71). The concept of original in philology is one of the most complex and widely debated (see Avalle 1972, 33-34); its contours become even less clear in the criticism of audiovisual source and electronic music. The conceptual and lexical issue is far from having been resolved. The author's justifiably prudent approach in the note thus becomes perfectly understandable, providing a short review of audio sources as complement to the sentence which introduces the guide to listening: «è a questa struttura» – the one in the CD – «che si riferisce la lettura dell'opera che qui si propone».

20 It can be assumed, as a matter of fact, that the background noise on the tape is white, that is to say an equal distribution of energy across the frequency spectrum.

21 We are very distant here from the recommendations by IASA which – although insufficient from the viewpoint of the criticism of sources because of their vision based on selection of the best copy (Schüller 2005; Bradley 2009) which does not take into account complex traditions with authorial variants as in the case of *Ages* – provide some minimum quality standards for remediation processes of the audio signal from historical audio documents. Even remaining true to the choice of returning the sound fabric to the form in which it was recorded in FON170 and choosing the IASA viewpoint, the question remains for exam-

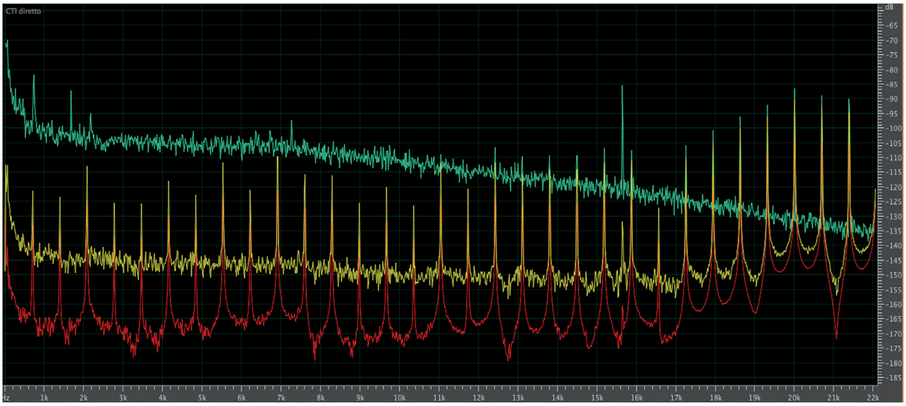

Figure 15. *FFT analysis (Blackmann-Harris window 4096 points) of the various noises before the music in CD2.*

To try and understand the path leading to the audio published on CD2, the best approach seems to be moving directly from the analysis of the document R2 in our possession which, as the publisher informed us, contains a copy of the tape FON170. It is unlikely, however, that this should be the same signal transfer on which the curators of the Die Schachtel edition worked: between the two recordings, in fact, there is a difference in the tape's running speed; this variant is not significant in the analog domain, but it is definitive in a disjunctive sense in the digital domain, where copying processes do not affect (or should not affect) this parameter. Other clues are the linearity of the equalization in R2, perfectly compensated during the reading phase of the analog antigraph, and the better signal/noise ratio, although unbalanced between the two tracks: 58.20 dB on track 1 and 51.55 dB on track 2. Unfortunately, the lack of indications as to the re-mediation and post-production processes leading to the creation of CD2 make it impossible to make safe assumptions as to the relationships between both sources; this makes the

ple of why the curators should not have opted for a restoration approach of a reconstructive type (see "Recorded music: from the ethics of preservation to the critical editing", in this book) and did not recreated the structure of the audio in FON170 starting from the sound fabric saved in Q26, the best copy in their possession (as also Claudia Vincis seems to hint in her essay on page 71), thus gaining more than 10 dB in terms of signal/noise ratio.

dramatic quality decline of the published audio even more difficult to comprehend.[22]

From the catalogue of the Archive of the Studio di Fonologia Musicale (Novati 2009) we learn that the tape FON170 also has another marking in the RAI catalogue: MI/15/S/84191, and is a «copy made from TO/7.5/S/232101 for use abroad with announcements and re-announcements» (Novati 2009, 164). At this point, however, the tracks are lost. If FON170 is a copy, does its antigraph still exist, i.e. the tape from Turin TO/7.5/S/232101? And if so, where is it kept?

The reconstruction of the events which led R4 to reaching the Maderna archive in Bologna does not clarify the picture, indeed it further complicates it. This document is a sort of 'anthology' of music by Maderna created at the RAI production center in Rome. It also has a RAI marking – RO/71/2/722096 – and, apart from *Ages*, it also includes *Amanda-Serenata VI* for violin and orchestra and *Aulodia* for oboe d'amore and guitar. The audio of *Ages*, according to the handwritten instructions on the casing, derives from another RAI tape, marked TO/15/171088. The tradition is divergent: R4 does not refer us back to the antigraph of FON170, but rather to another tape in Turin, characterized by a higher quality format.[23] Does this tape still exist?

MP1 is not definitive in this regard. Not only does the document from which it has been taken – according to the officials at Prix Italia who kindly provided us with a copy – fail to include any indication as to its origin, also the poor quality of the signal, due to the extreme compression applied to prevent the audio from being illegally used, does not even allow for significant measurements in terms of signal/noise ratio, or for clear identification of significant discrepancies with other documents. What is noteworthy, though, is the slightly shorter duration and the absence of the disturbances which disfigure CD2.

22 Due to the poor quality of the audio and the non-linearity of the response, the choice could have been made to made a new A/D transfer of FON170, using better quality equipment and choosing control strategies for these processes which were more stable, or publish the audio of R2.

23 The '15' identifies the running speed in inches of the tape. Theoretically, a higher running speed corresponds to better recording quality in terms of signal/noise ratio and bandwidth.

Version D was found exclusively in libraries which today are part of university institutions: R5 in the Bruno Maderna Archive of Bologna University; R6 in the Luigi Rognoni Fund of Palermo University, where the musicologist's legacy is kept.[24] It is most likely that the first musicology studies about *Ages* might have been conducted exactly on a source which contains this version of the work. In actual fact, Tiziano Popoli, curator of the sheet dedicated to *Ages* in the catalogue published in the *Bruno Maderna. Documenti* (Baroni, Dalmonte 1985, 110-111), mentions a duration of 33'40", similar – after the natural tolerances in the running speed of analog documents – to that of document R5 (33'50"). Ulrich Mosch, who in 1999 edited a new edition of the famous book by Mila, *Maderna musicista europeo*, openly indicates the duration of the piece, which was absent in the original catalogue edited by Mila himself, as taken from this source (rounded up to 34'). In the catalogue of the Maderna archive curated by Mario Armellini and published in 1989 as part of the volume *Studi su Bruno Maderna*, a «raccolta di saggi che di quel primo studio [*Bruno Maderna. Documenti*, ed.] è da considerarsi un naturale prolungamento, come se fossero entrambi accomunabili sotto un'unica etichetta: Maderna I e II» just the tapes A5 (our R4) and B1 (R5) can be found (see Baroni, Dalmonte 1989, 9). The curiosity of our web surfers is thus satisfied!

HOW LONG WILL A MAN LIE I' THE EARTH ERE HE ROT? URGENCY AND ISSUES AS REGARDS AUDIO DOCUMENTS REGARDING MADERNA'S WORK

After this journey through archives and documents, completed by our web surfers in order to try and fill the gap lasting more than three minutes between literature and audio sources, our memory goes back to the clear picture of archive difficulties outlined by Jean Thévenot in 1961:

24 In R6 there seems to be a compression, characterized by saturation and distorting. It is not clear whether this characteristic is due to an actual intervention on the recorded audio or whether it might be caused by the non-professional format with which the tape has been recorded and by the poor quality of the machines used for reading it.

> Les développements de l'enregistrement sonore sont maintenant tels que nul spécialiste, semble-t-il, et *a foritori* nul profane ne saurait sans outrecuidance prétendre parvenir à un recensement exhaustif des archives sonores du monde, d'autant que, simultanément celles-ci restent encore affaire de pionniers (Thévenot 1961, 1184).

In those years, thanks in particular to Thévenot, the first studies were conducted on the difficulties in archive management of audio documents, considering that almost a century of history of sound recording had produced huge amounts of wax cylinders, records in the most varied materials and shapes, wires and magnetic tapes including a multitude of formats and more, with archives totally unprepared to deal with them because they did not have the necessary technical or conceptual means. How could the opposing missions of physical preservation of the item and accessibility to its content be reconciled in the world of audio? The old methods, consolidated on the one hand on hard copies of texts, and on the other in museum artifacts, could not be applied to audio recording; they needed to be reviewed completely. This was when a reflection started about the problems associated with audio storage, restoration and dissemination.[25]

In Maderna's specific case, the urgency of preserving and analyzing the tapes where the composer's work was saved was clearly underscored by Mila as far back as 1975:

> Rimangono le registrazioni delle sue esecuzioni, a organica integrazione delle partiture. La conservazione dei nastri magnetici e il loro periodico rinnovo sono un solenne dovere delle istituzioni musicali che le posseggono, poiché esse costituiscono un sussidio indispensabile della notazione scritta, insufficiente da sola a configurare il risultato sonoro che l'autore-direttore si proponeva. E non sarebbe da eludere l'opportunità che qualche amico o discepolo di Maderna venisse incaricato di trascrivere in note musicali i nastri delle esecuzioni di Maderna stesso. Certamente si incorrerebbe nel rischio di irrigidire in una versione unica, *ne varietur*, la pluralità di combinazioni

25 Tracing a history of the reflection about preservation, filing, restoration and editing issue as regards the audio documents fixed onto a carrier falls outside the scope of this paper. On this topic, please refer to "Recorded music: from the ethics of preservation to the critical editing", in this book.

> virtuali che Maderna lasciava all'estro estemporaneo del direttore, ma d'altra parte si assicurerebbe la riproducibilità, e quindi la possibilità di frequente e ripetuto ascolto d'almeno una versione autentica, scongiurando il pericolo che questi capolavori svaniscano nel nulla, se affidati soltanto alla deperibile materia del nastro magnetico (Mila 1999, 109-110).

This is not the venue to start discussing details of the debate about the score-performance-recording relations and about the ecdotic and interpretation issues, of which Mila was already well aware, associated with work whose aesthetic elements are based on indetermination or a certain degree of execution variability, and thus necessary not univocally fixed in the notation on the score. This question has been extensively discussed as part of the editing work in Maderna's production, supervised by Baroni and Dalmonte, which is still under publication by Suvini-Zerboni (see Baroni 2000).

Much has been done as regards the publishing of instrumental work; nevertheless the issue of preservation and critical edition of electronic music – and of radio dramas in particular – is still unresolved; indeed, Mosch himself, when in 1999 he edited the book by Mila, does not provide catalogue indications regarding this part of Maderna's corpus because «esse sono di difficile reperibilità» (Mila 1999, xiv).

Apart from the difficulty in finding sources already highlighted by Mosch, there are other methodology-interpretation issues with which a critic has to deal before publishing work whose existence is entrusted exclusively or partially to audio carriers. These are clearly outlined by Baroni in an essay written in the year 2000, where the concern expressed by Mila is also extended to electronic music and radio broadcasting:

> In questo caso dovremo risolvere problemi filologici decisamente originali. Di fronte a nastri che venti o trent'anni di conservazione non sempre accurata hanno cominciato a perdere qualità, sono necessari due interventi essenziali: il primo e più urgente è quello della loro copia su supporto digitale [...]. Il secondo tipo di intervento richiede un lavoro assai più complesso, lungo e difficile: si tratta infatti di pensare non a una pura e semplice copia di salvataggio, ma a un vero e proprio restauro del nastro. Ciò che la copia su CD può conservare è infatti la versione fonica dell'opera così come ora esiste nel vecchio nastro, con alcuni elementari interventi di pulizia sommaria.

> Ma ci si può anche chiedere: «Siamo proprio sicuri che questa versione sopravvissuta corrisponda a quella inizialmente registrata dall'autore?», e per di più si può aggiungere: «Fino a che punto è lecito spingere la pulizia che accompagna il riversamento in digitale? Ci si deve limitare alla materiale ripulitura esterna del nastro o si può arrivare anche a eliminare eventuali suoni spurii come clic, fruscii o altro (Baroni 2000. 270-271).

This problem had not yet been solved in 2003, to the extent that Nicola Verzina in the introduction to his historical-critical work about Maderna's production writes:

> La musique électroacoustique de Maderna n'a pas été traitée dans cette étude, cela surtout à cause de la spécificité et de la complexité des problèmes qu'elle pose et qui mériteraient un travail approfondi et une approche toute particulière (Verzina 2003, 16).

However, in the volume which constitutes the third moment of academic reflection in Italy about the composer, *Bruno Maderna. Studi e testimonianze*, edited by Rossana Dalmonte and Marco Russo, published in 2005 by LIM, the topic already no longer seems to fall within the scope of the discussion (Dalmonte, Russo 2005).

Verzina rightly talks about in-depth work and a completely specific approach. This approach has been defined by the MIRAGE team, starting with the PRIN project in 1999-2000, whose goal was exactly the preservation of Maderna's audio documents.[26] Research at MIRAGE continued over the years and the discussion has been extensively covered as part of the *International biennial meetings on audio restoration*. Its outcomes have led to the critical restitution work regarding electronic music on magnetic tape by Luigi Nono, presented as part of the *Meeting* in 2006. On that occasion Henri Pousseur,

26 The preservation and restoration work on magnetic tapes with compositions by Maderna was part of the critical edition of his work – co-financed by the Ministry for University and Scientific Research (MURST) – and whose implementation was supported by Udine University, as well as from the Universities of Bologna and Trento. Goals of the project: a) preservation and restoration of electronic music composed by Maderna at the Studio di Fonologia Musicale; b) preservation and restoration of the instrumental work executions conducted by the author and belonging to the Bruno Maderna Archive in Bologna.

whose position as regards the innovation-preservation axis was known to be strongly leaning towards the creative pole of innovation, wrote to Angelo Orcalli, curator and organizer of the event:

> J'espère qu'un jour, votre Institut pourra faire un travail analogue à celui que vous faites ou avez fait pour Luigi Nono, aussi pour les œuvres initiatrices de Bruno Maderna et de Luciano Berio. Ce serait d'une utilité historique tout aussi capitale. (Et j'aurais peut-être encore des choses à dire, dans ce contexte…).[27]

More than a decade of laboratory experience and studies about the issues related to critical editing of electronic and mixed music has thus provided new conceptual and operational tools to deal with this kind of work with a now consolidated wealth of experience. The surveys about the historical systems for audio production, laboratory practices, the mechanisms for creation and dissemination of recorded audio, allow us to consider the issues raised by Baroni in the year 2000 from a different perspective: that of the newly introduced criticism of audiovisual sources; this is a new research trend in the ecdotic area whose aim is to discuss the change in writing paradigms which took place with the introduction of recording techniques as part of music production and dissemination, in a way which is similar to what has been done with text bibliography starting from the moment when printing processes replaced the manual tradition, thus overturning text philology methods. From this new perspective, the questions raised by Baroni find an answer in the work related to recovering, reviewing, comparing and re-issuing audio sources: active preservation, study of variants (authorial and others) and audio restoration cooperate and mutually clarify each other. Today we need to ask ourselves: how to set up the re-mediation dia-system to correctly extract information from the document? From what kind of intervention, physical or signal processing, is the variant derived? At which point in the tradition and through which technological pathways has the signal emerged which we interpret as spurious?

27 E-mail by Henri Pousseur to Angelo Orcalli, 12 October 2006.

AN EXIT?

Unfortunately, in spite of all the progress in research about issues related to audio preservation and criticism of audiovisual sources, it seems fair to say that, in actual fact, the steps forward in the work done by many archives are slow, and the recommendations by Thévenot are actually still far from being accepted. The audio sources of works by twentieth century composers are now scattered in libraries worldwide. As a matter of fact, though, most of them have not yet acquired the technical skills, or facilities and equipment suitable to process audio documents in a way which is consistent with scientific research in the sector. As is shown in the review of the audio sources of *Ages*,[28] for this study it has been possible only in rare cases to analyze the physical document or one of its preservative copies. Something that archives seem to fail to understand is that writing criticism – most of the time after just listening to the music through headphones[29] – based on digital copies deprived of the original physical and of any information this conveys (presence of physical processing, handwritten indications, trademarks and manufacturing years, etc.), or even worse downgraded to prevent the threat of bootleg editions, is dangerously wasted time. In the same way that it is not possible to complete a philological survey on photocopied manuscript, a criticism of audiovisual sources cannot be based on reproductions which are neither authoritative nor authentic which, as already highlighted as part of the debate on legal and archival aspects, may be guaranteed only if there is a set of metadata which enables for transparent re-mediation processes (see Hirtle 2000, Vitali 2004, Hirtle, Hudson, Kenyon 2009 and Guercio 2013).

Our subject matter, of course, is new, which means that professional figures able to deal with the complexity imposed by this work started to be

28 See *Sources*, p. 226.

29 The indispensable value of computer audio visualization tools for the study of electronic music provides the basis for all of the most recent studies of an analytical nature, including those by scholars who have based their research on listening practices. It is an even more essential condition for a sources criticism, which requires for collation the spatial presence at the same time of the whole sound fabric of all documents, or in other words for musical time to be frozen and decomposable into one or more unified visual spaces which allow for the study and analysis of the audio signal in different domains (time, frequency, etc.).

trained only a few years ago. Nevertheless it is unacceptable that archives dealing with contemporary repertoires should delay hiring specialized staff until, as Mila already wrote in 1975, these masterpieces are destined to disappear forever, because of lack of skill in preserving them, not only passively but also actively: in the tradition of audio sources, poorly made copies of authoritative documents risk obscuring or transforming the image of the composer, they constitute 'parasitical arborescence' similarly to what was already seen by Baroni in the performance tradition (Baroni 2000, 266). A clear case in point is that of the magnetic tapes of *Déserts* by Edgrad Varèse: in spite of the repeated efforts by Casa Ricordi, and of the interest shown by numerous researchers, we have been waiting for more than fifty years for a critical edition and a systematic study of the versions of the electronic part of the work, which are in many cases stored inaccessibly for analysis on tapes jealously owned, without us knowing nothing about the conditions in which they are kept, in archives of at least two continents. The electronic interpolations which have changed music in the western world during the twentieth century can be listened to nowadays, after overcoming a myriad difficulties, through pale *simulacra* on CD, whose provenance or methods used by anonymous technicians to work on them we know nothing about. The situation is so serious that many orchestra directors, due to the poor quality of the audio available, and basically to the confusion between the different versions of the interpolations, prefer to remove the work from their repertoire or to deprive it of its electronic part.[30] International musicology has something to think about in this regard.

The problem also affects the area of publishing. Based on a consolidated tradition of studies, the publishers of texts fixed onto handwritten or printed documents can rely on professional figures which are able to deal not only with the material aspects of publication, but also with the critical-philological sides of the ecdotic process. As regards audio sources, unfortunately, however admirable and praiseworthy some publishing initiatives may be, the poor quality of the published audio and the absence or insufficiency of critical or technical *apparata* is testimony to the lack of suitable theoretical and operating instruments. All too often publishing houses are forced to delegate

30 See "Tracks in the deserts", in this book.

to others work which, guided by inefficiency and cost-saving criteria, leaves no margin for an overall picture regarding the tradition of sources, for that moment of reflection which should be the basis of publishing activities.

It is thus not surprising that in 1993, in the absence of theoretical guidance and a consolidated ecdotic methodology as reference, the record label Stradivarius should have decided to release a recording of *Ages* with no indications as to the sources or information about the audio re-mediation processes. Similar pioneering enterprises, to quote Thévenot, in the publishing of electronic music, have been important for the dissemination of compositions which would otherwise be inaccessible not only to the academic community, but also the audience of interested listeners and enthusiasts for whom the preferential point of access to music is definitely not the archive. A cause for concern, on the other hand, comes from noticing that – in spite of the research progress made in this field – after 20 years very little has changed in the Die Schachtel edition.

Today we know that every edition, in spite of its being driven by admirable intentions in terms of objectivity, is a re-writing operation. And this is even more evident in the case of analog audio, where publishing inevitably entails re-mediation processes. When re-issuing electronic or radio music compositions, where timbre and the sound output are primary and essential aspects of the work, it is always necessary to bear in mind that each processing of the audio, even the most common everyday practice of post-production (compression and limitation of dynamics, equalization, etc.) is bound to alter the sound fabric, constituting a restoration moment which results in innovations sometimes not expected by the authors. Those who edit an audio document today need to be aware of their accountability to the whole re-mediation chain: from the motivated choice of the document to be reproduced, to the setting up of the signal reading and transfer system, to interventions of restoration and/or post-production driven by the expressed aims of publishing, to the editing of critical and technical documents. As long as we fail to grasp the extent of the impact which recording has had on music creation and dissemination processes, and do not realize its impact in terms of criticism, valuable publishing initiatives will bear the brunt of the lack of technical and interpretation support which in other traditions (handwritten, printed) has made it possible to put together critical edition masterpieces, which are still models for the most famous philologists and bibliographers, essential *compendia* for any musicologist and every performer driven by the wish to really get to know the authors whom, in the words of Busoni, they are called upon to re-write. The task of a criticism of audiovisual sources mindful of variants, as clearly underscored by Mila with regard to recordings of instrumental work, is not – as a matter of fact – to constrain the work within a single version, but rather to reproduce its vitality and mobility, making sure that the scholar and listeners on several levels – as well as the performers – get an overview which is as comprehensive as possible of what the author intended, a sort of aesthetic benchmark. A discerning user will then have to detect any new possibilities.

This is where our web surfers, who by now have almost become musicologists, exist the stage because the critical study of the variants has taught them that the work lives, is renewed and re-actualized exactly in an endless process of re-writing which finally transcends the author in a vitality of which, in the case of *Ages*, a masterful example is the choreutic revisiting by the Tam Teatromusica group and the honesty in their statement of intents published on YouTube. Now maybe the Web will re-write *Ages* and the other works entrusted to it again, in the same way as audio recording has re-written our soundscape; it will re-combine them on the continuous re-mix which, in the perpetual renewal of the artistic act, incessantly searches for new stars in new skies.

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SOURCES

Audio sources

R1: Milan, Ricordi, [201?]. DVD with "Q26" written on the sleeve. According to the editor, it contains a re-recording of the Q26 tape kept in the Archive of the Studio di Fonologia Musicale. 4 BWF monophonic files (96 kHz, 24 bit), sterephonic: track 1 = track 2, track 3 = track 4. Duration of the work: 36'43" + 23" announcements.

R2: Milan, Ricordi, [201?]. DVD with "FON170" written on the sleeve. According to the editor, it contains a re-recording of the FON170 (MI/15/84191) tape kept in the Archive of the Studio di Fonologia Musicale. 2 BWF monophonic files (96 kHz, 24 bit), stereophonic. Duration of the work 30'53" + 23" announcements.

R3: Pordenone, MIRAGE Archive CBM 0039, 2006. DVD containing a preservative copy of the *Ages* magnetic tape (¼", 7.5 ips) owned by Giorgio Pressburger. Duration of the work: 36'54" [no final announcements].

R4: Bologna, Bruno Maderna Archive A5 (RO/7.5/702096), [s.a.]. Magnetic tape, ¼", 7.5 ips, 2-track, monophonic. Duration of the work: 31'08" + 23" announcements. On the case: «Riversamento a 7 ½" da Bobina: TO/15/171088». On a sticker: «RO – 7 ½ 722096».

R5: Bologna, Bruno Maderna Archive B1, [s.a.]. Magnetic tape, ¼", 7.5 ips, monophonic. Duration of the work: 33'50" + 23" announcements.

R6: Palermo, Rognoni Fund CD025, [s.a.]. CD-A containing a re-recording of the 092 SN 13 magnetic tape (¼", 3.75 ips, monophonic). Duration of the work: 22'20" + 24" announcements. Maybe truncated at the beginning.

R7: Basel, Paul Sacher Stiftung CD 10, [s.a.]. CD-A containing the re-recording of TS 1011 tape (¼", 7.5 ips, stereophonic). Duration of the work: 36'55", no final announcements.

R8: Basel, Paul Sacher Stiftung CD 37, [s.a.]. CD-A containing the re-recording of TS 1030 tape (¼", 7.5 ips, stereophonic). Duration of the work: 36'55", no final announcements.

R9: Pordenone, MIRAGE Archive ABM 0006, 2008. CD-A containing the re-recording of Florence, Tempo Reale TR527 and TR528 (2-channel, monophonic). Created by Tempo Reale. Divided in two parts. Duration of the work: 30'50" + 22" announcements.

CD1: Maderna, B. (1992), *Satyricon/Ages*, Milan, Stradivarius, STR 10061. Duration: 30'37", no final announcements.

CD2: De Benedictis, A. I.; Novati, M. M. (ed. by) (2012), *L'immaginazione all'ascolto. Prix Italia. Il premio Italia e la sperimentazione radiofonica*, Milan, Die Schachtel. Duration: 30'46".

NET1: Podcast RAI.TV (2011), *I gioielli del Prix – Ages, testo di Giorgio Pressburger e musica Bruno Maderna (1973)*.

NET2: *Prix Italia 1972 – Ages di Giorgio Pressburger e Bruno Maderna, in Radiopassioni, il forum*. RAI radio broadcasting of 10 October 2010, conducted by Sandro Cappelletto.

NET3: *Maderna Bruno – Ages. Radioinvention for soloists, chorus and orchestra (1972)*. Classical music on-line, added by: Kuumuudessa, 10 October 2012.

MP1: Mp3 file, 2013. 8 kHz, 32 kbit/s, provided by RAI direction of the Prix Italia. Duration: 30'36" + 23" announcements.

Part II
Audio Preservation and Restoration

From the archive to the event

Preservation, analysis and promotion of historical audio recordings at MIRAGE

Luca Cossettini

ARCHIVES, LIBRARIES AND AUDIO DOCUMENTS

For more than a century archives and libraries have consisted not only of books, manuscripts or silent scores, but have been complemented by audio documents which can be used through the sense for which they have been designed: hearing. Regardless of whether they are music performances, electronic artworks, popular music or recordings of life experiences, they overshadow the centuries-old predominance of vision and appear in their natural essence as acoustic phenomena. Furthermore, the birth and diffusion of home recording equipment led to the creation of a set of documents designed for private use, as a sort of sound journal, which often – especially if they bear witness to a wider cultural context – have become part of collections available to the general public.

It is possible to make a distinction between at least two types of audio documents: the recording of an acoustic event and the musical work designed – or performed – specifically for being recorded. In the case of the former type of document, the act of recording in a way 'objectifies' a life fragment: it is a choice of the moment to be immortalized, made by the person recording it, that makes it special, by releasing it from ordinary daily routine; recording thus becomes an ideal *analogon* of the real event, fixing the acoustic wave without the mediation of a language or musical code.[1] In the second instance,

1 Of course the system which allows for the recording of sound also imposes its own writing codes with regard to the audio message; professional operators are always well aware of this, while the general public often tends to ignore them. In actual fact it is worth remembering that the recording parameters of commercial devices used for home recording can rarely be adjusted.

the composition is produced by superimposing a musical idea which is born exactly from the relationship with the medium itself; the mere recording of sounds develops into a creative act by a composer who processes the audio with artistic purposes. More specifically, electronic works are the result of audio signal processing and control activities: an editing process of heterogeneous audio materials which the composer fixes using a writing form which is neither visible nor directly legible, but which can only be heard through an interface. It is the recording of a composition action which involves not only the composer but also the specific technology used, the sound engineers in the studio, and the relations with any performers. This leads to the creation of a distinction which results in two different ways of experiencing the technical instrument.[2] On the one hand there are recordings of events, sound journals, working notes, or intimate and personal memories, where creativity is put aside: it is the medium that imposes its rules; on the other side you have electronic works, as well as studio record productions, re-processed editions of musical performances (often flaunted as live recordings), where human creativity is revealed in the ability to 'force' the medium for expressive purposes (carrier manipulations, editing cuts, accelerations, decelerations and retrogradations which leads to a different reading of the parameters stipulated by the format, etc.). On the border between these two modes are the tapes used by composers. These are documents on which audio 'notes' are recorded, composition experiments, preparatory materials which can then be processed and lead to the final 'drafts' for the electronic work, copies of electronic parts (for studying or rehearsing), etc. These documents today are kept in the archives and are fundamental in order to study the genesis and the development of the work, as are drafts and sketches on paper.[3] This is the scenario with which scholars are confronted when studying documents kept in the composers' personal archives.

2 Some scholars give this distinction an ontological value (see Pouivet 2014); others think there is a continuum between the two poles (see Cottrell 2010).

3 Much has indeed been said about the study of sketches (see, for example, Borio 1999, Hall and Sallis 2005, or Kerman 1995). On the contrary, so far, no specific bibliography has been produced as regards the study of preparatory audio materials, considering the specific features of this type of document.

Scholars today are faced with a complex set of documents and need to review all of the analysis models formed on the basis of text abstraction: such painstaking revision work starts from recognizing the historical-documental value of the document, through new cataloging, information management, restoration and presentation systems, leading to the fruition of this cultural heritage by the general public.

I present here three significant examples of work done at MIRAGE which cover the spectrum of the various issues that confront anyone dealing with audio preservation and restoration work: 1) the work leading to preservative and access copies for the Archivio Storico del Teatro Regio (ASTR) in Parma was a mass preservation enterprise, where the most urgent need was to save the documents; as a consequence economic-organizational strategies of an industrial nature and systematic control procedures were used, processing a large number of documents in a short time. This work actually entailed defining and applying stringent operating protocols for the control of workflows, which could also be extended to other collections of audio documents; 2) the work done on the tapes from the Luigi Nono Archive (ALN) in Venice underscores the issues related to 'hybrid' audio documents, bordering between sound journal, preparatory materials and the electronic artwork, which meant that critical reviews of the sources were necessary in order to highlight the relationships between use and Work recordings; 3) last but not least, the 'museumification' work on audio recordings from the Riccardo and Fernanda Pivano[4] Library (RFPL) in Milan, completed on the occasion of the exhibition *Voci-Voices* (Treviso 2004), outlining the path leading to a sound journal of inestimable cultural value for the public at large.

4 Fernanda Pivano (Genoa 1917 – Milan 2009) was an Italian essayist, translator and writer. She was a prominent figure in the Italian cultural scene for her efforts in the translation and dissemination of works by contemporary American literature. Pivano brought to Italy a critical method based on direct evidence, the history of costume and on the socio-historical survey on writers and literary phenomena.

SAFEGUARDING THE TANGIBLE AND INTANGIBLE HERITAGE OF MUSIC: THE ARCHIVIO STORICO OF THE TEATRO REGIO IN PARMA.

With Law n. 167 of 27 September 2007 Italy, too, ratified the *Convention for the Safeguarding of the Intangible Cultural Heritage* (UNESCO 2003), approved on 17 October 2003 by the General Conference of UNESCO and which had already entered into force after the fortieth ratification on 30 April 2006. According to Art. 1, the purposes of the convention are:

1. To safeguard the intangible cultural heritage;
2. to ensure respect for the intangible cultural heritage of the communities, groups and individuals concerned;
3. to raise awareness at the local, national and international levels of the importance of the intangible cultural heritage, and of ensuring mutual appreciation thereof;
4. to provide for international cooperation and assistance.

The Convention defines intangible heritage as follows: «the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artifacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage». Audio recordings thus take on the role of primary sources. The scores serve to pass on the texts, the instructions to perform the work; audio documents, on the other hand, reproduce their performance practice, informing us about its specific interpretation by musicians and singers, about its various performances, about the expressive components of music which have historically shaped our musical sensitivity and culture.

The Teatro Regio in Parma, ever since it was inaugurated under the name Nuovo Teatro Ducale on 16 May 1829 with a performance of *Zaira* – music by Vincenzo Bellini and libretto by Felice Romani – has been witness and protagonist of major changes on the Italian and international melodrama scene.[5] The memory of these crucial pages for the history of music is today entrusted to a large extent to its Archivio Storico which, alongside portraits

5 For the history of the Teatro Regio in Parma see Capra 2007.

and photographs of artists, posters, drawings, sketches, technical projects, printed and handwritten musical scores, librettos, magazines, costumes and stage jewelry, also contains an inestimable audiovisual heritage.

In 2014 there was a national call for tender – awarded to MIRAGE – by the Istituzione Casa della Musica and the Municipality of Parma to start a digitization project for the audio recordings in the Archive. The work requested by Casa della Musica to the team from Udine finally led to the production of preservative copies for 352 audio tapes with recordings of concerts and Opera performances starting in 1961. The sound tracks, digitally remastered, were recorded both at high resolution (96 kHz – 24 bit), for preservation purposes, and in MP3 format (192 kbps and 320 kbps), which would allow for easier access by the public at large. The preservative copies are accompanied by photographs and specific catalogue cards which – based on musicology checks as regards content and technical certifications – attest to the originality and provenance of each document unit. Access to these recordings has proved to be extremely significant, both for documentary and artistic reasons: it will allow for a reconstruction of several decades of theatre history, as well as of an actual history of musical interpretation in the second half of the twentieth century, through the performances of all the great artists held on the stage of this prestigious theatre.

Active audio preservation

On 23 July 2014 a total of 302 analog ¼" magnetic tapes were transferred from ASTR (the headquarters of Istituzione Casa della Musica) to the MIRAGE Archive for digital re-recording work according to the contract. A second batch of 50 tapes was then transferred to MIRAGE on 22 June 2015.

From a preservation perspective the challenges created by a collection of audio documents are multifaceted. There are actually two types of preservation: passive preservation where the goal is safe storage of the document in suitable environments for its physical integrity, and active preservation which involves the information being continuously copied onto new carriers, always in step with the times.[6]

The work for the creation of a preservative copy is focused on recognizing the historical-documentary value of the item, in its dual nature as industrial product and human artifact. The audio documents provide information on several levels: the carrier is perceived as tangible object, available in space-time, its content is an intangible projection of a past event, perceivable exclusively through an interface. As witnesses of past events, audio documents are closely connected to the context within which they were produced; as artifacts they are subject to a natural aging process which inevitably affects the information contained. Creating a preservative copy, therefore, involves a process which can in no way be regarded as neutral. When the signal is copied onto a new carrier, a fracture is created in the history of the document: one phase in its development is 'photographed' and transferred to a more stable and reliable carrier; considering that the original is inevitably perishable, this transmission of information is entrusted to the new medium. The mere transfer of the signal is thus not enough to create an authorial copy. The distance between us and the moment when the original document was produced makes it necessary to set it within the historical and technological framework in which it was created; this means that, in a preservative copy, the following characteristics of the original document should be analyzed and certified: technological elements (material components, production system, re-mediation system), information content (primary information – the recording – and secondary information – ancillary signals), as well as historical-documentary records (information accompanying the document, events related to its preservation, its intended uses, evidence given by the technicians in charge of recording it) (see Orcalli 2006).

6 In the 1980s the issue raised by audio preservation and restoration opened a wide and long debate. For its reconstruction, please refer to Orcalli 2001. Canazza, De Poli and Vidolin went back to the topic in Canazza, De Poli, Vidolin 2011. Please also refer to "Recorded music: from the ethics of preservation to the critical editing", in this book.

Authenticity

In the active preservation procedures the information recorded in the audio document undergoes continuous transfer processes, it evolves, innovates and changes over time. In the digital neo-media ocean the carrier finally disappears, the document becomes virtual, its content fluid and free to be transported on the Internet, to be recreated in ever-changing places and contexts. After Benjamin we now that in the continuous renewal of re-production the categories of authenticity and originality seem to disappear: every communication act acquires value in itself, becomes original and authentic in its own way (see Benjamin 1936). The question can thus be posed as follows: if the authenticity of a document is established first and foremost by its material uniqueness, how is it possible to keep track of it once the audio signal is transferred onto a new carrier?

For centuries all evidence of a document's authenticity has been based on the texture of paper, on the presence of watermarks, on the typeface and chemical composition of the ink. None of this is available in the digital domain, where information is no longer linked to a physical carrier. Also audio documents, like hard copies, are subject to manipulations and counterfeiting. In a copy, however, they have a less profound connection to their original carrier (consider, for example, digital audio or *iTunes*, but also the perishability of analog carriers themselves); the distance from the event that acoustically generated them is often insurmountable. Such loss of a direct relationship makes the issue of source authenticity much more complex.

One way of guaranteeing the authenticity of a document in the digital domain is to keep track of re-mediations, this making copying processes transparent and the provenance from the original document always discernible. The question therefore seems to be related to a review of the sources: in order to verify authenticity, it is necessary to 'keep track' of any information transmitted over time, to study the mutual relationships among documents and find the authorial original. In this sense making sure that the tradition can be reconstructed means producing a set of metadata regarding the history of the document; the authorial level of such information is then determined according to the institution from which delivered them.[7] The issue thus shifts to managing 'meta-sources', a neologism created by Jean-Philippe Genet, also used by Andrea Zorzi and Stefano Vitali with regard to new and more complex publications facilitated by the flexibility of digital media, where the critical edition is complemented by a set of survey tools (inventories, reproductions, bibliographies, databases, search engines, etc.) which do not just enhance the text but also lead to new ways of reading and using it (see Zorzi 2003, Vitali 2004 and Cohen, Rosenzweig 2005). In order to ensure the authenticity of documents it is therefore necessary to prepare a set of metadata to complement the digital signal: specifications of the format chosen for data recording, message digests to check that future D/D transfers are correct, calibration diagrams and values in respect of the systems used to transfer the signal, process reports, catalogue cards, photos and videos of the original document.

Operating phases

From an operational standpoint the work done for ASTR was divided in several stages, assigned to two teams working in parallel.

Stage 1 – Photographic documentation of the document. The first step involved photographing each part of the original document (reel, casing, any attachments, etc.) using a *Nikon D90* camera with 12 megapixel sensor – *AF-S Nikkor 18-105mm* 1:3.5-5.6 lens. The images were then added to the preservative copy in JPEG format.

Stage 2 – Analysis of the preservation state and restoring of carrier functionalities. The tapes were then wound and unwound (spooled). This operation allowed for an initial assessment of the tape's preservation state (Table 1) and reduced the print-through (transfer of magnetization from one coil to

7 An in-depth debate has started in this regard within the international archive management community: see also Bearman and Trant 1998; Cullen, Hirtle et al. 2000; Guercio 2013.

the next due to long storage). *Studer A812* and *Studer A80* tape recorders were used which guaranteed safe tension and running speed conditions.

Later on, if necessary, physical work was done on the tape to restore its functionalities: restoration of splicing and, if necessary, addition of leader tape at the beginning or at the end, or treatment in a thermal incubator *Memmert BP400* at 50°C for one or more 12-hour cycles in the case of tapes showing signs of 'sticky-shed syndrome' (168 cases in the work under examination). Details of each individual treatment were added to the catalogue cards appended to the preservative copies.

Bad	Mediocre	Good	Excellent	Total
176	21	155	0	352

Table 1. Preservation state of the tapes

Stage 3 – Selecting the format. The ASTR tapes contain recordings made in various settings, many of which are unknown. Since no specific information is available regarding their production system, the technician in charge of transferring them has to reconstruct the format and calibration parameters of the reading machines inductively. Generally speaking, any issues related to selecting the format are connected with the following: a) running speed of the tape (table 2) which can be assessed by listening and with the help of the analysis of the ancillary signal due to electromagnetic induction (*hum* at 50 Hz); b) number and arrangement of tracks (tables 3 and 4) which can be measured through vertical non-invasive scanning of the tape using a reading head; c) equalization, in which case the element useful for detection – often not conclusive – is the study of background noise linearity and of ancillary signals on the machine which produced the recording (see McKnight 1969); d) noise reduction systems (*Dolby, dBx, Telcom, Adres,* etc.), which are difficult to assess through a mere signal analysis.

For the preservation work on ASTR tapes, the running speed was assessed perceptively and based on the ancillary signal analysis due to electromagnetic induction on a short digitally acquired signal portion. The number and position of audio tracks was determined using a reading head with variable zenith and micrometric screw (constructed by MIRAGE), assembled on a *Studer A810* tape recorder (Figure 1).[8]

No instructions were provided in the materials accompanying the documents, nor was any definite information available about the historical recording systems chosen to produce the tapes; use was therefore made of standard equalization curves CCIR (IEC1) and NAB (IEC2). The selected equalization parameters are shown in the individual cards accompanying the preservative copies. In just one case (document with AV14F25 marking) was the equalization reproduced as shown on the casing (CCIR) using digital filters, based on a transfer made using a tape recorder calibrated with NAB native equalization.

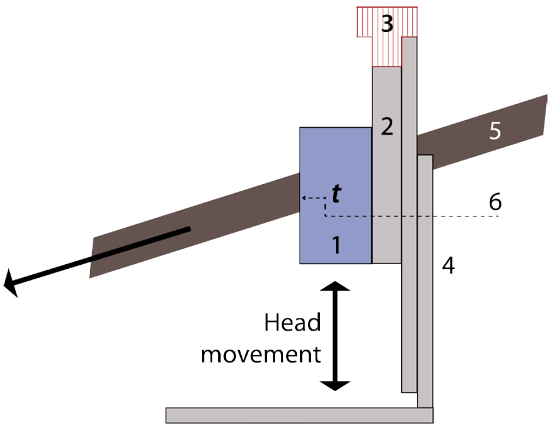

Figure 1. Track detection system: operating diagram. 1) Micro-head immersed in a plastic substance casing; 2) Graduated scale used for reading; 3) Screw mechanism for head movements; 4) Support fixed onto the recorder; 5) Magnetic tape; 6) Output signal.

It was finally ascertained that a single noise reduction system was used: *Aurex Adres*, in documents AV13C22 and AV13C23. The signal portions actually coded were selected by analyzing the digitally acquired signal.

8 This system was developed for the re-recording project completed by MIRAGE for the ASAC, La Biennale di Venezia (see De Mezzo, Orcalli 2003).

3.75 ips	7.5 ips	15 ips	More than one speed	Total
77	254	11	10	352

Table 2. Speed

Full-track	2-track	4-track	Total
77	254	11	352

Table 3. Tracks

Monophonic	Stereophonic	More than one format	Total
111	240	1	352

Table 4. Signal

Stage 4 - Reading and decoding the signal. Once the format of each document had been selected, the tapes were played with the following tape recorders:

- For ¼" full track recordings: *Studer A812* with full track head;
- for ¼" 2-track recordings: *Studer A812* with 2-track head (gap: 2 mm);
- for ¼" 2-track stereo recordings: *Studer A812* with 'butterfly' head (gap: 0.75 mm);
- for ¼" 4-track recordings: *Otari MX5050* with 4-track head.

The balanced output signal from the tape recorders was transmitted to the A/D converter (*PrismSound Dream AD-2* or *PrismSound Dream ADA-8XR*) through XLR balanced *Evidence Audio Lyric HG* cables.[9] For A/D conversion

9 The tapes coded *Adres* (AV13C22 and AV13C23) were digitized without compensation (*flat*). The signal was later decoded with a *Toshiba Aurex Adres AD-2* unit. The D/A and A/D conversion was completed with a *PrismSound Dream ADA-8XR* converter; for unbalancing and subsequent rebalancing of the signal a *Tascam LA-40 MKII* Balanced/unbalanced line converter module was used.

a sampling frequency of 96 kHz was used with a 24 bit-resolution; the acquisition level was set at 0 dBu = -18 dBFS, except for cases where the headroom proved insufficient (see documents AV14F49, AV15A01 and AV15A02, transferred with 0 dBu = -21 dBFS). The quality of converters and acquisition level were certified using the *Audio Precision APX-515* system; the relevant report was appended to the preservative copy.

The digital signal output from the *PrismSound Dream AD-2* converter was conveyed as follows:

- AES/EBU to a *Mac Pro* 5.1 workstation with PCI D/D *RME HDSPe AES* and *Adobe Audition CS6* software;
- AES/EBU to an *Apogee Rosetta 800* D/D converter; then FW400 to an *iMac* 7.1 workstation with *SonicStudio SoundBlade 1.3.5* software.

The digital signal output from the *PrismSound Dream ADA-8XR* converter was conveyed as follows:

- AES/EBU to an *Apogee Rosetta 800* D/D converter then X-HD to a *Mac Pro* 3.1 workstation with *ProTools 7.4* system;
- FW400 to a *PowerMAC 11.2* workstation with *SonicStudio SoundBlade 1.3.5* software.

The synchronizing of equipment was guaranteed by an *Antelope Audio Isochrone Trinity* wordclock generator.

For each document a dual acquisition was then completed in respect of the output signal from the converter. The stability of the system was finally checked by adding the two signals in antiphase.

During the transfer the signal was constantly listened and checked by means of the following monitoring system:

- *PrismSound ADA-8XR* D/A converter;
- *Focusrite Red 4* preamplifier and *Genelec 1032A* loudspeakers;
- *Tascam MH-40 MK II* preamplifier and *AKG K701* and *K271* headphones.

This perceptive check was complemented by a real-time spectrogram view of the converted audio signal: this made it possible to notice any frequency response reductions due to the 'sticky-shed syndrome' or other defects (*iZotope Insight* analyzer).

The analog magnetic tape players were calibrated with specific *MRL* tapes for the various speeds (3.75 ips, 7.5 ips, 15 ips), equalizations (IEC1/CCIR, IEC2/NAB) and fluxivity (250 nWb/m).

In line with the recommendations by IASA (Bradley 2009, item 5.4.7), the machine parts in contact with the tape were cleaned before transferring each tape (isopropyl alcohol for the heads and metal runners, distilled water for the rubber components); heads and runners were de-magnetized after every eight hours of use with a *Han-d-mag Model S* machine; the alignment of the machine (speed, level, azimuth, equalization) was checked every 30 hours of use. After three months' work the equipment was cleaned and integrally re-calibrated.

The *Adres AD-2* system was calibrated according to the reference signals recorded on tape.[10]

Each calibration procedure was checked and certified using the *Audio Precision APX515* system (output level, azimuth, equalization, SNR, THD, *wow and flutter*). The report generated by the system was appended to the preservative copy.

Stage 5 - Preparation of audio files, BWF specifications and MD5 checksum. The audio signal of each transferred track was recorded in Broadcast Wave Format (BWF) format at 96 kHz, 24 bit, monophonic (PCM coding). While preparing the preservative copy, attention was paid to the guidelines by EBU with regard to restrictions (file name and length) in respect of the BWF format (see EBU Tech 3285 v2). For each file the relevant MD5 checksum was produced to ensure the integrity of any subsequent digital copies.

10 The av13c23 tape included no reference signal. As agreed with the customer, the delivery included a copy without decoding and a compensation proposal for the intentional alteration based on the calibration used in the av13c22 tape.

Stage 6 - Production of the description card. The description card designed by MIRAGE consists of four parts: a) heading, b) description of the preservative copy, c) list of documents recorded in the preservative copy, d) description of the original document.

Heading

- Author (as agreed with the customer, for opera: author of the music; for recitals or symphonic concerts with more than an author: blank field);
- Title (as agreed with the customer, for opera: title of the work; for recitals:«Recital di» followed by the name of the singer/musician; for symphonic concerts: the name of the orchestra).

Description of the preservative copy:

- Title of the preservative copy. Author (as in heading), title (as in heading), theater, number of performance, date;
- Source (original source archive and catalog number);
- Carrier type and brand;
- Data format (data coding for digital files);
- File names;
- Beginning of the recording (the temporal offset from the beginning of the digital audio file and the re-recorded signal, excluding leader tapes);
- Sampling rate;
- Resolution (in bits);
- New catalogue number.

List of documents recorded in the preservative copy:

- Audio Precision certifications;
- Chart with the frequency response of the tape recorder;
- Diagram of the signal transfer and monitoring system (Figure 2);
- WAV audio files with BWF header, 96 kHz – 24 bit;
- Audio format specifications;
- Pictures of the original document;

- MD5 checksum for audio files;
- MD5 specifications.

Description of the original document:

- Original archive (with city);
- Catalogue number;
- Inventory number;
- Carrier (type and dimension);
- Texts and marks on the original document (diplomatic transcription of texts and marks on the case, on the reel and on the tape);
- Annexes (description of the annexes);
- Case type;
- Case brand;
- Carrier brand and model (only when indicated on the tape itself);
- Storage (e.g. open reel, cassette, etc);
- Spooling (tail-in or tail-out);
- Preservation state (perfect – new tape; good – no corruptions; mediocre – minor corruptions, no need for physical restoration; bad – major corruptions, physical restoration needed);
- Notes;
- Recording technique (analog or digital);
- Duration of the tape/sections;
- Speed;
- Tracks;
- Signal (e.g. monophonic, stereophonic, quadraphonic, etc.);
- Equalization curve;
- Noise reduction systems (e.g. *Dolby A*, *Adres*, etc.);
- Notes on the signal.

Stage 7 - Production of the preservative copy. The preservative copy was produced exclusively for archival purposes. It was recorded as follows: a) on a raid 1 server with Ethernet interface (*LaCie 2BIG NAS*), and b) on a DVD-R (*JVC Archival Grade*) with *TEAC DV-W5000U* burner.

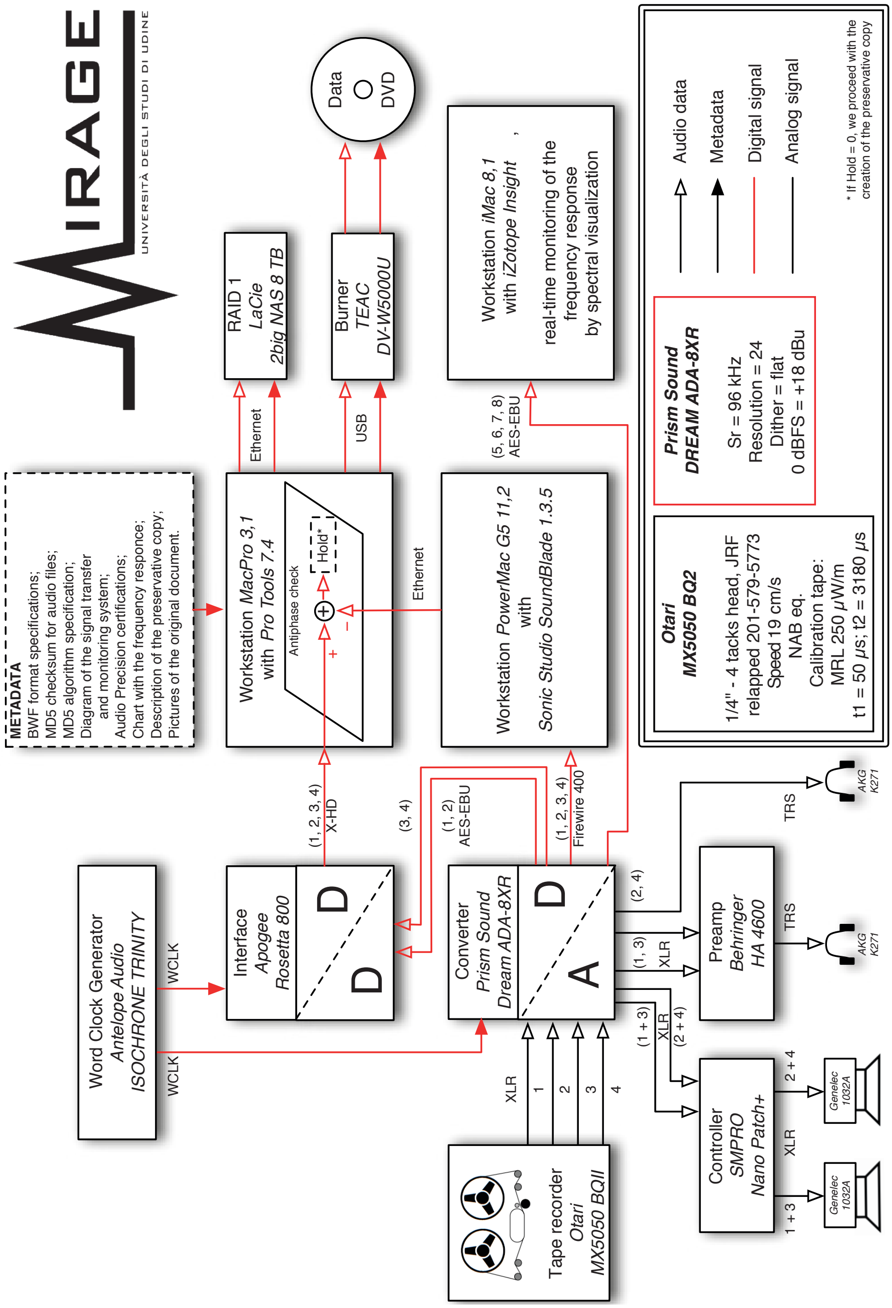

Figure 2. Diagram of the signal transfer and monitoring system.

Stage 8 - Production of access copies. In order to meet the needs for use of the audio material by the archive, apart from the preservative copy, an access tape in MP3 format was produced containing all the material for internal use of Casa della Musica. The access tape for Intranet listening includes:

- MP3 CBR 320 kbps, 48 kHz, 24 bit, no dither audio files, created with *Adobe Audition* CS6 (*Fraunhofer* encoder);
- access copy description card.

The access tape for listening on the Internet includes:

- MP3 CBR 192 kbps, 48 kHz, 24 bit, no dither audio files, created with *Adobe Audition* CS6 (*Fraunhofer* encoder);
- access copy description card.

These copies were burned on CD-R (*JVC Archival Grade*) using the *TEAC DV-W5000U* system.

Illegible tapes and their replacement

Among the 302 documents delivered to MIRAGE on 23 July 2013 there were ten tapes affected by the 'soft binder syndrome' (squealing): av13a15, av13a16, av13a17, av13a18, av13a19, av13a20, av13a21, av13a22, av13a45, av13a60. At the moment there are no definite and shared solutions by the international archival community for the restoration and reading of tapes damaged in this way, for this reason they were written off as illegible. In agreement with the customer, the decision was made to return the documents and to replace them. On 17 November, 2014 ASTR delivered to the MIRAGE Archive another 27 magnetic audio tapes in total. All of the documents contained in this batch were tested to check their preservation state and format. The tapes affected by 'sticky-shed syndrome' then underwent an incubation period and preservative copies of the first ten documents following their original order of marking were produced.

Information exchange

For the preservation of the ASTR audio documents the MIRAGE team had to face several issues, most of them caused by the dating of the tapes which, at a distance of nearly fifty years now, show typical problems of chemical and physical decay and of format recognition. The experience gained over the years by MIRAGE and the exchange of information within international networks (e.g. prestocentre.org) have allowed us to overcome difficult problems on the signal decoding (e.g. *Adres* noise-reduction system), on the choice of the most suitable machines for a faithful re-recording (see Schüller 1991), on the physical restoration of the carriers (see Schüller, Albrecht 2014, item 3). Other issues remained unresolved, because they are still debated within the international archival community (see Casey, Gordon 2007; Hess 2008; Schüller 2014 on the loss of lubricant – 'soft binder syndrome'). Once again we can affirm that progress and scientific updates are responsible for the ability itself to recognize documents and process the relevant information. The importance of the feedback principle,[11] reached through the exchange of information between archives and laboratories that are active in the audio field and beyond, is clear.[12]

11 See "Towards a systemic approach to the critical editing of music at MIRAGE", in this book.

12 A third batch of ASTR tapes, dating back to the early nineties, has been digitized by Audio Innova Srl – a spin off of the University of Padua – with procedures that are in continuity with the protocols developed by MIRAGE. As confirmed by the technicians and the researchers of the Padua Center: «la messa a punto di una metodologia standardizzata condivisa a livello internazionale è un obiettivo verso cui devono tendere le comunità archivistiche di tutto il mondo, così da creare un network di risorse che permetta la condivisione e faciliti l'accesso al grande patrimonio artistico culturale registrato sui supporti audio» (Russo, Burini, Canazza, Rodà 2017).

COMPOSERS' AUDIO ARCHIVES: THE LUIGI NONO ARCHIVE IN VENICE

In 2007, as part of a project for the preservation of its audio documents, the ALN (Luigi Nono Archive) delivered to MIRAGE one batch with ten tapes for preservative processing, which was the first step required for a study of the audio materials recorded on them (see Cossettini 2009). These are ¼" magnetic tapes, where Luigi Nono recorded preparatory materials and working sketches for the composition of *Como una ola de fuerza y luz* and *La fabbrica illuminata*.

Regarding the significance of Nono's audio tape collection, is worth quoting Alvise Vidolin, who was also in charge of the first major preservation work on these documents. The archive contains several working tapes related to pieces of electronic music:

> I materiali utilizzati nelle Musiche per 'Die Ermittlung' di Peter Weiss; molto materiale di *A floresta é jovem e cheja de vida*, con ben 13 nastri contenenti le registrazioni originali del Living Theatre; le registrazioni dei rumori del mercato del pesce di Rialto utilizzate in *Contrappunto dialettico alla mente*, ecc., i famosi scherzi elettroacustici di Zuccheri stesso, ma anche registrazioni di esecuzioni dal vivo e delle prove che precedono l'esecuzione pubblica, interviste, diverse registrazioni delle sessioni di lavoro Live Electronics nello studio di Friburgo e ovviamente molti nastri definitivi delle opere elettroacustiche (Vidolin 2008, 54).

They are indeed valuable documents because they shed light on the composition process which led to producing the electronic parts of the final compositions. Having successfully completed the preservative copy production phase, the question then arose of how to study the original document's sound fabric in respect of the other sources and of the works they contained.

Much has been written about instrumental and vocal music, regarding both textual issues and performance practice; on the contrary, work on the documentary interpretation of audio recordings underlying electronic music compositions is still in progress. In order to study this repertoire it is essential first of all not to lose sight of the composition approach and performance practice, and to consider the technological framework within which they were produced; this laboratory practice world is very distant from the traditional composer's 'writing desk'. Luciano Berio, as early as 1953, commented:

> Da molto tempo l'*homo musicus* ha dimesso l'alloro e il manto della tradizione, se mai questa è esistita all'infuori delle concezioni bergsoniane. Casella ha scritto che il musicista di oggi deve avere tutte le apparenze dell'uomo d'affari: cogliendo il sottinteso, noi potremmo aggiungere che il musicista di domani potrà anche vestire la tuta dell'esperto elettrotecnico: poco importa, pur che faccia musica necessaria (Berio 2013, 177).

It is also worth remembering that, in the same way as hard copy documents, the preservation and dissemination of recorded audio involve repeated copying and re-mediation processes (see Bolter, Grusin 2000 and Canazza, Casadei Turroni Monti 2006); the latter lead to a tradition which inevitably transforms the original document. The tradition of audio documents shows remarkable similarities with the textual tradition, although of a different nature: each copy innovates, creates diversity, evolves, introduces variants whose level of authoriality needs to be ascertained through a review of sources, which should be extended to cover the study of any relationships with traditional forms of writing. The issue thus needs to be approached from both an exegetical-interpretative perspective – in its dual meaning of sources review and aesthetic understanding – and from a technological standpoint, i.e. the study of electronic equipment for sound production and re-recording which serve a dual purpose: as musical instruments and writing systems.

The protocols for physical restoration, A/D transfer and creation of preservative and access copies used for the ALN resemble the one illustrated for ASTR. The content specificity, however, required considering a few further elements.

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

The most intricate problems as regards selecting the parameters to be used for re-recording were encountered with the preparatory tapes for *La fabbrica illuminata*, which presumably date back to 1964.

Up until the year 1972, when *AEG-Telefunken M15* tape recorders were bought, the Studio di Fonologia Musicale recorded on ¼" (mono and stereo) tapes using *Ampex 350* recorders, with NAB equalization. However, 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 for low frequencies and the CCIR standard for the modeling of high frequencies.[13] As a consequence all of the ¼" tapes produced at Studio di Fonologia Musicale before 1972-1973 are in this typical format (Figure 3).

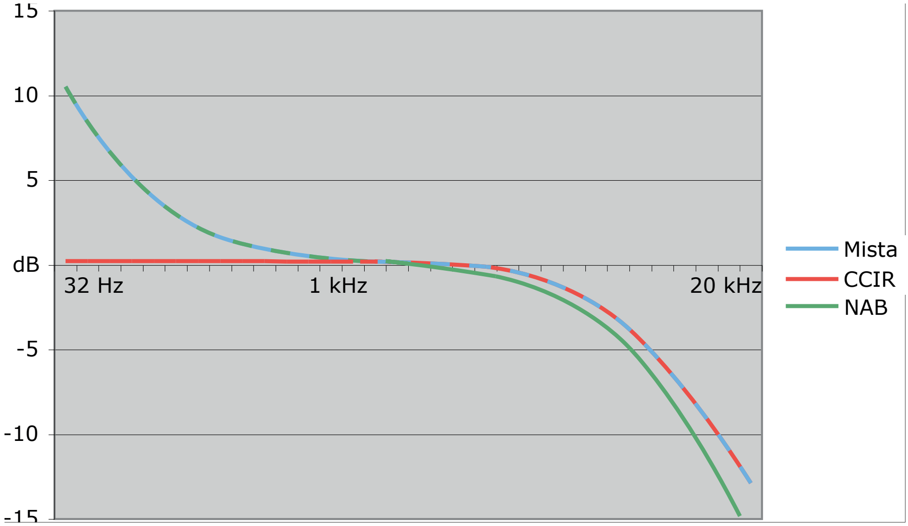

Figure 3. Mixed equalization at RAI.

There are two possible solutions for the correct transfer of the signal recorded 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. For the transfer of ALN tapes the first solution was chosen. In fact, 'forcing' the equalization of tape recorders – in this case *Studer A812* – actually undermines the linearity of compensation, especially at low frequencies, causing a worse quality response overall.

13 NAB standard: 7.5 ips and 15 ips: 3180 µs - 50 µs. CCIR standard: 7.5 ips: 70 µs; 15 ips: 35 µs.

Filming the running tape

In order to keep track of the montage splices and of any signs or writing on the tape, the running tape was filmed using a *Canon HV3025* digital video-camera. The video filming range was placed at a distance of 20 cm from the erasing head, so that it would be possible to transfer the materials while keeping the protective screen for the heads shut, to minimize disturbances due to electromagnetic induction. At the same time a stereophonic digital audio signal was acquired (re-synchronized calculating the offset between erasing head and reproducing head), which is merely a guide to reading the video. Figure 4 shows details of the filming equipment.

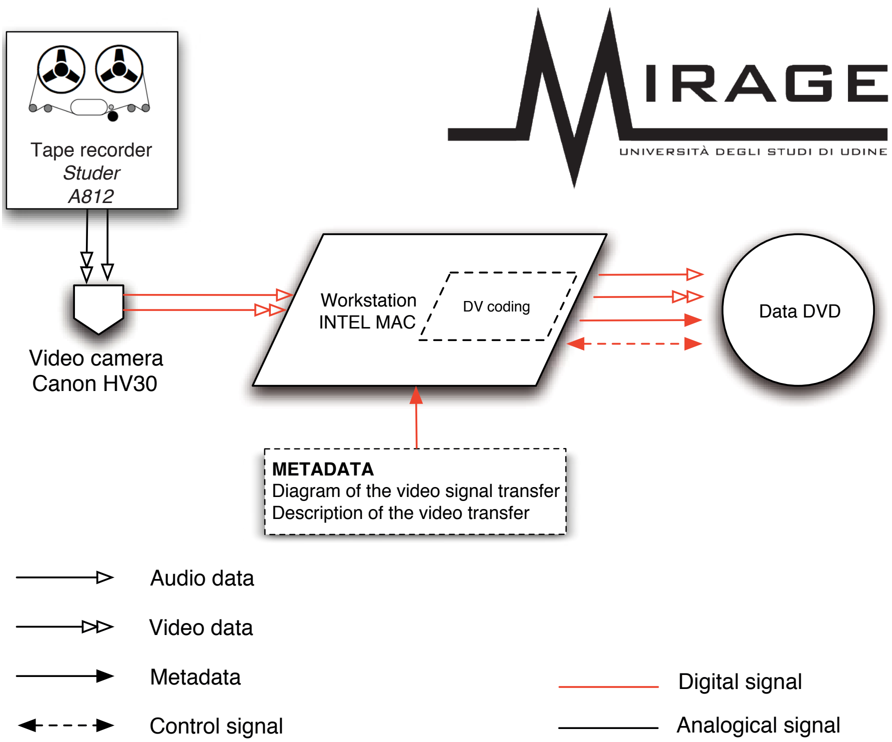

Figure 4. Diagram of the filming equipment.

A preliminary version of La fabbrica illuminata

In order to understand the documentary value of the recordings kept at ALN, a significant example will be provided: a tape with an 'archaic' version of *La fabbrica illuminata*. It is actually a preparatory tape for the work containing a recording of the composition dating to before the one documented by the RAI original tapes, which were used for a live performance with the singer (Milan RAI Q6), for a performance without the signer and for editions on record (Milan RAI Q7), as well as for radio broadcasting (Milan RAI E28), and the tape filed with the publisher Ricordi for copyright protection purposes and as rental copy (Milan Ricordi 214).[14] It is the ¼", 7.5 ips, monophonic magnetic tape, ALN 101. Corresponding to some of the splices on tape RAI Q6, in this tape there are silent sections, which were then deleted from the final version of the concert tape through physical manipulation of the carrier.

The discovery of this source sheds some light on the origin of the composition and on the stratifications in the first draft of the live soprano part. The first complete vocal part document is dated «14 August 64». It thus precedes by one month the world premiere of the work, which took place during the XXVII International Contemporary Music Festival – La Biennale di Venezia on 15 September 1964. The manuscript of the score – which belonged to its first performer, the mezzo-soprano Carla Henius until 1994, while today it is at the Paul Sacher Foundation in Basel – includes a substantial number of corrections, almost a palimpsest, with autographic and non-autographic rewritings added directly onto the manuscript or on sheets of music paper attached to the original document.

The composition consists of four sections plus a finale, where the former – in turn – is divided into four choruses. In the second chorus of the first section, for example, both Nono and Henius corrected and commented several times on a rest (Figure 5): sixteenth rest was deleted, Henius wrote in pen «etwas längere Pause» and added a quarter note rest. In the score published in 1967 by Casa Ricordi (Nono 1967) Luigi Nono carried out another revision and used a whole note rest.

14 See Nono 2010 and "The Critical Edition of *La fabbrica illuminata* by Luigi Nono", in this book.

On the other hand, having regard to the chronometric division which was marked by Nono on the score – which underlies a metronome value of 60 to the quarter note – there seems to be a synchronization issue with the tape which is difficult to resolve: the timeframe required for vocal intervention between the sound events recorded on the original tape is much shorter than the actual of the soloist musical phrase. In the preparatory tape ALN 101, on the other hand, the space introduced at this point is much longer, to the extent of easily allowing for a vocal intervention with a quarter note rest, as in the note added by Henius. In a later draft of the original quadraphonic tape (Q6), though, Nono physically cut the tape, shortening the intervention so that the phrase could be performed with a 16th rest (Figure 6).

To understand the issues related to these text and sound fabric innovations, reference can be made to the Nono-Henius correspondence and to the singer's diaries (Henius 1995) where the difficulties encountered by Henius in studying the vocal part of the tape which was sent to her in Germany are expressly mentioned, to the extent of requiring a rehearsal at Nono's house in Venice before the first public performance at the Biennale in 1964. In ALN, the only magnetic tape containing the electronic part of *La fabbrica illuminata* dated 1964 is ALN101. It is thus possible that the corrections to the manuscript might have been made during this rehearsal session, based on the original variant of this document, when Henius corrected the rest making it longer.

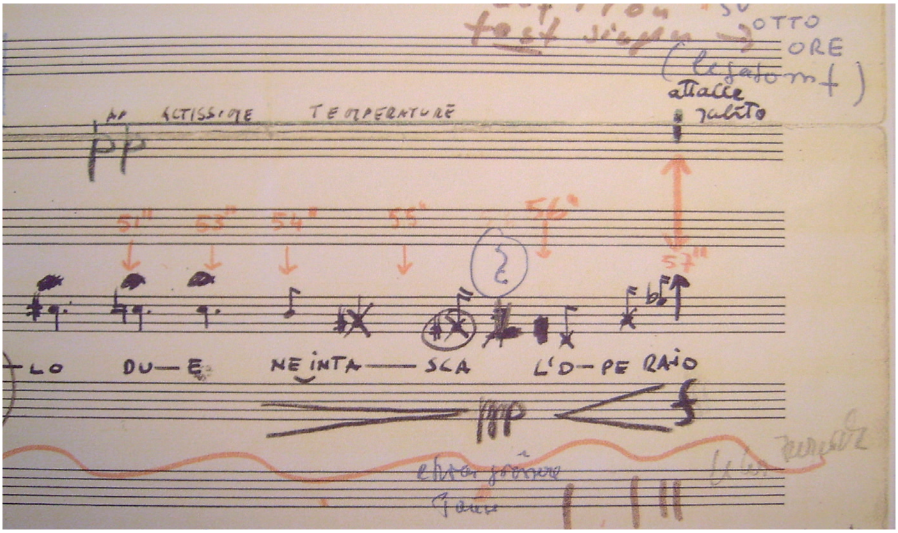

Figure 5. Correction of the rests in the score where the tape was physically processed (after «intasca»). Picture taken from a photocopy of the Basel manuscript kept at the Luigi Nono Archive in Venice.

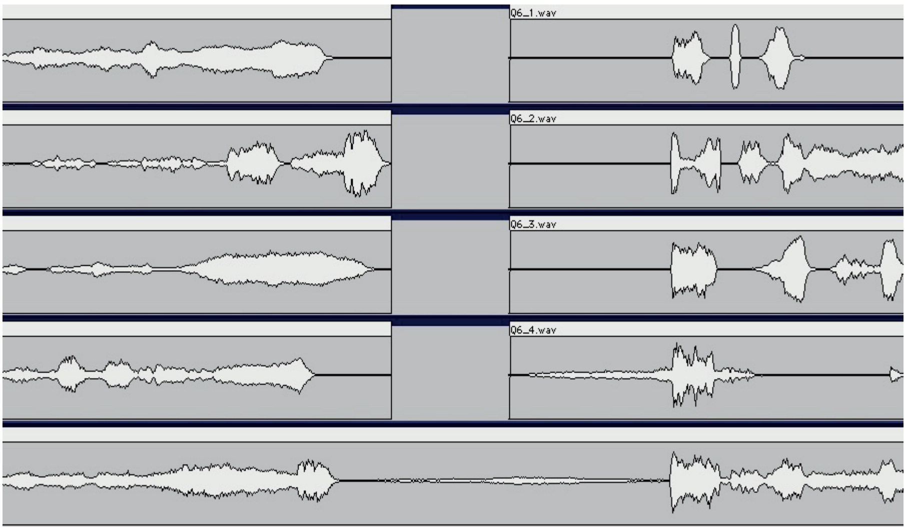

Figure 6. Audio deleted by physically processing the carrier: Q6 above; tape ALN 101 below.

TOWARDS A MUSEUM OF AUDIO DOCUMENTS: THE RICCARDO AND FERNANDA PIVANO LIBRARY IN MILAN

In 2003, MIRAGE was asked to complete preservative re-recording and restoration work on a batch of tapes (tapes, mini-tapes and compact cassettes) for RFPL (Riccardo and Fernanda Pivano Library) which, since 1998, has stored the archive and documentary heritage of the writer, including her father Riccardo Pivano's legacy (see Cossettini 2005 and 2006). When selecting the materials, priority was given to documents which were at high risk of degradation or difficult to read. The recordings cover a long time span: from 1957, the year in which Fernanda Pivano probably had the possibility of buying her first *Geloso G255* recorder, to the beginning of the 1980s. These audio documents are part of the writer's personal memory, their content is unpublished and thus often hard to interpret. They are recordings of conferences, readings, conversations, working sessions with writers, musicians and poets. The conditions in which the sound was recorded are often not optimal: the microphones were too far away or there are extremely intrusive ambient noises which tend to drown the message, revealing the sometimes fortuitous nature of the recording.

The meticulous preservation of the documents made it possible to slow down the natural degradation of the carriers; an exception to this are tapes where rapid deterioration is due to factory defects.[15] It is only natural that in the case of personal archives, constructed in the course of many years of work in various situations and places, the documents should come in a variety of formats. Most of the tapes was produced with recorders for domestic use, which often fail to meet the standard formats for professional equipment and tend to seriously alter the signal. With such a complex case study, it is impossible to use mechanical systems for retrieval. In order to select the nec-

15 The experimentation in the area of audiovisual carrier chemistry has often led to producing tapes which have proved unstable over time. For example, see the *BASF LH Super SM* 'red' compact cassettes produced in the middle of the 1970s, of which several samples can be found in RFPL: the excessive drying of the binder on these tapes causes strong attrition with the head while they are running, leading to lower entrainment speeds and to noise emissions which can also be detected in the reproduced signal. This problem is also known as 'squealing' or 'soft-binder syndrome'.

essary parameters for calibrating the reading devices, in-depth studies were completed on each document, as well as a survey on its creation process.

It is worth mentioning, in particular, the case of the running speed selection on the *Geloso G255* tape recorder. Unfortunately, the machine used by Pivano[16] is no longer available and it was thus not possible to use it for testing purposes. The data found initially with regard to *Geloso G255* listed its running speed as 1.875 ips. If the tapes were played at this speed, however, Pivano's voice became practically unrecognizable.

Given that no direct information was available, in order to produce a preservative copy, the choice was made to select the speed inductively. In these cases the noise produced by the recording system used becomes a useful source of information for the purpose of reconstructing the historical-technological identity of a specific document. More specifically, in these recordings the continuous presence of a stationary signal at 42.5 Hz was detected, which is in contrast with the usual 50 Hz typical of alternating current systems used in Europe. A recording speed which exceeded by 15% the rated value was thus assumed. Finally, some research conducted on the technical bulletins of the time fully confirmed this assumption, revealing the existence of a 'U' version of *G255* designed for use as a dictaphone: what was once considered as noise (*hum*) became a useful source of information.[17]

To produce a preservative copy the original running speed was restored through a resampling of the digitized signal, resulting in a frequency translation by 15% which brought back the fundamental frequency of the disturbance to 50 Hz. An equalization curve consistent with the translations was then digitally redrawn. This procedure made it possible to restore the original voice characteristics.

Further speed corrections, on deviations not attributable to the conscious implementation of non-standard speeds but rather to defects in the machinery used, were completed when producing the copies intended for general use. In line with the aims of a preservative approach, the choice was made not to correct such intentional alterations in the preservative copy:

16 Analyzing the tapes, the information about the documents and the testimony of Fernanda Pivano herself confirm that this was the recorder model she used.

17 See "Recorded music: from the ethics of preservation to the critical editing" and "Towards a systemic approach to the critical editing of music at MIRAGE", in this book.

these disturbances remain and are transmitted as witnesses of the historical-technological framework in which the document was created.[18]

Use as part of the Voci-Voices *exhibition*

The Benetton Iniziative Culturali Foundation decided to promote a section of RFPL by organizing an exhibition to showcase some of its most significant documents to a large audience. More specifically, these include conversations, interviews and speeches whose protagonists are Fernanda Pivano herself and some key figures of Italian and American culture, including Ungaretti, Hemingway and Ginsberg (see Di Capua 2004).

Pivano's tapes, except for some poetry readings, do not include 'works of art' produced with a view to be recorded then reproduced later, they are actually a durable recording of moments in the writer's life. They are valuable as notes, a journal, or albums. Due to Pivano's popularity and to the events which led her life to be so often intertwined with that of major representatives of international culture, these 'acoustic snapshots' should be seen as part of a broader cultural context. For many documents, however, it was necessary to fill a historical gap of more than 40 years, with the subsequent differences in terms of aesthetic and cultural sensitivity. Cataloging in itself is not sufficient to produce culture: the document needs to be continuously re-mediated and re-contextualized depending on the moment it is being used, to acquire new meanings from the new audience which interprets it. The salient phases in the literary activity of the writer's life were thus brought back to life by creating a multimedia exhibition pathway consisting of sound and audiovisual documents, photographs and hard copies (of journals, correspondence, notebooks, etc.); the images that accompanied the acoustic documents were projected onto Plexiglas panels behind which the backgrounds were just discernible and which illuminated the rooms. The viewer, in this way, was totally immersed in a fragment of history recreated – often idealized – but which guaranteed a broad emotional involvement.

18 For a discussion on the procedure adopted for re-recording and restoration see Cossettini 2004 and 2006.

Also the reproduction technology had changed: the small internal speaker in the *Geloso* device was replaced by a ceiling loudspeaker system which allowed the sound to reach the whole room; private listening in the home thus became public listening in large rooms. Such a radical re-mediation intervention required signal processing aimed at adjusting it to the new interface used for sound diffusion. The perception of a sound event, as a matter of fact, is always related to the place and conditions in which the signal is reproduced, because each change in technology involves message modifications. When moving from the preservation level to that of mass use, therefore, the audio material needs to be adjusted to the relevant context and to take into consideration both the sound diffusion systems used and the acoustic characteristics of the place where it is reproduced. During the post-production phase the signal was treated with techniques similar to those used for the post-production of documents intended for commercial purposes. Interventions which would be unacceptable on a preservative copy, for example the dynamic compression used to eliminate marked intensity ranges which could jeopardize understandability, thus became an indispensable method in order to make the message intelligible.

Consistently with an aesthetic approach, geared towards enhancing the potential of the document, it was necessary to compensate any imperfections caused by the recording technique and to remove – as much as possible – any distortions or alterations in the signal, also attenuating background noise and the secondary signals introduced by the machinery used at the time.

Correction of fluctuating speeds

Some of the tapes recorded by Pivano using a *Philips EL3541A* device presented running speed problems. The machine that produced these documents was taken to the lab and subjected to standard functionality tests which confirmed the presence of the defect found when the tapes were analyzed. As a matter of fact, in the recordings dating back to 1967 and in later ones, the signal is distorted by the fluctuating recording speed which, within time-frames of a few minutes, reaches deviations sometimes in excess of 20% compared to the rated speed of 3.75 ips.

In order to restore vocal signal intelligibility, the documents affected by this alteration were segmented in fragments lasting several minutes and the frequency deviation in respect of the 50 Hz of the disturbance introduced by the power supply (*hum*) was calculated. The speed was then reconstructed translating the signal in frequency until the *hum* reached the exact frequency. This procedure is similar to the method used to restore recording at 5.5 cm/s (2,165 ips).

Batteries running out

Many recordings on compact cassette include interviews which were recorded by Pivano using hand-held battery-powered devices. These were often not charged. The drop in voltage caused a gradual slowing down of the running speed of the tape, therefore – if the latter is reproduced today at rated speed – it tends to run faster and, as a consequence, there is a translation towards higher frequencies.

Of course, in the cases where the machines are powered with direct current, there is no *hum*. The situation is therefore that of not having stationary signals as reference to reconstruct the original running speed. In order to restore synchronization, or at least intelligibility, reference has been made to the fundamental frequency (f_0) of Pivano's voice which is assumed to remain constant, except for local variations. The f_0 was then analyzed to trace the intonation curve. A time-variant resampling was then applied to rectify this curve. The speed has been corrected, although the distortions introduced by the insufficiently powered amplification stages still remain.

With restoration interventions on the signal the last phase of the process has been completed leading the audio document from the level of preservation to that of mass use, based on perception. If in the preservative copy the concept of historical truthfulness is oriented towards the source of the signal and the goal is to transfer everything that has been recorded in the document, when preparing the material for use the word 'fidelity' goes back to the specific meaning it has in the theory on information: the signal must not lose any properties useful for the recipient. In both cases, in order to be meaningful a document needs to be contextualized. For the preservative copy the context depends on the historical and technological conditions of the past time when the document was created; for aesthetic purposes the context is always the present in which the document is reproduced. An exhibition is thus the latest processing phase of archive materials and concludes the long path of the audio document from its recognition to its being displayed to the a wide audience.

CONCLUSIONS

For several years now archives and libraries have been actively preserving and making audio documents available for reference, transferring the audio signal from the analog to the digital carrier: this procedure is regarded as conclusive, sufficient to safeguard and pass on these documents to future generations through successive cloning. The need to standardize interventions on preservative copies is a result of format development: the librarian needs to abandon the old concept of striving for the eternal carrier and replace it with an approach aimed at safeguarding the contents of the carriers in digital form to ensure the 'eternal' ability to produce subsequent generations of identical copies (clones) (see Schüller 2001). In the course of re-mediation, however, documents undergo a re-contextualization process which radically transforms the way they are understood and interpreted: the repositioning of data on new digital carriers, even though its aim is to preserve the document, causes a change which affects first and foremost the sound interface, i.e. the device through which substantial signal transformations occur. These are not mere coding points, but rather transducers which enhance certain components in the audio and attenuate some others; as a consequence they affect the representation of the signal itself (consider for example the choice of the sound amplifying and diffusion system and of the physical location where it is positioned). In this regard restoration inevitably needs to consider the place where the document becomes known. This issue is made even more complex by the extended availability of archives and libraries online through the Internet.

This immense audio document heritage, bearing witness to a century of voices, noises, music, soundscapes, therefore needs to be dealt with using multi-disciplinary strategies, which can combine critical-historical analysis with technological knowledge. It is indeed problematic to regard the recorded sound fabric as a text; on the other hand there is no denying that the production system of audio documents is a form of writing and that the copying processes on which the rules for their diffusion and preservation are based contribute to creating a tradition. It is exactly because of the absence of a text in the linguistic sense of the word and of the specific characteristic of this form of document that the instrument of text criticism cannot be applied directly. It is thus necessary to define new methods: a study of the 'audio writing' foundations provides essential details for correct access to information; the reconstruction of tradition makes it possible to detect errors and flaws which might have entered the duplication processes or been caused by the carrier becoming deteriorated over time (an essential step to guide any restoration interventions aimed at a new use within a changed media context); the study of relationships with traditional forms of writing (scores, composition models, sketches, etc.) helps clarify the processes which might have led to producing the sound fabric in the forms in which it has reached the present day.

The importance of institutions such as ASTR in Parma, ALN in Venice and the RFPL in Milan which preserve and make available hard copies, as well as the 'acoustic' heritage recorded on audio documents, thus becomes apparent: it is here that the tension between the issue of preservation and that of dissemination, between text and work, becomes evident; and wherever there is tension the space is open for research, with preservation and review of sources being the first step to create a concrete foundation in support of historical and musicological studies.

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The reissue of the *Dischi per lo studio del canto ambrosiano*

Alessandro Argentini, Alessandro Olto

RECORDING AND CIRCULATION

Sacred music has been a part of the recording industry since the very beginning. In fact, «all major record companies recorded sacred music along with other music genres» (Gronow 2011, 20). At least in the early days, however, the record had not yet managed to distance itself from its merely playful component, almost a funfair attraction, which had characterized it when it first started to become popular; record producers were well aware that, in order to promote it properly and to counteract the competition which was just as aggressive, reckless marketing strategies were called for.

The first great opportunity were the events held in Rome in April 1904 (as an appropriate tribute to Gregory the Great, thirteen centuries after his death). On this occasion, a few months after the publication of *Motu proprio Tra le sollecitudini* on sacred music (November 1903) by the newly-elected Pope Pius X, the results of a ten-year reform of the Gregorian repertory were introduced to a large and representative audience. For the first time, apart from the traditional written documents, the events of the Roman days were passed on through a new *medium*: the salient moments of liturgical celebrations and presentations to the Congress were recorded by Gramophone Company. The speakers themselves, most notably Baron Kanzler, did not fail to underline the documentary, diffusion and didactic possibilities offered by the new technology with reference to Gregorian chant (see Argentini 2011).

Based on these assumptions it was almost unavoidable that, about thirty years later, the Scuola Superiore di Canto Ambrosiano e di Musica Sacra in Milan – committed to promoting 'new' repertoire and its correct interpretation by means of teaching, as well as public performances and publications

– should decide to produce didactic records[1] (a decision taken by the teaching board of the College at the end of 1935), thus inaugurating a capillary 'teacher-less' didactic system.[2]

The label of choice, almost forcibly in the case of records, was the famous Odeon, which at the time had representative offices and a recording studio for Italy in Milan, at Via Monviso.[3] The result of this operation were six shellac 10-inch records, labeled Odeon, which were recorded in Milan in 1936-37 by the Choir of the Scuola Superiore di Canto Ambrosiano e di Musica Sacra conducted by M° Marziano Perosi. These records include *Canti popolari delle messe e benedizioni* (with trade numbers 0057, 0058, 0059)[4] and the *Missa pro defunctis* (with trade numbers 0060, 0061, 0062),[5] performed according to the Ambrosian rite.

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1 There were precedents for this type of work: already in 1930 a total of 12 records of Gregorian chant were commercialized (choir of the Benedictine Monks of the Abbey of St. Peter of Solesmes, conducted by Dom J. Gajard). These are His Master's Voice – The Gramophone Company LTD 12-inch editions (catalogue number D1971-82), divided into two albums. The reviewer for Gramophone defines them as follows: «this is a magnificent set of records from Solesmes itself, the very centre of the great restoration and reformation of Gregorian Chant, or Plain song, which the Benedictines of that Abbey undertook seventy or more years ago, and which is not yet complete» (*Gramophone* 1931, 24); the Musical Times, on the other hand, highlights their didactic intent: «such records are for the specialist, and are designed mainly for instructional purposes. Yet there must be many ordinary listeners to whom authoritative performance of this music will give pleasure» (*The Musical Time*s 1931, 427).

2 In the 1930s, in Milan, the Benedictine monk Gregori M. Sunyol, was asked by Cardinal Schuster to compile a list of chant books critically reviewed for the Ambrosian liturgy: in 1934 the official edition of *Praeconium Paschale* was published, then in 1935 *Antiphonale missarum*, and in 1939 the *Liber vesperalis*.

3 The reasons which led the management at Scuola Ambrosiana to decide to record some performances from the Ambrosian repertoire, the choice of excerpts, the relationships between the College itself and Odeon (Carisch) as regards the recording and printing of two sets of records, their distribution and failed commercialization are all described in detail by Giordano Monzio Compagnoni (Compagnoni 2011).

4 Matrix numbers: 0057: MO 6420, MO 6421; 0058: MO 6422, MO 6423; 0059: MO 6424, MO 6425 (MO means Milan).

5 Matrix numbers: 0060: MO 6918, MO 6919; 0061: MO 6920, MO 6921; 0062: MO 6922, MO 6923.

The appended documentation (correspondence between the Pontificio Istituto Ambrosiano di Musica Sacra – PIAMS, Carisch and Società Italiana di Fonotipia) shows that the recordings were made on 5 March 1936 (Series 1) and between 1 and 10 March (presumably on the 8th) 1937 (Series 2). It should be noted that, in spite of the one-year gap between the two recording sessions, their trade numbers – which are different from those generally used (four or five digits followed by one letter) – have no interruptions; their matrix numbers, on the contrary, are clearly separated and are compatible with the numbering criteria followed for commercial recordings by Odeon. The use of traditional numbering for the matrices points to the conclusion that Odeon really intended to market these recorded products; there are, indeed, a number of recordings made during the same period by Odeon sound engineers and marked with the prefix 'prv.' (private), which constituted the Special (Odeon) series made up of matrices not intended for commercialization.

Nevertheless, the selling of records remained a prerogative of the College: «si intendeva distribuire il materiale fonografico al di fuori del normale circuito commerciale, cosa che ne decretò l'esclusione dai cataloghi» (Compagnoni 2011, 71). Evidence of this is a review of the first series of records published in November 1936 by the British journal Gramophone, which includes the following information: «the records can only be obtained on order from the Parlophone Company»[6] (Gramophone 1936, 19).

The popularity of the first set of records surpassed all expectations: in a short time at least 1200 copies were circulating, thus paving the way for a Series 2. The latter proved just as successful, to the extent that the Società Italiana di Fonotipia officially suggested it should be marketed abroad. This project, however, was not followed up: as in the past, the records continued to be distributed directly and exclusively by the College (Compagnoni 2011).

6 Parlophone (or Parlophon) is the English reference label for Lindström group, which also includes the Odeon label, distributed in Italy by Carisch.

As is well known, the time limits imposed by the side of a 78 record often influenced its musical contents. Ever since the first acoustic recordings, the issue arose of adapting a piece of music whenever its length was not compatible with the limits imposed by the space of one side of shellac record (the first ones measuring 7-inch, later 10 and 12). At the beginning abrupt cuts were made by the performers; only on 20 November 1913 was it possible to record for the first time a symphony (Beethoven's *Fifth*, conducted by Arthur Nikisch), almost in its complete form, on several records.[7] As regards sacred music, the recording of extended compositions «began in 1930s following the first full-scale recondings of symphonies and operas. This was due to technical improvements in record production, but also in a growing demand for recorded music» (Gronow 2011, 20).

The recordings of the *Dischi per lo studio del canto ambrosiano*, even though the new techniques were used, include several adjustments of the musical contents to the limitations of the carrier. The parts that make up *Ordinarium Missae* or *Missa pro defunctis* are actually of variable length, from more than three minutes to less than 15 seconds; as a consequence, in order to optimize and unify as much as possible the duration of individual sides, two significant choices were made: 1) some sections were deleted; 2) the succession of pieces was not followed. For example, side A of record 0057 contains two pieces: *Gloria I* (*Tonus festivus*) and *O salutaris*; the latter is at the moment of Holy Communion, and not immediately after *Gloria*; the sum of the times of the two pieces (2'40" and 0'34" respectively), however, allows for them both fitting on one side. The next side (disc 0057, side B) contains *Gloria IV* (*Tonus dominicalis*) lasting 3'18".

7 It was decided that the change from one side to the other would occur close to a significant musical point, such as for example the end of a section or of a theme. In the absence of formal articulations, the choice was made to play the last chord once again on the new side. In the event of transfer onto another carrier, two different solutions are possible, depending on whether it is an archive or listening copy: keeping the repeat of the chord in the former or deleting it in the latter. Sometimes, in order to avoid abrupt interruptions between one side the other, some conductors (for instance Sir Henry Wood) were used to perform a *rallentando* towards the end of the side, which in this case resulted in musical non-sense which would never be used during a concert performance.

The choice of optimizing the use of each side (also, presumably, due to cost reasons) thus becomes clear. It appears, after listening, that all pieces included on each side are performed uninterruptedly – and at the time no editing work was actually possible; this leads to the conclusion that the 'list' of contents and the precise succession of the individual records must have been defined some time in advance of the relevant recording sessions.

The *Dischi per lo studio del canto ambrosiano* have been subject to preservative re-recording and documentary restoration by the MIRAGE team at the University of Udine; the project, promoted by PIAMS, led to a CD being produced which contains both the tracks from the preservative transfer alone and those which have been restored.[8] This re-mediation on a new carrier has allowed for unprecedented access to the material: thanks to the use of markers placed to divide the content of the various sides into tracks, the restored listening copy makes it possible to hear for the first time, setting a track list based on their liturgical structure,[9] the exact order of the chant, something which would be extremely complex – not to say impossible – using the original analog carrier.

ACTIVE PRESERVATION

Methodology

The preservative re-recording of the *Dischi per lo studio del canto ambrosiano* was completed at MIRAGE during the working sessions from 15 to 17 April 2009.

The method used to produce the copies is based on preservative approach: it takes account of the set of information presented by the document seen

8 *Dischi per lo studio del canto ambrosiano* – Coro ambrosiano della Scuola superiore di Canto ambrosiano e di Musica Sacra – M° Marziano Perosi (PSA003CD).

9 The booklet that goes with the CD, in actual fact, also includes the liturgical structure of the pieces – which, as already mentioned, is different from what is found on the records – with an indication of the relevant track number.

as an artifact. It focuses on the physiognomy of the document and its goal is to preserve the unity of the document. Identification of the format and the choice of reproduction/listening equipment are crucial. Any intentional alterations in the signal occurring in the recording phase (e.g. equalization) must be compensated for. The remediation process with the new digital medium must represent, directly and with the maximum transparency, the informational and material characteristics of the original document as it is now (see Orcalli 2013).[10]

Cleaning and restoring the carrier

The six records under examination were in an excellent state of repair; some bronzing powder was found on the groove, detached from the label, in the traditional Odeon coloring (dark blue background with gold letters). The records were then washed with distilled water and neutral detergent solution. The examination of the carrier showed slight deformation and a small undulation of the surface. There was also noticeable eccentricity of the guide hole; this minor defect was sufficiently extended to convince us to make the copy removing the pin from the plate to achieve optimal position of the groove in respect of the rotation axis.

Digitizing the audio information

The transfer from the analog to the digital domain was completed without introducing subjective alterations or 'improvements', such as for example de-noising etc., based on the assumption that artifacts which are unintentional and undesirable (background noise, clicks, distortions) are in any case part of the audio document, regardless of whether they are produced by repeated playing or caused by unsuitable storage of their carriers.

10 See also "Recorded music: from the ethics of preservation to the critical editing", in this book.

Reproduction system set-up:

- Turntable: *Diapason Archive* with variable speed (15 to 135 rpm), derived from direct-drive *Technics SL 1200* MK II;
- Arm: 12" *Diapason Archive*;
- Cartridge: *Shure M44-7* moving magnet;
- Stylus: *Expert Stylus* 3.0 mil truncated elliptical;
- Weight: 40 mN;
- Speed: 77,9 rpm, as the European standard;
- Preamplifier: *Elberg MD12* with variable equalization.

The use of a (stereophonic) moving magnet cartridge allowed for the storage of files transferred stereophonically, thus for the acquisition of important ancillary information, such as the different degradation on the two sides of the groove.[11] Following the IASA instructions (Bradley 2009, item 5.2.6.7), two transfers of the signal were completed:

- Flat;
- Equalized: treble turnover = flat; bass turnover = 250 Hz; lower bass turnover= 50 Hz; cut frequency at 10 kHz = /; boost at 50 Hz = 12 dB.

The choice of equalization parameters was determined by the presence on the mirror[12] of the records under examination of a graphic artifact: a 'C' included within a circle which identifies the *Blumlein* equalization system,[13] used by several labels for commercial recordings between 1931 and 1944.

11 If an access and/or restored copy is produced later on, it is possible to choose the channel with the best signal (see Bradley 2009, item 5.2.4).

12 The mirror is the surface included between the end of the grooves and the label. Apart from the exit groove it may include significant elements such as: matrix number, take, equalization curve indicators, recording date.

13 This method, perfected by Alan Blumlein in order to avoid having to pay the royalties due to Western Electric, owner of the first equalization system, was used by several labels in the Gramophone Company group (HMV, Zonophone, RCA Victor), marked by a square on the corona, and of the Lindström group (Columbia, Odeon, Parlophone), marked with a C inside a circle (see Copeland 2008, 99- 131).

Digitization system set-up:

- A/D converter: *PrismSound Dream* AD*-2* at 96 kHz / 24 bit;
- A/D levels: 0 VU Meter (+4 dBu) = -18 dBFS;
- Workstation with *RME Digi96/8* PAD and *Adobe Audition 1.5;*
- file format: BWF.[14]

Each transferred track was identified by means of a code, e.g. 'ODE_A_Gloria_I_77,9_3,0te_HMV.wav', where:

- ODE: refers to the label (*Odeon*);
- A: indicates the side of the disc;
- Gloria_I: derived from the title on the label;
- 77,9: reading speed (rpm);
- 3,0te: stylus diameter (3 mils in this case) and type (te = truncated elliptical);
- HMV: equalization;[15]
- .wav: file extension.

Message digest

The preservative copy included, as control instrument for the integrity of the audio files, a message digest of the original BWF files, calculated by means of the MD5 algorithm.

14 The audio signal is stored in the Broadcast Wave Format (see EBU 2011), 96 kHz, 24 bit, stereo, with PCM coding. The preservative copy includes information on the BWF format encoding, which allows for the insertion of metadata through the addition of appropriate headers, so that it will be possible to interpret the audio data stored in the file correctly.

15 Equalization is reported with an indication of the different presets of the Elberg MD12 preamplifier (WSTRX, HMV, COLMB, etc.); parameters are explained in the documentation. In case of no equalization, the indication 'flat' is reported.

Photo documentation

The information found on the record and on the label, and the details found on publishing containers (sleeves) were saved in the preservative copy in the form of raster images, contained in folders attached to the individual records; the appended documentation (correspondence, handwritten notes) was also saved in the form of raster images in a separate folder.

Data sheet

To each preservative copy a sheet was added with a list of all the documents which are an integral part of the copy itself, some metadata of the audio signal and a description of the original analog audio document, to ensure preservation of the document unity through the preservative copy.

The description card designed by MIRAGE consists of four parts: a) heading, b) description of the preservative copy, c) list of documents recorded in the preservative copy, d) description of the original document.[16]

The outcome of the active preservation work are two data DVDs (CPIAMS0001 and CPIAMS0002 of the MIRAGE Archive).

16 For a detailed example of a MIRAGE preservative copy, please see "From the archive to the event", in this book.

AUDIO RESTORATION

The audio restoration of the *Dischi per lo studio del canto ambrosiano* took place at MIRAGE, during several working sessions, from October 2009 to April 2010.

Methodology

The restoration was completed starting from the audio tracks resulting from the preservative re-recording described in the previous paragraph, in their equalized version. The restoration of each document was anchored to the less corrupted channel in the stereophonic signal.

The operating phase involves two steps: 1) 'objective' analysis of disturbances and study of their nature – considering the production system specificities at the time the recordings were made – 2) listening to the sound fabric in respect of the acoustic limits of the *medium*, made even clearer by modern-day sound diffusion systems.

The audio signal analysis revealed, in all documents, morphologically similar disturbances, which were thus treated with similar procedures.

Restoration system set-up

Workstations:

- *Sonic Studio SoundBlade 1.3.4* with *NoNoise II* restoration suite on *Mac Pro*;
- *Adobe Audition 3* and *Steinberg WaveLab 5* on PC.

Monitoring system:

- *PrismSound* ADA-8XR D/A converter;
- Preamp: *Focusrite Red 4*;
- Monitors: *Genelec 1032A*;
- Headphones: *AKG K-701* and *K-271*.

DeClick

The word *click* refers here to an impulsive broadband noise (isolated local disturbance, stochastic noise, lasting less than 5 ms), mainly due to the effect on the record surface of any scratches or dust (Figure 1). To remove these disturbances interpolation algorithms were used,[17] in a non-automatic manner, operating within the time domain depending on the characteristics of the signal found in a defined area around the disturbance.

DeCrackle

The set of small discontinuities in amplitude produced by the porosity and wearing out over time of the material constituting the carrier was treated globally with the *SonicStudio DeCrackle*[18] function. It was agreed with the client that the scope of the work should be weighted in order to reduce the disturbance to a satisfactory extent, without however introducing perceivable alterations of the useful signal, and to ensure transparency of the medium in respect of the sound fabric (Figure 2).

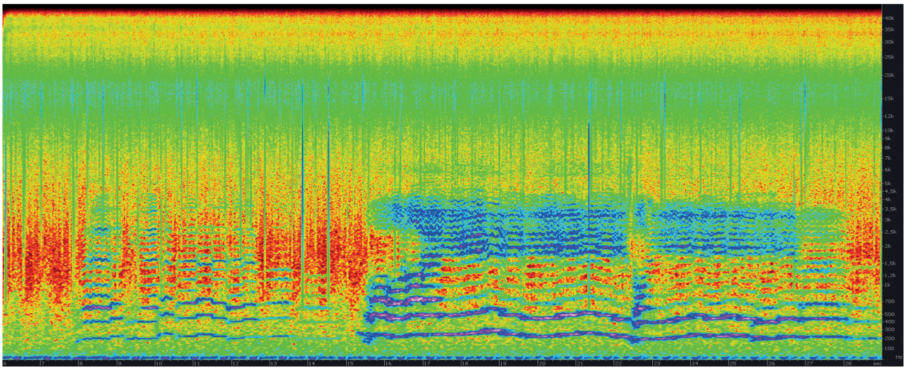

Figure 1. CPIAMS0002, excerpt from 'ODE_A_Requiem_77,9_3,0te_HMV.wav'.

17 *SonicStudio SoundBlade 1.3.4*, NONOISE II plugin, algorithms: *B-General*, *B-General* L–>R, *B-General* R–>L.

18 *SonicStudio SoundBlade 1.3.4*, NONOISE II plugin, *DeCrackle* algorithm, Threshold = 0.95.

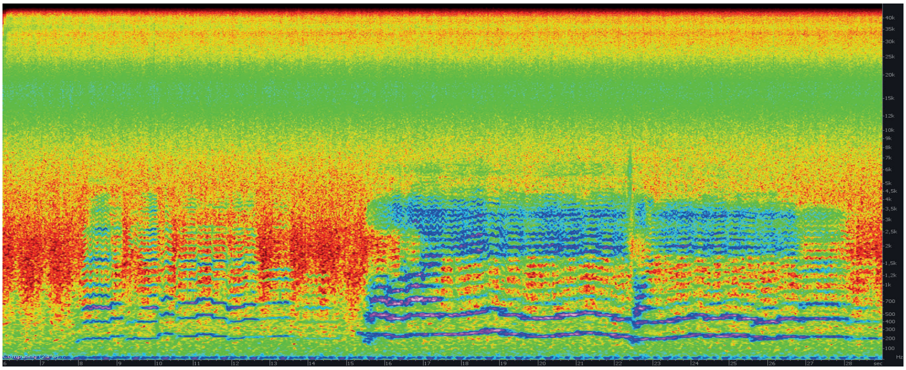

Figure 2. The same excerpt after Declick and DeCrackle.

Background noise I: multiband compression

First of all multiband compression was applied to the background noise (overall disturbance, broadband stochastic noise), in high and low frequency, set in such a way as to reduce noise and its amplitude fluctuations; the frequency region containing the musical signal, on the other hand, was not treated.[19] The compression of low frequencies also made it possible to reduce what is known as *rumble*, global low frequency noise (40 ± 10 Hz) introduced by the mechanical components of the recording system at the time.

Background noise II: DeNoise

The *SonicStudio DeNoise* algorithm[20] was then applied, which works by spectral subtraction. Attention was paid to the choice of parameters to avoid damaging the useful signal to a substantial amount: after the *DeNoise* action, an attenuation of background noise by ~ 2 dB was measured (Figure 3).

19 *Steinberg ME Compressor*: Band 1: 25 Hz – 74 Hz; in -14 dB; out -20.9 dB; gain -6.9 dB; global attenuation -2.3 dB; Band 2: 7.3 kHz – 10.3 kHz; in -17.4 dB; out -20.3 dB; gain -2.9 dB; Band 3: 10.3 kHz – 24 kHz; in -17.8 dB; out -31.8 dB; gain -14 dB; global attenuation -3.3 dB.

20 *Sonic Studio HD 1.9*, *Broadband DeNoise* algorithm, Threshold = 10; Attenuation = -21; Sharpness = 1.37; Bandwidth = 1.66.

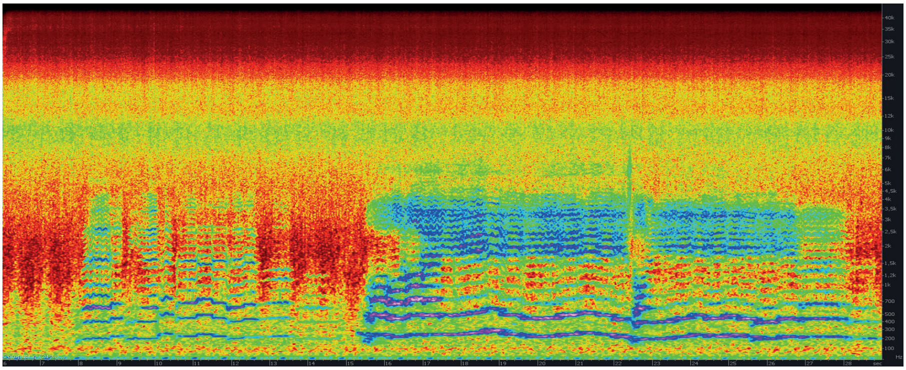

Figure 3. Multiband compression (low and high frequencies) and DeNoise.

Special procedures: specific disturbances

The reduction of background noise cause some isolated clicks to become perceivably apparent, which used to be hidden by the noise itself; they can be morphologically divided as follows: a) disturbances covering the whole spectrum of perceivable frequencies; b) disturbances which affect only a specific frequency band. In the first case interpolation algorithms in the time domain were used;[21] in the second instance, work was focused on the time-frequency domain, exclusively on the frequency regions affected by the disturbance, using spectral interpolation algorithms.[22]

Moreover the slight undulation on the disc surfaces, during the signal acquisition phase, caused a cyclical noise on the whole recording, variable in length (from 300 to 600 ms) and affecting the frequency band up to 2kHz (Figure 4). The restoration work[23] was limited to reducing the disturbance in the frequency bandwidths not affected by the useful signal (Figure 5).

21 *SonicStudio SoundBlade 1.3.4*, NONOISE II plugin, algorithms: *B-General*, *B-General* L–>R, *B-General* R–>L.

22 *SonicStudio SoundBlade 1.3.4*, *reNOVAtor* plugin, algorithms: *horizontal*, *left* and *right*, FFT window size: 1024, 2048 e 4096 samples, Accuracy: 2, 4 and 8.

23 *SonicStudio SoundBlade 1.3.4*, *reNOVAtor* plugin, algorithms: *horizontal*, *left* and *right*, FFT window size: 1024, 2048 e 4096 samples, Accuracy: 2, 4 and 8.

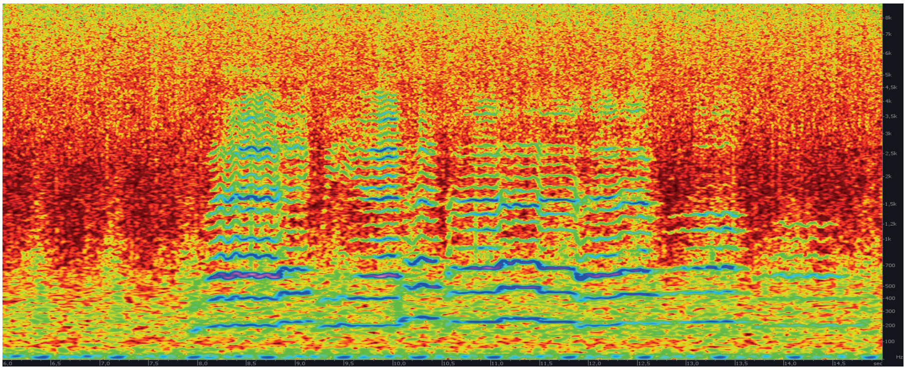

Figure 4. Detail of the cyclical noise (mid-low frequences).

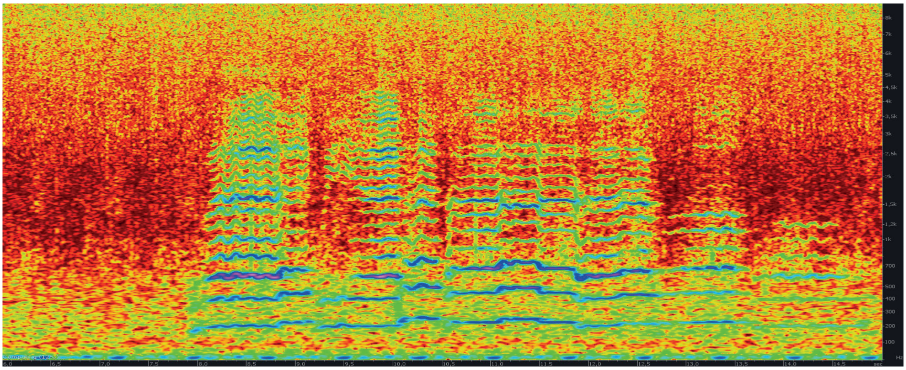

Figure 5. Attenuation of the cyclical noise.

Work on background noise III: filtering

In agreement with the client, in order to ensure transparency of the medium in respect of the sound fabric, the choice was made to further reduce the high frequency broadband noise, in the regions not affected by the useful signal, using a low-pass 9800 Hz filter of the tenth order.[24]

24 *Adobe Audition 3, Scientific Filter* plugin (linear phase filter).

Checks

Perception analysis and checks. After each restoration phase, a listening check on the signal obtained by adding the processed file to the antiphase of the non-processed file, in order to detect the amount of disturbances removed and confirm the absence of perceivable artifacts in the signal.

File integrity checks. For each of the phases described, it has been made a copy of the file on which work was done: the copying process correctness was checked using the *hash* MD5 function.

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Part iii
Critical Editing of Electronic and Mixed Music

The critical edition of the electronic part of *Y entonces comprendió* by Luigi Nono

Luca Cossettini, Angelo Orcalli

More than sixty years have gone by since the beginnings of electronic music on analog magnetic tape; this historical distance leads to considering these works also from the viewpoint of their documentary value. However, shifting the scales of criticism from the synchronic axis of the formal and aesthetic analysis of musical works to the diachronic element with focus on the documents raises some method issues regarding the material, technical and composition specificity of these audio recording forms.

As an artifact which has survived the vicissitudes of time, electronic music work – in the same way as all the recordings which constitute the audiovisual heritage – needs to be preserved in its materiality and brought back to the functionality associated with its being a record and memory of audio data. However, as musical work it has a different value compared to the mere recording of an event. In the same way as any other recording its purpose includes fruition, nevertheless the original documents which represent it are the result of composition actions. The recording is often subject to various interventions over time, designed by the author to meet the audience's taste or dictated by the performance conditions of the work. Sometimes these interventions are made directly on the carrier or on copies: these are often significant variants leading to new documents. Moreover the continuing success of the work means that the recordings are subject to changes caused by the technological development of audio re-mediation and diffusion equipment. All music on a carrier is nothing but stable, and the study of the transmission phenomenology of these documents, most notably of authorial electronic music, involves complex processes which are comparable to the history of other documentary traditions.

To exemplify such complexity, we have chosen Luigi Nono's composition *Y entonces comprendió*, dated between 1969 and 1970, for magnetic tape on four tracks, three sopranos, three reciting voices and chorus, based on extracts from *El circulo de piedra* by the revolutionary Cuban poet Carlos Franqui (Franqui 1970).

A BELATED POSTHUMOUS RESTAGING

The premiere of *Y entonces comprendió* took place in Rome, on 21 March 1970;[1] the author himself curated its sound direction. The music was conducted by Nono for the last time on 23 October 1977 in Venice. Its posthumous restaging was not before 28 September 2005, at the Malibran theatre in Venice, to inaugurate the 49th International Music Festival at the Biennale di Venezia, *La musica e il suo doppio*.[2] The reasons for such a long silence in the performance tradition are at the first instance political. In addition to the well known Nono's idea of a music closely linked to contemporary social problems – therefore rejecting the idea of repertoire – it is possible that among the causes of the silence there was also the historical rupture between Fidel Castro and Carlos Franqui occurred as early as 1971 (see Franqui 2006). In an interview with Enzo Restagno Nono says: «il mio omaggio alla rivoluzione cubana era però destinato a suscitare dissensi, perché nel frattempo Carlos Franqui si era allontanato alquanto dai compagni di Cuba. Così mi venni a trovare in una situazione imbarazzante». However «*Y entonces comprendió* era una composizione alla quale tenevo molto, così non ritirai il pezzo, che venne poi inciso dalla Deutsche Grammophon» (Nono 2001b, 530-531). Another reason is related to the sources on which the work relies. The electronic part, produced at the RAI Studio di Fonologia Musicale in Milan, was recorded on a four-track magnetic tape, which was then used for live performances. Many copies were then made from this original: for copyright

1 Mary Lindsay, Liliana Poli, Gabriella Ravazzi, Kadigia Bove, Miriam Acevedo, Elena Vicini, voices, RAI chamber chorus of Rome, conducted by Nino Antonellini.

2 Based on the critical edition and restoration of the electronic part edited by MIRAGE. Vokalensemble Netzwerk Musik Saar: Sopranos, Wakako Nakaso, Dorothea Brandt, Naomi Grundke; Voices, Miriam Möckl, Malaika Ledig, Franziska Erdmann; Conductor, Stefan Litwin; Tonmeinster Alvise Vidolin with the assistance of Nicola Buso.

filing, radio broadcasting, preservation and restoration; all these documents are scattered across several archives today: the Archive of the Studio di Fonologia Musicale has the final montage versions, master copies and duplicates for radio broadcasting; the Ricordi archive has the copies filed for copyright protection, rental copies for concerts, plus a recent restoration; the Luigi Nono Archive in Venice has most of the preparatory materials and recently generated copies. There are also two complete record editions with chorus and voices: the first one was published in 1971 by Ricordi, the second by Deutsche Grammophon in 1974. It is therefore a complex tradition which includes re-editions with format variants and active preservation works which were completed, over a thirty-year period, by repeatedly copying the signal onto new carriers.

As regards the live vocal dimension, Nono wrote a score for the chorus but not for solo voices, whose performance is not constrained by a traditional text, but rather designed as collaboration with the female performers based on their expressive features: from the tape production – with the voices and based on the voices – to the solo part definition. The task of constraining times and sound materials is entrusted to the magnetic tape, present almost for the whole duration of the performance:[3] on the back of the tape Nono himself added essential instructions for sound director which takes on the role of musical conductor. The performance practice was defined during numerous rehearsals with the composer, then entrusted to the female performers' memory.[4] Nevertheless, this cannot be considered 'open work' (*opera aperta*) or mere improvisation: the soloists need to engage in an actual 'dialogue' with the tape, an invisible double which upsets the identity of the actors on stage. The performers are thus forced to rely on handwritten notes using 'part notebooks':[5] templates where pitch, dynamic and agogic elements were listed, with precise references to the relationship between live and recorded sounds.

3 If the work is performed with a live chorus, a final solo chorus section is included.

4 See "*Y entonces comprendi*ó by Luigi Nono: spatialization of sound and theatrical practice", in this book.

5 See ALN (Luigi Nono Archive) 35.09.01; ALN 35.09.02; ALN 35.09.03; ALN 35.09.04; ALN 35.09.05; ALN 35.09.06.

A restaging of *Y entonces comprendió* therefore needed to include a heterogeneous multitude of documents, many of which in the form of sketch or draft.[6] Restaging this work also involved a review of the state of the art in electronics: the music in *Y entonces comprendió* revealed its duality not only as a specifically theatrical action but also in the actors' dual role on stage. The artistic direction choices made by the Venice Festival organizers were extremely specific. Giorgio Battistelli asked the publishing house Ricordi, the Archive of the Studio di Fonologia Musicale and the Luigi Nono Archive for access to the greatest possible number of audio sources, then entrusting MIRAGE to work with the RAI Audio Lab in Milan on a clearer reconstruction of the audio documents tradition for Nono's work, as well as to restage the work for concert performances.[7]

6 A preliminary analysis of the publishing issues related to music which has not been finally set on a score was conducted by Marinella Ramazzotti based on correspondence, contracts, concert programs, composition sketches, etc. (see Ramazzotti 1997 and 1998).

7 In Italy mention should be made of two preservation projects started by the musical publishing industry in partnership with RAI in Milan: the preservation and restoration project of electronic works by Bruno Maderna (with Suvini-Zerboni) and the one related to Nono's electronic production (with Casa Ricordi). The restoration of the electronic part of *Y entonces comprendió* is part of the project by Casa Ricordi. The re-recording onto a digital carrier of the *Y entonces comprendió* documents was partly completed at the RAI Audio Labs in Milan, partly at MIRAGE (an exception is the Hamburg Deutsche Grammophon 2530 436 record, which was re-recorded by technicians from the Biblioteca Manfrediana in Faenza), according to criteria of active preservation drafted by MIRAGE. Once its digitization had been completed, the signal could be processed using dedicated software for audio processing and algorithms for automatic detection of disturbances. With the aid of sequencers the individual tracks on each document were synchronized one by one; the signal was compared both by listening and by comparing waveforms and spectrograms. Whenever errors or variants were found, the signal was carefully analyzed to determine their nature.

SOURCES OF THE WORK

Preparatory materials

The magnetic tape in the Luigi Nono Archive, which has been coded on the casing as *Prova comprendió* (RO),[8] is an essential document to understand how this work originated. The sound fabric recorded here has a longer duration than those on all other sources. It is actually the only document containing a version of the electronic part preceding the one authorized by the author. This monophonic mix of the R1 document derives from an earlier processing stage of R1 than the physical work on the carrier which, by expunction of audio material, has led the music to taking the shape attested by the rest of the tradition: some silence sections have been removed, where there were probably supposed to be live voices or extra chorus parts[9] (Figure 1 and Table 1). The total audio removed from R1 after the creation of RO amounts to about 3'25".

The production sources (RAI)

The 1" quadraphonic magnetic tape R1 kept in the Studio di Fonologia Musicale is the oldest quadraphonic version of this work that has reached us so far. The annotations and graphic markings written directly on the tape near the solo voice entrances, used also in other audio documents by the author as support for the conductor, have led to the conclusion that this document, or a copy thereof, could be used for live performances. In the final section of the tape there is a repeated section in the versions 'with chorus' and 'without chorus'. The correspondence kept in the Luigi Nono Archive[10] confirms the need for the author to create a variant 'with chorus' of the electronic part in order to compensate for the lack of a live chorus for the concert

8 See *Sources*, p. 318.

9 See ALN, 35.10.01/1, ALN, 35.07/1-10 ex ALN, Q57.

10 See VE ALN, Vitali, 70-05-26 d.

scheduled for 30 June, 1970 in Amsterdam. The document has reached us in the 'with chorus' montage version of the work; the part 'without chorus' was discovered wound up at the end of the tape, after a section of leader tapes.

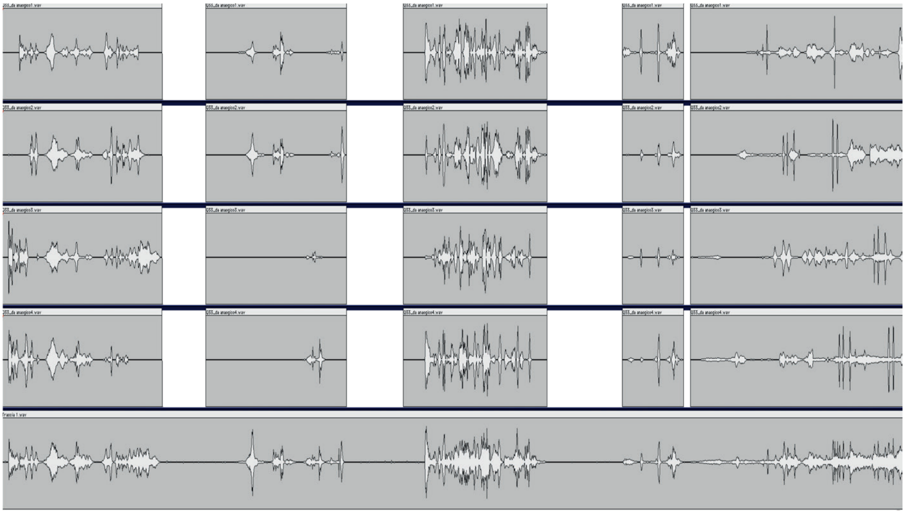

Figure 1 – Comparison between R1 (first four tracks) and R0 (fifth track) with the deleted parts highlighted. Detail of the first 11'.

R1 - Splices	*R0 – Silence fragments removed*
2'21"	32.07"
4'02"	43.84"
5'36"	58"
6'22"	5.85"
10'44"	0". It means that the splice was present in R1 before the creation of R0
12'02"	1"
20'39"	4.38"
26'19"	4.80"
34'01"	25.60"
35'16"	20"

Table 1 – material removed from R1. Analysis of splices.

The version 'with chorus' lasts 32'02", while the one 'without chorus' lasts 30'32". The version 'with chorus' includes a final section for 'solo chorus' which is 1'30" long. There is thus no difference in length between the two versions because the work, if performed in concert using the electronic part 'without chorus', includes a live final intervention from the chorus.

The comparison shows that the version 'with chorus' was obtained through a mix of the electronic materials already included in the version 'without chorus' through a recording of the chorus no longer available, after spatial collocation of the sound events. The tape includes physical splices which indicate direct interventions by the author on the carrier aimed at redefining the structure of the work. As the oldest quadraphonic document and with material interventions by the author, this tape is suitable for comparison with the other sources.

A derivation of R1 is R2, a stereophonic mixdown with the addition of chorus and solo voices. It includes a version of the work obtained from the mix of: a) electronic part; b) solo voices; chorus. The signal is recorded on a magnetic tape with four tracks, repeated two by two. The work lasts 32'02".

The tape includes physical splices, some of which correspond to those found on R1. Their presence reveals parallel processing on the carrier of both documents, subsequent to mixdown, which has led to permanent changes of the sound fabric.[11] The notes on the casings and the analysis of the signal lead to the conclusion that the electronic part in R2 derives from a stereophonic mixdown of the signal on R1 'without chorus'. Figure 2 shows a detail of the handwritten notes on the back of the casing of R2. The first diagram shows the configuration of tracks in the document (the correction is noteworthy): track 1 is the same as track 2 (marked with A) and track 3 is the same as track 4 (marked with B); the second one shows how the mixdown from R1 was completed: track 1 and 2 of R2 = track 1 + track 3; track 2 and track 4 of R2 = track 2 + track 4 of R1. The tests confirm this derivation.[12]

11 The logs at Studio di Fonologia Musicale show a booking made by Nono for the days from 16 to 18 March 1970. On this occasion the montage of R2 was probably completed for the radio broadcast on 21 March 1970. This is the form in which the document has reached us.

12 A comparison was made between R2 and a stereophonic version of R1 obtained by means of a mixdown similar to the indications given on the casing.

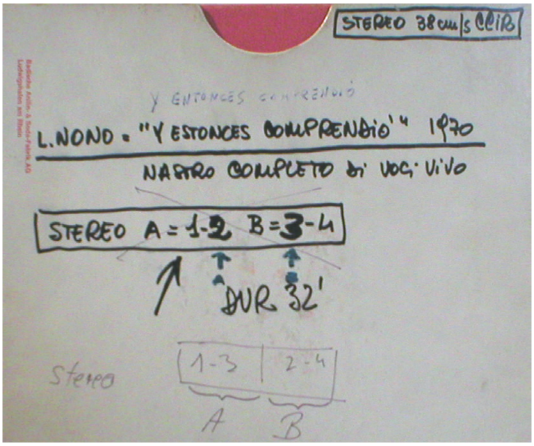

Figure 2 – Casing of R2. Position of the channels and derivation from R1.

Moreover, the analysis of the signal from R2 documents the presence of splices in R1 which are not physically present in R2.

The solo voices have been transferred to R2 from a tape no longer available. No source is available here for the recording of the chorus either, transferred to the final section of R2, as well as in R1 'with chorus' and in all published sources. It is possible to deduce perceptively that a same recording might have been used to produce all the sources 'with chorus'. Where the chorus is present, indeed, all documents show the presence of the same extra-musical sounds (e.g. the noise from the podium when the pages are turned). It can be excluded, on the other hand, that the chorus in R2 might be a derivation of the stereophonic mixdown of R1 'with chorus'. Conventionally, in line with what can be perceived through listening, it is possible to indicate the two channels of the lost 'chorus' tape with 'F' (microphone placed close to the female section of the chorus) and 'M' (microphone placed close to the male section of the chorus). These have been transferred to R1 and R2 as follows:[13]

- R1. Track 1: F – Track 2: M – Track 3: M – Track 4: F;
- R2. Tracks 1-2: F – Tracks 3-4: M

13 Given the complexity of the signal in the parts where there is no chorus, due to the editing of several heterogeneous materials, these tests were conducted perceptively.

It is clear that if the chorus in R2 had been a mixdown derived from R1 'with chorus', completed using the methods described above, it would have become monophonic; it is possible to conclude, therefore, that it has been transferred to the two documents following two separate pathways, probably in separate moments.[14]

There is only one structural variant between R2 and R1: at 7'09", close to a physical splice in R2, there is a clear repetition of a 1" fragment in 'electronic solo' and 'electronics + voice' version. No electronic material has been added compared to R1 (which has no splices at this point). In the second repetition of this fragment there is a background noise increase by about 3 dB. This shows the juxtaposition of a more elaborate and later generation tape[15] (Figure 3). The addition of the duplicate fragment creates a gap lasting about 1.5" between R2 and R1. The re-synchronization, common to both sources, occurs on the splice at 12'03".

The non-perfect matching between splices and the presence of repeated materials have led to the conclusion that there was no direct re-recording from R1 to R2. To explain the variants it is, indeed, necessary to postulate the existence of some processing stages of the carrier and signal which involve tapes no longer available (copies for use, created for technical reasons), which definitely include the lost tapes with voices and chorus, as already mentioned, and at least one copy of the R1 mixdown.

R2 is the oldest analog source with chorus and solo voices. It will therefore serve as reference document for comparison with other sources where the work has been saved in this version.

14 R14, copy of the radio source broadcast by RAI on 21 March 1970, provides another chronological clue. The analysis of the signal confirms that this source is a derivation of R2 (mixdown, dynamic adjustments and applause additions). The version 'with chorus' of R1 was created later, in May 1970, on the occasion of the concert in Amsterdam (see ALN, Vitali, 70-05-26 d).

15 Experiments conducted in the lab show an increase in background noise by about 2-3 dB for each copying process of an analog tape, using professional equipment.

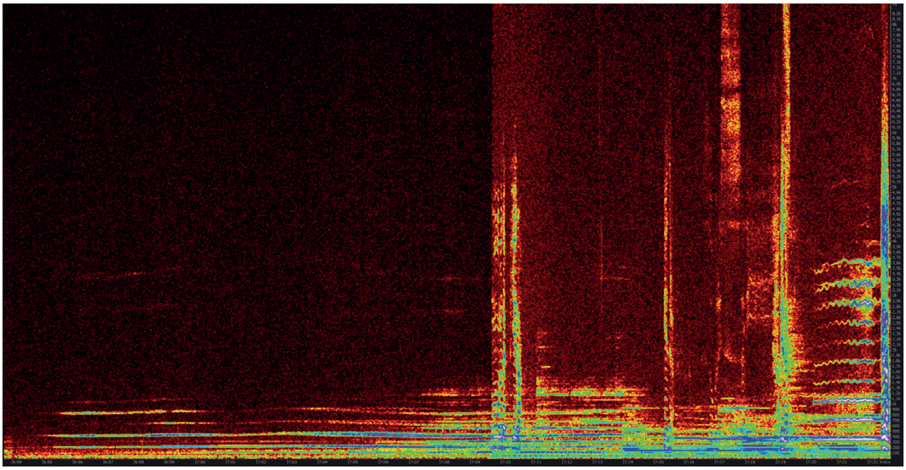

Figure 3 – Variations of the background noise close to a montage point in R2 at 7'09".

Version for copyright filing

The Ricordi Archive includes a version of the electronic part (R3) which was filed for copyright protection and rental purposes together with the chorus score. The carrier does not include any physical splices, which means that the copy was made after the processing documented by the splices in R1. The only variants compared to R1 are a difference in the reading speed, which leads to an increase in duration by 0.1%, and the addition of a test signal at 1016 Hz at the start of the tape, followed by leader tape.

Copies for concert performance

Apart from the official tapes kept in the archives of the production center and by the publisher, there are copies for use. As usually happens in the tradition of audio documents, these are created for practical purposes related to the work's performance. They appear in a variety of formats.

The sound director Alvise Vidolin, one of the custodian of most of Nono's performance tradition, has in his archive copies of the concert tape (R4).

These actually include two stereophonic tapes which are a copy of R3 made after the author's death.[16] The duration of the recording is shorter by 0.14% compared to R1; there is also a test signal, which was copied from R3, at 1017 Hz.[17] One of the two tapes shows physical splices. The comparisons with R1 'without chorus' do not point to any structural variants. Minor signal drops are found close to these splices; one is therefore led to conclude that this physical processing of the carrier might have been conducted before the work was recorded. The following is also noteworthy: a) a clear increase in terms of background noise (by more than 3 dB); b) a stationary signal at 716 Hz which might probably be caused by electro-magnetic interference; c) upsetting of the dynamic balance between the tracks (which is probably due to a calibration defect in the copying system).

In the 1990s also the interfaces for reproduction changed, as did perception sensitivity. Then the age of audio restoration began.[18] An interesting source in this regard is the DAT copy of WO 016/91 kept at Ricordi Archive (R5): listed by G. Ricordi & C. as «original master DAT», which is a restored digital copy of R4.[19] The distinguishing features of this restoration are: a) a slight reduction of the background noise; b) the elimination, through a notch filter, of the disturbance at 50 Hz, and, only on tracks 3 and 4, also at 150 Hz and 350 Hz; c) upsetting of the dynamic balance between the tracks.[20] The restoration has changed the general sonority, but it has not affected the structure of the electronic part. Its content is therefore consistent with R1.

16 See delivery note for R3 from G. Ricordi & C. to M° Alvise Vidolin, 19 October 1990.

17 The 1 Hz difference between tapes R4 and R3 is due to the discrepancy in running speed.

18 See "Recorded music: from the ethics of preservation to the critical editing", in this book.

19 See delivery note Ricordi n. 7718 p. 5, 23 April 1991.

20 The restoration clearly reflects the technological and theoretical conditions of the time it was completed. The unbalancing between tracks and the application of differentiated filters on different channels, indeed, could be partly due to the separation of one quadraphonic into two stereophonic tapes of R4 – the source from which it is derived – made necessary in order to read the quadraphonic antigraph R3, partly to the intent of achieving better attenuation/elimination of disturbances. As regards digitization and restoration processes in the 1990s on behalf of Casa Ricordi – as well as the origin of the sources in the Luigi Nono Archive – see also Vidolin 2008.

The derivations of R5 then include: a) the WO 016/91 DATs of Ricordi Archive (R6); listed by G. Ricordi & C. as «production master DAT missato», a stereophonic mix of R5.[21] The mixdown was completed in the following ways: track 1 = R5 track 1 + R5 track 4; track 2 = R5 track 2 + R5 track 3; it is therefore different from that of the electronic part in R2; b) the magnetic tape 190, also at Ricordi Archive (R7) which, as also specified in the notes on the casing is an analog copy on a ¼" magnetic tape of R6. The signal analysis confirms this derivation. All of the disturbances found in earlier generation copies can actually be found here.

The first digital preservative copies

In the 1980s the archives of production studios and publishing houses had to deal with the digital revolution. The shift from analog to digital carrier was a prerequisite, but not a sufficient condition, for use of this heritage. Tape recorders were replaced by an apparently endless variety of digital recording systems, with varying degrees of success, over the years. By the end of the 1980s the question was to set up preservation strategies aimed at transferring the signal from carriers at risk of perishing onto new filing systems which would hopefully be more stable and longer lasting. This was the beginning of the age of active preservation practices for audio recordings.

For *Y entonces comprendió* an important source is the DTRS *Fonologia* Q33-34-37-28 (R8). This document, according to the notes on the casing and the documents of Maddalena Novati, is a preservative copy of tapes kept at the Studio di Fonologia Musicale, which also include R1 and R2,[22] in section one and two respectively. As a safety measure, the digitized signal has been replicated so as to take up all of the eight channels made available by the DTRS (track 1=5; 2=6; 3=7; 4=8). The duplicate of the signal is perfect (the result of the subtraction is 0).

The structure of the work contained in the first part of the tape is identical to that of R1; there are, however, a few non-structural variants. In two

21 See delivery note Ricordi Nr. 7718 p. 5, 23 April 1991.

22 The other document here re-recorded are MI RAI Q37 and MI RAI Q28.

points on track 1 there are clear local increases in intensity, preceded by noise and followed by clicks (from 10'42" to 12'35" there is a difference of +8.4 dB; from 18'55" to 19'15" of +14.5 dB; Figure 4). The almost instantaneous transition, the absence of fading or traces of montage and the presence of noise all lead to ruling out the chance that these differences compared to R1 could be authorial variants found in an analog copy no longer available; they could therefore be classified as transmission errors. There are also digital clicks.

The content of the second section of the document is perfectly consistent with R2.

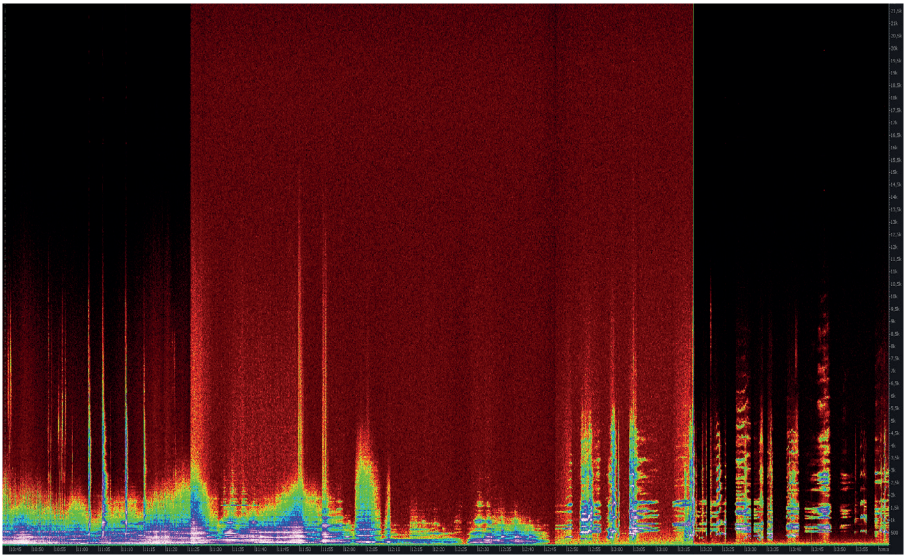

Figure 4 – Increase by 14.5 dB on track 1 of R8 between 18'55" and 19'15".

Study copies

To further complicate the tradition there are the copies given by the archives to researchers for study reasons. To analyze the electronic part the scholar could use some copies on DAT, provided by the publisher. More specifically: R9 and R10.

The source R9 consists of four DATs, with eight tracks in total. As in the case of R8, the signal is replicated following the pattern 1=5, 2=6, 3=7, 4=8. The content is similar to that of R1 'with chorus'. In track 1, and consistently in track 5, there are local dynamic increases (from 2" to 10" +14 dB; from 2'50" to 2'56" + 12 dB; from 8'04" to 8'14" + 7.5 dB), similar to those in R8, but located in various moments of the work. This is a digital transfer from R1 probably of a generation similar to R8.

R10 instead consists of two DATs, with four tracks in total. The recording includes a version 'without chorus' of the electronic part, consistent with R1. The sound fabric contains all the typical errors of R4 (stationary signal at 716 Hz, drops caused by splices, etc.); also the duration of the recording is similar. We are therefore led to conclude that this document is a digitization of R4.

Back to the archives

A large number of archives, such as Luigi Nono Archive in Venice, where audio documents are contained which belonged to the composers, were created in the 1990s, during a pioneering phase in audio preservation. They tenaciously collected a huge amount of electronic music audio sources, also from third parties, and made sure that they were readily accessible to scholars who could assess their authenticity and relationships with the rest of the tradition. At the time when these copies were created, the chosen carrier for their use was the Audio CD (CD-A) (see Vidolin 2008).

The Luigi Nono Archive in Venice made available some CDs containing several versions of *Y entonces comprendió*, more specifically R11, R12 and R13.

Document R11 included a version 'with chorus' of the work which contained substantial structural differences compared to R1 'with chorus'. In actual fact, there were some discrepancies in terms of duration and synchronization of sound events. Tracks 1 and 2, recorded on the first stereo track of the Audio CD, lasted 31'17"; tracks 3 and 4, recorded on stereo track 2 of the CD-A, lasted 31'47"; R1 contained four tracks, all with the same duration of 32'02".

Synchronizing the tracks with R1 it has been possible to highlight the differences and study them. They are not electronic material processing outcomes, but rather actual gaps (Figure 5). The cuts found are undoubtedly the result of digital processing of the signal which changes morphology in the interval of one-two samples. The sound fabric is thus disfigured by clear transmission errors or by digital processing of the signal not attributable to the author. Having revealed the gaps and re-synchronized the common materials, the match with R1 is perfect. The gaps on tracks 1 and 2 coincide (the file is stereo). The gaps on tracks 3 and 4 coincide (the file is stereo).

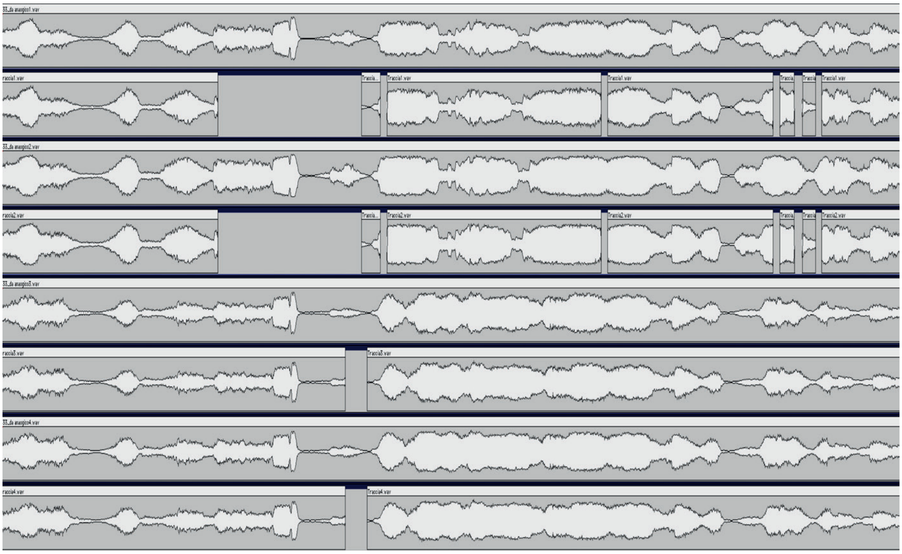

Figure 5 – Gaps in R11 (cuts on the tracks 2, 4, 6, 8); detail revealed by the comparison with R1.

There are also all the disturbances found in R9 (local dynamic increases – Figure 6 –, digital clicks, etc.). Mention should also be made of the dithering and of a stationary signal at 3900 Hz with harmonic components. The presence of the latter disturbance, of a clearly analog nature, leads to conclude that R11 could have been a copy of R9 made after conversion into the analog domain. It was probably a digitization of the audio signal from the analog output of the DAT player.

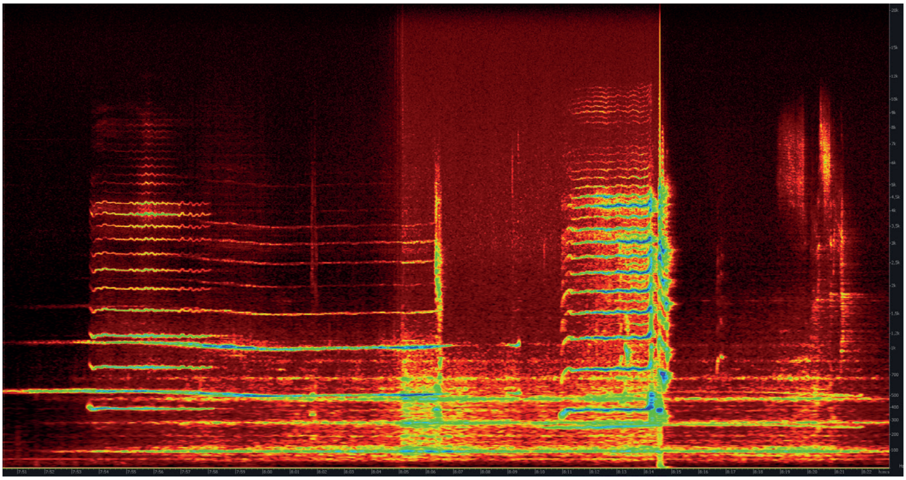

Figure 6 – Increase by about 7.5 dB for 10" at 8'05" of R11*, track 1.*

Document R12 included a version 'without chorus' of the electronic part. On tracks 3 and 4 a deletion was made of the signal section containing the test frequency: it is therefore impossible to reconstruct the synchronism of tracks without a comparison with another uncorrupted source. Compared to R1 the duration is shorter by about 9.2%; the signal has been translated to higher frequency: the *hum* is measured at about 54 Hz. There was a clear format interpretation error: given that the ratio between 48000 and 44100 (two of the most widespread sampling frequencies) is actually 9.2%, it is possible to assume that the source of this document in digital format, with a sampling frequency of 44100 Hz, might have been erroneously read with a sampling frequency of 48 kHz.

During the comparison work the speed was corrected to make the signal comparable to that on R1. No structural variants were detected. It is worth mentioning the presence of all the errors induced by R4. The test results lead to the conclusion that R12 could be an erroneous transfer of a digital copy of R4, presumably R10.[23]

23 It is interesting to note that the most serious errors occurred in the digital processing of the signal. The approximations typical of the analog domain are totally negligible compared to the damage caused by unskilled and careless digital processing. Also in this case the professionalism of traditional centers such as the RAI Audio Lab stands out, which has

Document R13 contains the stereophonic mixdown of R11 and R12, which was completed in the following ways:

- Track 1 = track 1 + track 3 + track 4
- Track 2 = track 2 + track 3 + track 4

It is therefore different both from the one in R2 and from the one in R6. No further structural variants or errors are introduced.

Radio broadcasts

An interesting case in point are the sources of radio broadcasts. The Archive of the Studio di Fonologia Musicale makes available for research purposes DAT Z139 (R14), the access copy to the ¼" tape Z139. It includes a transfer of the radio program 'I concerti di Roma' which was broadcast on 21 March 1970 at 7.15 pm on *Terzo canale*. The original document is kept in the *Teche* RAI Archive in Rome, cataloged as RAI DRTN MI00076826 according to the list «Anagrafie complete» and Roma RAI NASE MI76826 according to the list «Anagrafie di magazzino».

This document does not include any recording of the concert but a monophonic version of the work with chorus and solo voices which was produced in a studio. The sound fabric derives from the one saved on R2, with specific procedures for radio broadcasting. The interventions consist in the mixdown of channels, the addition of applause before and after the performance and an adjustment of dynamics which would have jeopardized its use for radio broadcasting (there does not seem to be any compression, but exclusively an adjustment of volumes which is particularly clear in the final section). Also the equalization is markedly different.

produced official copies in line with the principles of preservation ethics (R8 should be considered a 'tape for use' therefore it has not undergone such stringent checks as official copies, hence the presence of some errors which in any case to not alter the structure of the work).

Editions on record

Finally, for a complete picture of how this work was received, it is also essential to study its editions on record. Two records facilitated the dissemination of *Y entonces comprendió*: the first one was published by Ricordi and the second by Deutsche Grammophon.

The first one (LP1) is part of the publication entitled *El circulo de piedra* which includes: a) texts by Carlos Franqui; b) a lithography collection by Adami, Calder, Camacho, Cardenas, César, Corneille, Erró, Jorn, Kowalski, Lam, Miró, Pignon, Rebeyrolle, Tápies and Vedova; c) the vinyl record with a complete recording of the work (electronic part, solo voices and chorus).

The content is consistent with that of R2. There are, however, clear correction interventions made in order to adjust the signal to the needs of the new medium (from tape to record); these include, for example, the division of the work into two parts so that both sides of the record could be used. Mention should also be made of the following: a) a slight dynamic compression, which was probably partly due to an adjustment intervention, partly for the different dynamic response of the record; b) a slight and not constant overlapping of the two channels due to crosstalk problems in the document, as well as – probably – also to editing interventions aimed at 'centering' the signal in space to adjust it for listening at home.

Less justifiable is a discrepancy by more than 1% found in the running speed which reduces the duration of the work by about 20" (apart from the break between the two sides of the record there is no structural variant). This was probably due to a defect during the matrix production phase which was used for record printing. Engraved on the vinyl crown are the printing dates of the copy under examination:[24] 15/06/1970 on side 'A'; 16/06/1970 on side 'B'.

The Deutsche Grammophon edition (LP2) includes on side 'A' *Como una ola de fuerza y luz* and on side 'B' *Y entonces comprendió*. The content of the record is consistent with that of R2. The record is stereophonic, however the R2 channels have been mixed further in two identical channels (probably due to erroneous interpretation of the diagrams on the tape casing, Figure 2);

24 This copy was made available courtesy of Nuria Schönberg Nono.

the signal is therefore pseudo-stereophonic. The only variant encountered is a slight difference in running speed by 0.2% which reduces the duration of the work by about 4".

Open questions

It is not possible to make any definite assumption about the form of the work when it was first performed in Rome in 1970, because R14 is not a recording of the concert but a studio processing of R2. Moreover, since it is not possible to date the interventions on the carriers, it is not possible to know when the cuts were made between R0 and R1.

However, R14 leads us to conclude that, right from the radio broadcast on 21 March 1970 the work might have been set in the form confirmed by all sources, and documented in an authoritative and comprehensive way by R1, as regards the electronic part, and R2 for the complete version with chorus and solo voices. The fact that the radio broadcast was presented as a recording of the concert could suggest that the structure of the work on the occasion of its premiere in Rome is the one documented by this source and therefore by R2.

RECOGNITION OF THE SOUND FABRIC

The study of the tradition of audio documents for *Y entonces comprendió* confirms without any doubt the presence of a reliable and uncorrupted master copy: the recording on a 1" four-track tape marked Q33 in the Archive of the Studio di Fonologia Musicale. This is the oldest comprehensive source for the electronic component; all previous records are preparatory materials, which enlighten us as to the genesis of the music, but do not include the composition in its approved form.

Apart from preparatory materials, the Luigi Nono Archives in Venice also included digital copies which were either not reliable or clearly corrupted: R11 and R12. For a long time these copies have been considered as evidence of authorial variants. Reading the misalignments caused by the asynchronization of cuts on the four tracks in R11, one can note for example repetitions as canon, between one pair of channels and the other, of the same event, or also the reflected return of an event, to the extent that space does not represent its meaning. One can thus be led to imagining a development of the music which is not confirmed by sources, where Nono adjusts the spatial techniques of stereophonic recording to the dramaturgy of live quadraphonic listening (see Pellegrini, Schaller 2002).

At the time, audio sources in electronic music were not critically studied. Audio records, until that time, had been described exclusively in terms of preservation issues. It is thus understandable how difficult it was to work on these sources without consolidated editorial methodology. In actual fact, on a purely artistic level, it seems possible to accept a 'madrigalistic' interpretation, similar to counterpoint writing, the latter being extensively used by Nono in his instrumental music. Nevertheless only through the study of audio sources is it possible to understand to what extent this concept was put into practice, starting when the composer had to deal with electronic methods for sound production and recording. It is not enough, then, to refer to Renaissance Venetian polyphony to explain such a variant: any assessment from a critical-musicology perspective needs to take into account the production system, on a technological level and in terms of laboratory practices – bearing in mind that the feasibility of these variants with the quadraphonic magnetic tape technology is easily questionable[25] – as well as the aesthetics. Nono did not apply previous composition models a-critically to composition on tape: on the contrary he radically restyled composition practices, surpassing them by adjusting the models to the means available. The point of reference, therefore, was not only Gabrieli, but also Varèse, well-known and appreciated by Nono. Even though the multi-channel recording technique

25 It is indeed impossible to produce such time discrepancies two by two on the tracks of a quadraphonic tape without repeated copying processes which would lead to an apparent and easily measurable drop of the signal-to-noise ratio. A remake of the quadraphonic mix based on the preparatory materials, on the other hand, would have led to inevitable structural variants due to the impossibility of completing two editing and mixing actions which were exactly the same using the analog audio reproduction and processing equipment available to the composer.

might lead us to thinking in terms of linear development, the electronic music by Nono, as already happened in the case of Varèse, did not help consolidate strictly instrumental counterpoint techniques, but rather paved the way for a new way of considering audio materials. Already in *La fabbrica illuminata* the counterpoint technique is not automatically transferred from written music to tape; on the contrary, following Varèse's model, it becomes a movement of sound masses through space.

RESTORATION OF THE SOUND FABRIC BY MIRAGE

The time distance which separates us from the completion of our restoration work in 2005 today allows us to assess the interventions of the time in relation to the technology which was available then. This is an essential point for the criticism of audiovisual sources because the act of recognizing the work implies an awareness of the technical-theoretical capabilities of the laboratory which, at a given time, starts to work on the restoration of audiovisual tracks.

By its own nature restoration works in an area of tension consisting, on the one hand, of knowledge derived from historical research and, on the other, by mathematical models representing the recorded signal. To the extent that the recording on tape of electronic music is a projection of the technical-theoretical choices made by the composer, the restoration, as editorial action, is placed between two methodological contexts: that of the composition act and that of the restoration act which is also historically determined. The user friendliness of commercial software dedicated to restoration might lead to conclude that 'cleaning up' is a neutral and transparent operation. The signal processing algorithms dedicated to removing disturbances and improving the quality of a signal, on the contrary, derive from assumptions about the nature of noise in relation to the signal; these theoretical assumptions are not devoid of a certain degree of relativism which pervades all research based on modeling. This epistemological situation increases the subjective responsibility of those in charge of restoration, thereby encouraging a systematic comparison between different models on the basis of their restoration effectiveness, examined also from a perception viewpoint.[26]

The strategy chosen at the time for the restoration of the electronic part of *Y entonces comprendió* involved a *SonicStudio HDSP 1.9* workstation on *Power Macintosh G4* computer. Analyzing the signal was not easy: the software did not implement visualizations in time/frequency, which meant that the disturbances had to be found exclusively by perception and/or looking at the waveform (time/amplitude); there was also a frequency/amplitude visualization system available (FFT), which however did not allow for adjusting the length and characteristics of the analysis window. For the analysis of stationary disturbances, as well as for more precise amplitude measurements (minimum and maximum RMS, SNR, etc.) it was necessary to use other software. *SonicStudio* then offered automated algorithms to detect local disturbances which worked on a statistical basis; but even though their detection thresholds could be adjusted, it was not possible to interpret the nature of the corruption. In actual fact it was necessary to avoid using automated procedures because the usual detection algorithms are not able to distinguish involuntary impulses from those intended by the composer and voluntarily recorded as integral part of the composition. A case in point are the similarities between a *click* and a rapid sound attack.

Also the restoration work involved some difficulties. *SonicStudio* offered several interpolators in the time domain for the removal of impulse disturbances and one *denoise* system based on the principles of spectral subtraction. The interpolators made it possible to reconstruct the corrupted signal by estimating the surrounding data of only very short audio portions (< 1000 samples); it was thus impossible to intervene effectively on most drop-outs and on low-frequency impulse disturbances. For denoising, the computing power was not sufficient for a real time processing on high resolution (96 kHz), which means that the perceptive tests needed to be performed on files with limited resolution (48 kHz). The restoration work thus entailed long processes related to comparing and testing the result on final full-resolution files, produced by batch processing which in some cases could take several hours.

26 See "Recorded music: from the ethics of preservation to the critical editing", in this book

Preliminary work

The study of the tradition of audio documents for *Y entonces comprendió* does not leave any doubt as to the presence of an original, authorial and uncorrupted source: R1. It contains the electronic part of the work divided into five sections:

- *Caballo*;
- *Muro*;
- *Camilo*;
- *Noche*;
- *Lucha*.

R1 has been taken as reference document for the restoration. The first operation involved searching for and cataloging any disturbances or anomalies. Even though the digital domain makes it possible to complete tests on the sound fabric with a degree of accuracy which cannot be achieved in the analog domain, finding and cataloging disturbances and anomalies requires the ability to discern corruption of the sound materials, an operation which cannot be entrusted to the automated workings of restoration software. There are many possible representations of sound, each of which is based on a model which is often insufficient to explain electronic writing. Also the information about the methods for sound generation, even assuming that the generators are known, leave an endless series of interpretation possible. Within this framework it becomes important to be aware of the practice and technique of electronic music. The subsequent wide margin of subjectivity assigns to the person in charge of restoration the role of interpreter, who has to make choices which need to be inspired by ethical principles of transparency in operations: hence the importance of expressly stating the methodologies used for each intervention.

Research work was completed on each individual channel;[27] both loudspeakers and headphones were used for listening.[28] In order to make comparative tests reliable, the amplitude of the audio signal in all documents was standardized at -6 dBFS.

The sound fabric analysis

Stationary disturbances. The search for stationary disturbances conducted on the whole recording has revealed the presence of a signal at 50 Hz (*hum*) of limited amplitude (-74 dB RMS), with components at 100, 150, 200 Hz, whose causes seem to be due to electromagnetic induction between the power grid and the recording equipment, and the residual alternating current, a phenomenon known as *ripple*.

Impulse disturbances. During this phase a survey method was defined which could give the best guarantees to detect disturbances, based on subjective criteria (the assessment by the person in charge of restoration) and objective parameters (automated search through the restoration software). The operations made it possible to detect the disturbances, as well as a few doubtful cases, which were then classified. A list was compiled showing the totality of anomalies detected on the tape.

The impulse disturbance detection was conducted in three phases: 1) carefully listening to the sound materials on the four tracks: at first on multiple channels, then one track at a time; 2) filtering: this work consisted in applying a fourth order high pass filter with cutoff frequency at 4 kHz; in this way the graphical representation of the time/amplitude domain, without the low and medium components, highlights any impulse disturbances; 3) automated search for disturbances through a detection algorithm. The system reports any candidate sites, that is to say potential clicks. The algorithm was set

27 We used: FFT most commonly on 32768 samples (other resolutions were used in particular cases) with Blackmann window; amplitude statistics (RMS, peak amplitude, DC offset, etc.) on 50 ms window.

28 We used: *SonicStudio* HDSP on *Power Macintosh G4*, version 1.9; *Apogee Rosetta 800* D/A converter; *Focusrite* RED *4* preamplifier; *Genelec 1032A* monitors; *AKG K501* headphones.

with parameters useful to detect disturbances lasting about 1 ms: this average value was derived from measuring a significant number of disturbances.

The click-detect operation, as part of the logic of the system, is preliminary to automated interpolation operations conducted later on candidate sites; the decision was made, however, to leave out this second phase and use only manual interpolators. This strategy was also made possible by the limited number of disturbances (hundreds, and not thousands as – for example – in the case of materials from records), which meant that manual procedures could be used, involving longer test times but greater flexibility and precision compared to automated systems.

The use by the composer of sound materials without impulse characteristics has made it easier to assess the areas to be subjected to interpolation: it is fair to say, in general, that there were no uncertainties as to the opportunity for each individual intervention because the disturbance could not be confused with the sound materials. The only exception where different approach was used concerns the assessment of the singers' labial noises. These noises appear in the points where the voice is recorded from very close up; they can be mistaken for impulse disturbance, therefore special attention was paid in the cases where they occurred just before or just after voice emission: the survey of the time duration of doubtful cases after listening led us to rule out restoration for all noises exceeding 5 ms. In actual fact, no clicks were found lasting longer than 2 ms, so all labial noises exceed the 5 ms duration: this value was thus chosen as threshold for the restoration work.

As further verification, the text vocalized by the female performers was analyzed: for example, when the text by Franqui (1971) says: «Y decian que *el hombre* che *subìa* de abajo habìa desaparecido arriba en las alturas» (in italics the words uttered by the female singer), the last verse of *Camilo en el aire*. The presence of the labial consonant 'B' made it possible to clearly classify the case in point as 'labial noise' rather than as disturbance.

Broadband noise. The broadband stationary noise (*hiss*) can be due to several factors, including Johnson-Nyquist noise from the microphones, preamplifiers and other equipment used for recording. Repairing this disturbance is a critical factor when re-editing of work on tape because in electronic music the hiss may be a composition choice or caused by involuntary signal alterations. When restoring electronic music tapes the boundary between remake and preservative intervention is defined by analyzing the musical technology of the time, which makes it possible – in many cases – to clarify the voluntary or involuntary nature of the recorded hiss, to determine whether any noise should be attributed to voluntary technical solutions and musical choices by the composer, or – instead – if it should be regarded as an alteration attributable to equipment not working properly or merely to aging of the carriers (see Brock-Nannestad 2001).

The restoration work

Stationary disturbances. The test conducted on the low frequencies of the sound fabric detected the presence of partials at 50, 100, 150, and 200 Hz. In this case, however, the decision was made not to remove the *hum*. Once again the analysis of the sound sources used for the composition has been decisive, in that it allowed for finding sound materials intentionally added to the work (indicated by the composer as «tubo basso» (low tube),[29] at low intensity (-60 dB), significantly present for several seconds at the frequencies 32, 46, 56 and 95 Hz. A *hum* reduction intervention using *notch* filters centered at 50 and 100 Hz, inevitably interfering with nearby frequencies, would alter the morphology of this sound.

Impulse disturbances. Impulse disturbances appear with an extremely varied morphology, both isolated and in 'swarms'. They can be caused by micro-degradations of the carrier or by imprecise splicing of the tape, or also by unintended alterations of the signal introduced during the recording phase (micro-impulses of an electric and electrostatic nature). Manual declicking differs from the automatic one because it makes it possible to check each individual restoration operation.

The most effective way to remove the disturbance involves locating it visually, in order to give the system instructions as to the duration of the

29 The words «tubo basso» were written in colored pencil on the reel of the tape N *062* of the Luigi Nono Archive in Venice, and indicate a sound of a percussive nature (metallic) used for the final montage of R1.

material to be interpolated, as well as to the type of interpolator required. Generally speaking, for typical isolated clicks, the *Sonic Solutions type B* algorithm has been used.

In the case of clicks in swarms, two intervention methods were considered, strictly dependent on the nature of the disturbance: traditional methods were used if the result of the interpolation did not create artifacts; in other cases a different approach was chosen which involved treating the disturbances like a global phenomenon, as if it were a 'crackle', even though this could be assigned to a locally defined time interval. For this disturbance the solution chosen was local decrakling, of *type E*, which can be applied to a file portion: the system complete the interpolation only if any discontinuities are detected in the signal. This option proves especially useful in cases where the disturbances cannot be seen in the graphic representation.

Declick algorithms were used also to correct some drop-outs, when the duration of the disturbance did not prevent the interpolator from working effectively.[30]

Broadband noise attenuation. The *SonicStudio* system implemented an algorithm for the attenuation of broadband noise. Its operation can be seen as an approximation in discrete blocks of Wiener filtering in the frequency domain: the assumption is that an estimate is known of the noise power spectral density; the method consists in analyzing through filters the corrupted signal, then weighting the various spectral components in relation to the estimate made on noise. The re-synthesized signal is the result of a subtraction of frequency components in the corrupted signal and an estimate of the noise power spectral density (see Ephraim, Malah 1984 and Cappé 1994). It was thus necessary to analyze the background noise on a recording segment devoid of intentional signal. The parameters of the spectral subtraction algorithm were then chosen based on the restoration objectives and defined also in relation to the new medium onto which the originally analog signal was being transferred. Nothing was done as regards noise amplitude

30 With more recent restoration software which allows for interpolation, re-synthesis or other targeted processing also in individual frequency regions, for example *iZotope RX*, today it would be possible to work effectively also on longer lasting drop-outs.

discontinuities. For the same reason the audible sonority variations found in some points where there are splices on the tape were respected.

The most problematic phase during the spectral subtraction operation is the transition between the appearance of noise and the subsequent masking of sound materials. The *SonicStudio* obtains its 'footprint' of the noise (*estimate*) by analyzing a signal portion, whose frequency content is divided into 2048 bands (*bins*): an FFT is then calculated for each of them. All of these FFTs are then averaged out, with the mean result constituting the relevant *estimate*. The composer used materials with frequencies starting from 32 Hz and an intensity of -60 dB, therefore the action by the *denoiser* has been limited to between 150 Hz and 24 kHz because in these frequencies the sound materials, if present, always abundantly exceed the noise threshold in terms of amplitude; on the other hand, in the flat area between 0 and 150 Hz, there is some processed material (which was already mentioned when discussing the need for removing the hum or not) at intensity levels close to the noise threshold, from which it occasionally emerges before it is masked again. The risk of deleting also primary information is therefore high. To exclude the action of restoration in the critical band between 0 and 150 Hz two different approaches were considered.

The first possibility, the only one included in the system, consists in limiting the frequency of the denoise process by means of two points, known as *cutoff* (low *cutoff* and high *cutoff*), beyond which the algorithm does not intervene. In our case it was sufficient to limit the process using only the low *cutoff* point, set at 150 Hz, below which the algorithm was not used. The advantages of this method are that it is easy and simple to use; it has, on the other hand, at least two disadvantages: a) it is not possible to know beforehand how the system will respond; it can be assumed, however, that b) the algorithm will be abruptly enabled in the *cutoff* area and the transition moment cannot be controlled during restoration.

A more experimental method, not included in the system, could be used thanks to the flexibility of restoration instruments, forced due to musical requirements. It consists in manually altering the *estimate* which the system uses as reference for spectral density, thus causing an 'artificial' reduction in system sensitivity in the area up to 150 Hz: in actual fact this intervention leads the system into believing that a spectral density between 0 and 150 Hz is lower than it actually is, subsequently the noise reduction intervention does not take place. We decided to use this method which guarantees a smooth transition between the two frequency bands.

For the final setting of parameters in the subtraction algorithm, the implications on the sound fabric were considered, for the purpose of achieving a noise reduction by about 5 dB.[31]

Other tests, conducted to check the correctness of noise reduction operations, compared the spectral components in a region without primary information of R1, and the same region in the restored version. The result is a reduction of the RMS noise power by about 3.2 dB. A further test involved comparing the two versions at a point where there is a low-intensity signal (-67 dB RMS), in order to make sure that the algorithm does not subtract, apart from the noise, also primary information. The final test was conducted on the correct behavior of the algorithm during the stand-by phase, that is to say when the amplitude of the primary information certainly exceeds the estimate. No interventions of the restoration algorithm are noticeable: the result thus confirms the forecast.

Towards an aesthetic approach

In numerous points, more specifically on track 1, the signal shows local saturations and distortions. These disturbances, typical of the creation and transmission of electronic music, are often caused by signal processing and by the tape montage process; it is reasonable to assume that they might have been introduced during the composition phase. The fact that saturations have been found also in all other sources, including the published one, shows their presence in R1 starting from the exact moment that the first copy of the signal was made (R2). This suggests ruling out the possibility that they might be a result of tape degradation over time. It is therefore reasonable to

31 The parameters used were: *Max reduce* -16; *Threshold* 18; *Sharpness* 1.5; *Bandwidth* 1.5; *Cutoff low* 0; *Cutoff high* 24.000.

conclude that Nono could have listened to[32] and authorized these 'imperfections'. Nevertheless, consideration ought to be given to technological development of reproduction equipment and to the cultural changes this causes in terms of sound perception. Apart from the operations completed for documentary restoration, these alterations have also been attenuated using procedures for impulse disturbance removal. Where the material sounded more or less identical corresponding to other tracks, the latter has been used consistently to replace the distorted segment.[33] The goal of this approach was not to clarify the author's intentions but rather to produce a version which would be more appealing to listening sensitivity in this day and age.

32 Of course the perception we have today of these distortions is completely different from that of 1970 due to the different technological setting we are now operating in. On the one hand the limitations of loudspeakers of the time led to attenuating most of the disturbances; on the other side, today's listening habits, trained in high-fidelity systems, lead us to classifying any distortion as error or inconvenient disturbance; in the past such a 'disturbance' was the only way in which the power limits of the loudspeakers could be overcome, to give a feeling of having 'more volume'.

33 As in the case drop-outs, also in this instance more recent restoration software makes it possible to work more precisely, exclusively on the frequency bands affected by the disturbance, thus making the intervention less invasive.

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R2: Milan, RAI, Q34, 1970. Magnetic tape, 1”, 15 ips, 4-track, stereophonic. Stereo mixdown of R1, with chorus and solo voices.

R3: Milan, Ricordi, 10, 197[0?]. Magnetic tape, 1”, 15 ips, 4-track, quadraphonic. Without chorus. Copy of the electronic part.

R4: Padua, private collection Alvise Vidolin, 1991. 2 magnetic tapes, ¼”, 7.5 ips, 2*2-track, quadraphonic. Without chorus. Re-recording of R3.

R5: Milan, Ricordi WO 016/91, 15 March 1991. 2 DAT 2*2-track, quadraphonic. Without chorus.

R6: Milan, Ricordi WO 016/91 (2), 8 aprile 1991. DAT 2-track, stereophonic. Without chorus. Mixdown of R5.

R7: Milan, Ricordi 190, 1991. Magnetic tape, ¼”, 7.5 ips, stereophonic. Without chorus. Re-recording of R6.

R8: Milan, RAI *Fonologia* Q33-34-37-28, 199[?]. DTRS, 8-track, 48 kHz, quadraphonic. Backup copy. It contains: the version ‘with chorus’, the version ‘without chorus’ and a stereophonic mixdown with chorus and solo voices.

R9: Pordenone, MIRAGE Archive ‘Black DAT’, 199[?]. 4 DATS, 4*2-track, quadraphonic. With chorus.

R10: Pordenone, MIRAGE Archive ‘Red DAT’, 199[?]. 2 DATS, 4*2-track, quadraphonic. Without chorus.

R11: Venice, ALN CD 108, [199?]. CD-A, 2 stereo tracks, quadraphonic. With chorus.

R12: Venice ALN CD 109, [199?]. CD-A, 2 stereo tracks, quadraphonic. Without chorus.

R13: Venice, ALN CD 110, [199?]. CD-A, 2 stereo tracks, Stereophonic. Both versions: with chorus and without chorus.

R14: Milan, RAI [?], [199?]. DAT, 2-track, stereophonic (double mono). With chorus and solo voices.

LP1: Milan, Ricordi SAVC 501, June 1971. LP, 33 rpm, stereophonic. With chorus and solo voices.

LP2: Hamburg, Deutsche Grammophon 2530 436, 1974. LP, 33 rpm, stereophonic. With chorus and solo voices.

The critical edition of *La fabbrica illuminata* by Luigi Nono

Luca Cossettini

La fabbrica illuminata (1964), for soprano and magnetic tape, is the first work by Luigi Nono entirely constructed on the dialogue between two musical dimensions: electronics and voice solo.[1] The work is dedicated to the factory workers at the Italsider steel plant in Genoa-Cornigliano, with texts by (and elaborated by) Giuliano Scabia and a fragment of *Due poesie a T.* by Cesare Pavese (see Pavese 2014). Although it was written expressly for the opening concert of the Prix Italia 1964, it was not performed on that occasion because the administration of the RAI found the strong political bias of the texts to be offensive to the Italian government. The first public performance consequently took place in Venice on 15 September 1964, during the XXVII International Festival of Contemporary Music – La Biennale, with mezzo-soprano Carla Henius as soloist and Nono as sound director.

When Nono received the commission from the RAI he had been working with Scabia on *Un diario italiano*, of which *La fabbrica illuminata* was planned to be an episode. The motivating impulse behind the original, subsequently abandoned project was the composer's view of the musical stage as a vehicle for addressing pressing social and political issues, which was inspired by both the Soviet avant-garde (including such authors as Vsevolod Emil'evič Mejerchol'd) and the political theatre of Erwin Piscator. *Un diario italiano* would have been Nono's second *azione scenica* or 'stage event' after *Intolleranza '60* (1961).

1 Nono had already come into contact with sound generation and production technologies at the Studio di Fonologia Musicale, when the tapes of *Omaggio a Emilio Vedova* (1960) and *Intolleranza '60* (1960-61) were produced. *Omaggio a Emilio Vedova* is a purely electronic composition, almost a study of the possibilities offered by the electronic medium; *Intolleranza '60*, on the other hand, deals with the issue of spatializing acoustic elements (the chorus), but without creating actual dialectics between reproduced and 'live' sound.

In May 1964 Nono, along with Scabia and Marino Zuccheri, the sound technician for the RAI Studio di Fonologia Musicale in Milan, went to the Italsider steel plant in Genoa to collect material on the working and living conditions of the workers there. They recorded industrial noises and sounds of the men at work, while Scabia wrote down some of the words, orders, and factory slang he heard and came away with union publications that would be useful for assembling the text.

Much of the musical and literary material that had already been generated for *Un diario italiano* was adopted and adapted for this new composition. Working with Scabia, Nono replaced some of the choral texts with new ones based on the material collected at the Italsider plant, while a fragment of the second scene (*Sogno incubo. 5 donne*) became the basis of the third section (*Giro del letto*). Thus *La fabbrica illuminata* assumed the contours of an autonomous composition.

For the tape Nono used selections of music sung by the chorus of the RAI of Milan directed by Giulio Bertola, 'thematic' improvisations sung by mezzo-soprano Carla Henius, voices and noises from the Italsider plant, and synthesized sounds. All this material was elaborated at the Studio di Fonologia Musicale, where it was combined and electronically modified often beyond recognition. Nono described it thus: «nessuna *mimesis*, nessun rispecchiamento. Nessuna arcadia industriale. Nessun naturalismo populista o *popular*».[2]

Nono produced the electronic part with the technology of the 4-track magnetic tape and the equipment at the Studio di Fonologia Musicale. The voice solo part, on the other hand, was essentially written using traditional notation: the representation of pitch is integrated by micro-tonal indications, whereas that of durations does not always follow the division into measures, because sometimes a chronometric division is used. During the concert performance, the live voice communicates with the audio which is reproduced mechanically. In order to establish the relationships between these two domains, the author has added to the score a symbolic modeling system for the events recorded on tape which sets durations, contents, pitch and dynamic articulations; it is a sort of transcript/translation of the electronic part that

2 From the program notes written with Scabia for the first performance (Nono 2001A, 448).

guides the dialogue between human being and machine, i.e. between performance and reproduction.

A review of the sources for work constructed in this way, and where documents are established using non-conventional writing forms on heterogeneous media (one magnetic tape and one score), requires specific ecdotic and hermeneutic tools, which, in a publishing praxis that is still young, need to be clearly defined, tested and fine-tuned. Even though the score is a text which is defined and closed in itself, exactly because of the presence of a dialogue with the electronic component, its interpretation is inextricably linked with the analysis of the audio document, nor should one forget that audio documents and musical text are characterized by a different transmission and publishing phenomenology. An inter-disciplinary approach is therefore essential: in the case of autographic notation, use is made of musical text philology, extended also to interpreting composition sketches; for the electronic part, on the other hand, the study of the recorded sound fabric needs to be conducted through a reconstruction of the writing bases of the Studio di Fonologia Musicale (interaction between composer, sound engineer and recording/production/listening equipment) and of the audio document transmission and dissemination (copies for the live concert, recording, production for the radio).

Score and magnetic tape, however, although inextricably linked due to the very nature of the composition, do not evolve independently following parallel pathways. Variants – not only authorial but also traditional – in the sound fabric are often reflected in as many corrections on the score, and vice-versa; as a result, the tradition is made extremely complex by a new form of contamination. Having reconstructed the history of how the various documents and recognized authoritative documents are transmitted, it therefore becomes essential to study also the relationships between sound fabric and musical text in each 'development stage' of the sources. It is basically a matter of understanding the relationship between the two dimensions, that is to say the constituting element itself of the composition.

THE SOURCES

The live voice solo part

The scores which document authoritatively the vocal part in *La fabbrica illuminata* are four: three manuscripts and one anastatic print of a manuscript.

The Paul Sacher manuscript - Basel.[3] The first complete document found is dated «14 August 64». This means that it was completed one month before the world premiere of this work. The manuscript belonged to the mezzo-soprano Carla Henius – its first performer – until 1994, when it was sold to the Paul Sacher Foundation in Basel, where it is still kept today. It includes the full solo part and, above the pentagram, a transcription with symbols of some sound events memorized on tape which serve as a reference to interpret the relationships between the two domains. The synchronization between tape and voice is guided by a chronometric division, timed with a one-second precision, which is also placed above the pentagram.

The document includes several layers of autographic notes and revisions by the singer; there are also some corrections on strips of paper glued to the manuscript. In order to differentiate graphically the note elements, use was made of pencils and pens of different colors: black for the musical text and for the literary text; green for the symbolic transcription of the content of the tape; red for titles, times and some dynamic elements; blue for references to intonations to be taken from the tape and a fine-tuning of the draft of the electronic part. Only in this document, moreover, do we find micro-tonal intervals, marked by drawing arrows between the notes with a pencil.

The score is divided into four sections:

- *Coro iniziale*, divided in turn into four subsections, using Roman numerals;
- *Giro del letto*;
- *Tutta la città*;
- *Finale*.

3 For simplicity's sake, the manuscripts are named here with reference to the institutions which owns them. A detailed description of the documents can be found in Nono 2010.

The time division of the solo part is prescribed by two notation systems: the duration of the sounds is sometimes dependent on the actual value of the notes, with reference to precise metronome indications; on other occasions there are notes without a value and the time is approximately divided according to the chronometric instructions based on the recorded sound fabric. In other instances the two systems coexist; in these cases it seems that the indicative reference is a metronome set on 60 to the quarter note. At the beginning of each section, including the subsection of the *Coro iniziale*, the chronometric references to the tape are reset.

Luigi Nono Archive manuscript - Venice. Before finally leaving the original to Carla Henius, Nono made a photocopy of it,[4] which was then used to study the part with the soprano Liliana Poli, already starting in December 1965, and for later performances. This copy was then changed and integrated by the author, as confirmed by a very dense layering of the text. One of the most noteworthy interventions is the full revision of the time references to the tape based on new measurements and the deletion of almost all resetting on the chronometer. The solo part was subject to minimal variations.[5] The only structural change is the deletion by barring of micro-tonal intervals, except for a single passage in the final melody. Only in this manuscript do we find indications as to the use of stage lighting.

Ricordi manuscript - Milan. The manuscript from the Luigi Nono Archive is the direct antigraph of the autographic copy filed in 1967 with Casa Ricordi for printing. The latter is an extremely simplified score in its tape/voice references, although it is very clear and precise in its indications as to voice emissions, which are fine-tuned to include the smallest expressive details (for examples, some indications are included such as «quasi parlato», «quasi sussurrato»). The indication «ca» (*circa*, approximately) is added to many time references, proving the intention not to associate the phrasing to the chronometric pulsation of the tape. The printed edition of 1967, finally, is the anastatic reproduction of a revision of this manuscript, which consists in a correction of small typos and errors.

4 Venice, Luigi Nono Archive: ALN 27.17.02/01-15.

5 See the critical apparatus in Nono 2010.

Analyzing these documents diachronically there appears a precise development of the solo part; the writing is gradually defined and expressed with increasing clarity: especially as regards interpretation nuances of the voice emission. The same cannot be said, however, of the indications on the magnetic tape, which are changed and corrected with each draft, and contain noticeable inconsistencies. This extraordinary internal development of the texts can be essentially explained based on the relationship with the electronic component: it is actually not possible to understand the genesis of the variants unless, while analyzing the texts, a survey is also conducted on the tradition of audio documents.

The audio documents

The original tapes are kept at the Archive of the Studio di Fonologia Musicale. They are two quadraphonic tapes and one monophonic tape, indicated respectively as Q6, Q7 and E28.

RAI Q6 tape. The oldest document containing the electronic part to be played during the concert is the quadraphonic tape Q6, which was produced in the summer of 1964. The sound fabric consists of the selection and electronic processing of materials from different audio sources: a) recording of the RAI chorus, performing a score written on purpose for the tape (and which should thus be regarded as preparatory material)[6]; b) improvisations by the mezzo-soprano Carla Henius interpreting an outline from the literary text;[7] c) voices and sounds recorded at Italsider; d) synthesis sounds.

Q6 includes traces of the montage work (for example physical joining – splices), noticeable at direct inspection of the carrier and detectable from the audio signal. The authoritativeness of this document is confirmed by its being basically identical to the sound fabric found in more recent copies.

6 The original written choir part can be found at the Luigi Nono Archive. ALN 27.14/01-12.

7 The original recording is documented by a *unicum* kept in the Luigi Nono Archive: ALN N78 – archive copy DAT 17 – access copy CD 33.001/002.

RAI Q7 tape. Produced in 1965, Q7 descends from Q6 with the addition of the solo voice on tracks 1 and 2. It is interesting to note that in Q7, apart from the traces left by the Q6 joining on the audio signal, there is some splicing materially made on the carrier, which corresponds to what has been found on tape Q6; this is evidence of work being done at the same time on two documents. The duration of the recording is about 14 seconds shorter than Q6. There are, however, no structural variants as regards the sound fabric; the only difference is in the running speed. In actual fact, a constant shifting by +1.6% is measured, with a subsequent transposition of higher notes by ~⅛ of a tone. This difference is most likely unintentional; it should rather be attributed to a flaw in the running speed of one of the tape recorders used at the Studio di Fonologia Musicale. In a letter written by the author to his wife Nuria on the occasion of drafting the score for *A floresta é jovem e cheja de vida*, his subsequent electronic work, reference is made to a tape recorder running with a delay of about 1 minute every hour,[8] that is to say 1,6%.

Apart from this macroscopic speed variant, the recorded solo part – compared to the autographic scores – shows substantial differences covering all musical parameters (pitch, duration, dynamics, voice emission, etc.). The Q7 tape (or its copies not received) has been used for auditions and performances without a singer, by Case del Popolo, cultural associations or in venues where it was difficult to organize performances with live singing (as was the case in Latin America); it was thus intended for very different audiences and listening conditions compared to concert halls. For these reasons, the sound fabric contained in Q7 should be regarded as a separate version of the work, apart from the one intended for live performance. A descendant of this tape is also the Wergo edition on LP record (1968) which consists in a stereophonic mixdown, a further adjustment of the sound fabric to meet the requirements of listening at home.

RAI E28 tape. The E28 tape consists in a mixdown of tape Q6 with the addition of a recording of the solo voice part. In this case it constitutes a mono-aural electronic version of the work, which was specifically designed for

8 Luigi Nono/Nuria Schoenberg correspondence. Nuria Schoenberg Nono private collection.

radio broadcasting. Also here the recorded voice solo part appears to be markedly different from the score. Moreover, in several points, the voice performance and montage are different from those on tape Q7. On 13 February 1965 this version was broadcast by RAI Channel Three as 'recording of the concert at Foro Italico in Rome'.[9] Carla Henius, in her notebooks (Henius 1995), mentions how difficult it was to get satisfactory footage of this work's performance at Foro Italico. Composer and Singer had to go to the Studio di Fonologia Musicale on the 10th of February to record the solo voice and edit the radio version.

Ricordi 214 tape. A number of copies has been made from the three original tapes. Among them mention should be made of the one which was filed, alongside the score, with Casa Ricordi in 1967 as rental copy for live performances: the Ricordi 214 tape. It is a quadraphonic tape containing two copies made from the original RAI Q6 tape, recorded in succession on the same reel. This document was produced with equipment calibrated at non-nominal running speed, which reduced the duration of recordings by 0.4% and 0.6% for the first and second copy respectively.[10]

9 In the Archive of Teche RAI in Rome a copy is kept of this document, with applause added at the beginning and at the end – the RO172893 tape – filed as recording from the auditorium made during the broadcast, not intended for subsequent broadcasting.

10 There is a restored copy of this document, produced on behalf of Casa Ricordi at the beginning of the 1990s (Ricordi Archive DAT 92 and its copies for rental on CD-A. See also Nono, 2010. As in the case of the copy of *Y entonces comprendió* restored in the 1990s, the work on the audio signal perfectly reflects the technology and sensitivity of the time). Also for the electronic part of *La fabbrica illuminata*, therefore, new restoration work was completed, on behalf of Casa Ricordi (DVD attached to Nono 2010), linked to the oldest document recognized as original and in line with the developments in critical editing. From a documentary viewpoint, however, the 1990s restoration work becomes fundamentally important: it was used for almost twenty years in numerous live performance of *La fabbrica illuminata*, and its sonority affected the perception of the work, producing and establishing a sort of vulgate; its study is indispensable today in order to reconstruct how the work was received.

MUSICAL TEXT *VS* SOUND FABRIC

In 1967 Nono delivered to Casa Ricordi the necessary documents for the performance of *La fabbrica illuminata*: the autographic score for the solo voice and one magnetic tape for the electronic part. However, when trying to perform this work, one is bound to encounter synchronization issues: the references to the tape on the score delivered for printing do not coincide with the timings of the Ricordi tape; on the other hand they are consistent with those of Q6. The tape is reproduced from the beginning of the work, then stopped only when the *Finale* section starts; this means that the Ricordi copies, due to the errors in speed, accumulate a gradual displacement with regard to the times noted on the score. It is only after about 12'14" that synchronization is restored by resetting the chronometer at the beginning of the section called *Tutta la città*.[11]

In dealing with synchronization issues in the analog domain, mention should be made of the tolerances implicit in the technological media used for the creation/reproduction processes of the sound fabric.[12] Any error, though minimal in the presence of perfectly calibrated machinery, is inevitable and implicit in the composition and production process of any electronic work on tape. The ensuing variability of audio sources, however, is ill suited to the structural rigidity of a score such as that of *La fabbrica illuminata* which includes synchronous points with precision levels to the second, and an interval sequence which is still affected by the use of serial techniques. The resetting of the chronometer, required in the first draft of the score at the beginning of each section, limited any lack of synchronization due to errors in the tape running speed to very short sections of the work. In this way the displacement did not accumulate and, unless the error was really

11 If we consider the first copy made on the Ricordi tape, the displacement accumulated at this point in the work is by now ~3 seconds; this is sufficient to irretrievably distort the tape/voice dialogue. If we use the second copy, the said displacement increases to ~4.5 seconds.

12 The tolerance in the running speed of tape recorders in use at radio studios, for example, is set at around ±0.22% (4 seconds every 30 minutes). It was then set, by International standards CEI/IEC 94-1:1981, Geneva, IEC, 1981, at ±0.2% for professional equipment, and at ±2% for domestic equipment.

macroscopic, it was not even noticed because it remained well below one second in duration, the precision with which references to the tape are given. The only exception is the section *Giro del letto* which lasts about 3 minutes; here any discrepancy greater than 0.5% becomes apparent.

By analyzing the timings of tape references in the section *Giro del letto* from the Basel manuscript, it appears that some inconsistencies in the tape/voice dialogue were already added starting from the very first draft of sound fabric and musical text. As a matter of fact, if we compare the time division noted in the score with the audio recorded on tape Q6, there is a gradual displacement by about one second every minute (~1.6%). It is extremely likely that these references were taken from a preparatory tape, then slowed down – consciously or not – considering also the defects of the machinery used during the montage phase. This discrepancy was eliminated only through a review of the references in the manuscript kept at the Luigi Nono Archive.

In the composer's notes[13] we find models of the micro- and macro-structure of the work, as regards both the solo part and the sound fabric. This model is solid until it remains an abstract form on paper, disconnected from its performance – as can be the case in the solo part. However the matter becomes more complicated in the case of the tape which – even though it is also essentially a form of writing – also includes a performance component. At the moment of playing, one inevitably has to face the indetermination of the media used, whereby media literally refers to anything that stands between the model and its performance as acoustic phenomenon, which might be the voice performing the musical notation, the composer working on the electronic instrument, or the sound recording, reproduction and diffusion equipment itself. Nono was perfectly aware of this. Ever since the time of *Omaggio a Emilio Vedova*, indeed, he saw the Studio production as an empirical process, where the final form does not consist in an *a priori*, but is created *in progress*, through an instinctive process guided by the suggestion of the material and by the instruments used. For these purposes a suitable choice is that of the actual audio materials which make up the tape of *La fabbrica illuminata*: improvisations by Carla Henius, recordings of the chorus, not

13 Kept by the Luigi Nono Archive.

devoid of execution errors, and recording of noises from a factory, aleatory material by definition; all of this is first de-structured then brought to a high degree of processing. An even more significant testament to such deviation from the models is the variability of the live performance, both for the tape and for the solo part, confirmed by the author himself and reaffirmed on several occasions by the performers' statements (see Cossettini 2010, 231-259).

In an interview with Sigrid Neef Nono says:

> Un nastro di musica elettronica, quando viene prodotto, non è affatto stabilito definitivamente. Ci sono compositori che sostengono questa idea. Per me è diverso. La dinamica e il carattere della mia musica, anche di quella elettronica, dipendono dalle condizioni date della sua esecuzione, dalle reazioni dell'ascoltatore e degli interpreti, e io stesso devo poter reagire a questo. Con diverse orchestre, a seconda delle diverse condizioni, regolo il nastro elettronico in modo diverso. Sono contro l'industrializzazione della musica promossa dall'editoria e dalle nuove tecniche di incisione del suono. Io stesso mi oriento alla prassi di Bach, Haydn o Mozart. Spesso loro hanno scritto da una domenica all'altra una cantata, una sinfonia o un concerto e non hanno pensato che questo lavoro dovesse rimanere per l'eternità. Questa idea di riproducibilità fu sostenuta solo con l'affermarsi dell'editoria e con le nuove tecniche d'incisione. Quando con *La fabbrica illuminata* utilizzai musica elettronica non mi interessava affatto pensare quanto spesso avrei eseguito il lavoro. Poi l'ho eseguito spesso, ma è stato sempre qualcosa di diverso, a seconda che fosse di fronte agli operai nella sede dell'Unità o nelle sale delle fabbriche, o in una sala da concerto, o a Cuba, in Francia, nella RDT... (Nono 2001B, 189-190).

This dynamism in the performance act has translated into a great mobility of the texts, in painstaking review and adjustment work on the score which followed its original draft. This work was never finally completed: as a matter of fact there are many inconsistencies remaining also in the printed edition.

From non-autograph to autograph: the variants by Carla Henius approved by Nono

The inconsistencies between tape and score inevitably cause, and have always caused, serious problems when studying the part. The Nono/Henius correspondence shows the difficulties encountered by the singer in correctly interpreting the relationships between manuscript score and the tape copy sent to her by the author to prepare the concert. Indeed Carla Henius herself, during this study phase, introduced the first variants to the score. Recent restoration work on the Basel manuscript revealed a text layer previously covered with strips of paper glued by the author to introduce corrections to the solo part; in this way some notes by Nono and the singer have become legible which reveal the stepwise definition of the solo part. It is interesting to note that this original draft was much more formally consistent than the following drafts: one review after the other, the original composition model – which was still intact here – gradually started to come apart, until it was completely lost in the final draft.

Such a development in the text is hardly explainable with formal or stylistic reasons; the mischievous doubt, also encouraged by listening to the tape, that Carla Henius, being a mezzo-soprano, tried to 'lower the notes' to compensate for a physical limitation in her voice, seems mostly unfounded; in actual fact also some notes in a medium register are moved, others are even made higher. Then why does this text evolve, change, sometimes even undermining the formal structure of the work?

An approach based on the relationships between musical text and recorded sound fabric from a diachronic perspective could provide fascinating input into understanding this development. Independent errors are introduced in the creation and tradition of manuscripts and audio documents; these create displacements between musical text and sound fabric which affect the consistency of the model on which the composition is based. It is extremely likely that the variants introduced in the musical text are an attempt by the author to stop this entropy, in order to keep the formal relationships between the two dimensions unaltered.

A very eloquent example of this can be found in the development of references to the tape in the section called *Giro del letto*, from 7'03" onwards.

The score published in 1967, at this point, includes a minor second interval between the tape, *B*♮, and the solo voice, *B*♭ (Figure 1). In the sound fabric on tape Q6, however, at this point there is no natural *B*, but rather a voice note with a vibrato between *G*♯ and *A*.

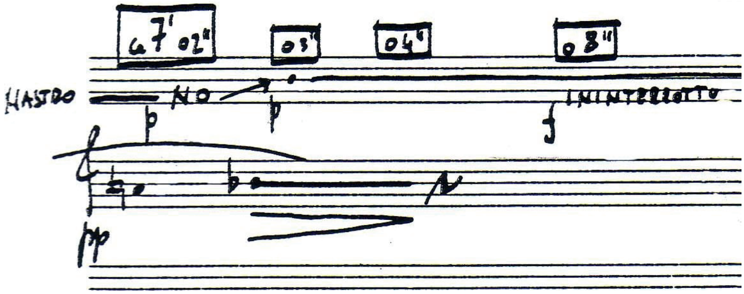

Figure 1. Reference to the tape at 7'03". Nono 1967.

The genesis of this mistake becomes clearer if the documents are analyzed backwards, to include the annotations covered in the Basel manuscript. In the first autographic draft at this point a unison meeting was expected between voice and tape on *G*♯ (Figures 2 and 3).

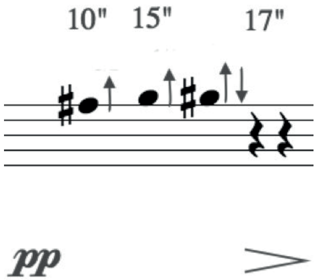

Figure 2. Basel manuscript: draft covered by a glued strip of paper (transcript).

In the original draft, near the final note on the short chromatic scale, Carla Henuis wrote «B» (*B*♭ in german). This reference is accepted by Nono, who transposed the passage by one augmented sixth downwards. This correction, probably aimed at making the text clearer, was then rewritten on a separate sheet, subsequently glued onto the previous drafts. The two references to the tape visible in Figure 3, as can be gathered from the different tonality of the inks on the original manuscript, were added at a later stage. To the original reference (*G*♯), perfectly consistent with tape Q6, a second one is added to *B*♭, taking the flat from the «o» in «fermano», a text sung by the voice recorded on tape. In other words, to meet a requirement from the performer, Nono loses sight of the relationships between score and tape, introducing a clear error.

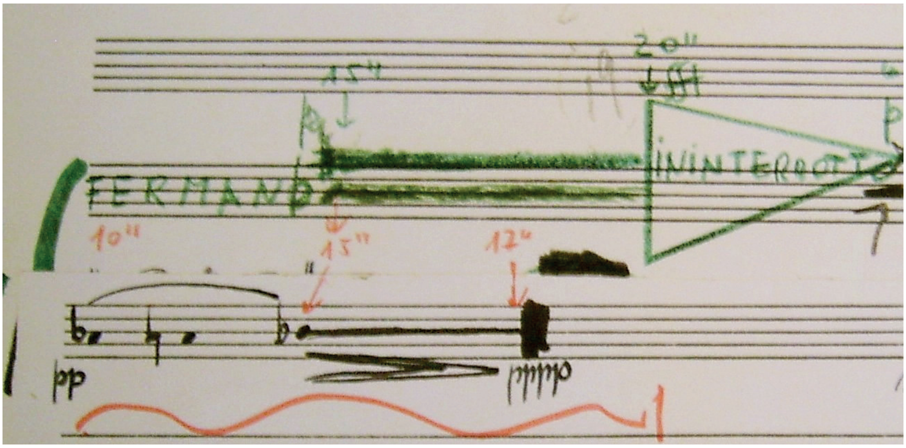

Figure 3. Basel manuscript: final draft. Picture taken from the photocopy kept at the Luigi Nono Archive in Venice.

When he edited the draft for printing, the author referred to the timings from tape RAI Q6 or from a copy of his, without apparent errors in speed. It is highly likely, listening to the original sound fabric, that Nono realized the inconsistency and decided not to note down in the published manuscript any meeting between tape and voice; there is a strange *B*♮ – probably not considering the 'emergency' flat note – and all other references are deleted (Figure 3). This means that any chance of reconstructing the original dialogue is lost.

The subsequent reference shows a similar development. The first draft included a unison between voice and tape on the note *A* found on track 2, as can be seen from the original reference in the Basel manuscript (Figures 4 and 5).

Figure 4. Basel manuscript: draft covered by a strip of paper (transcript).

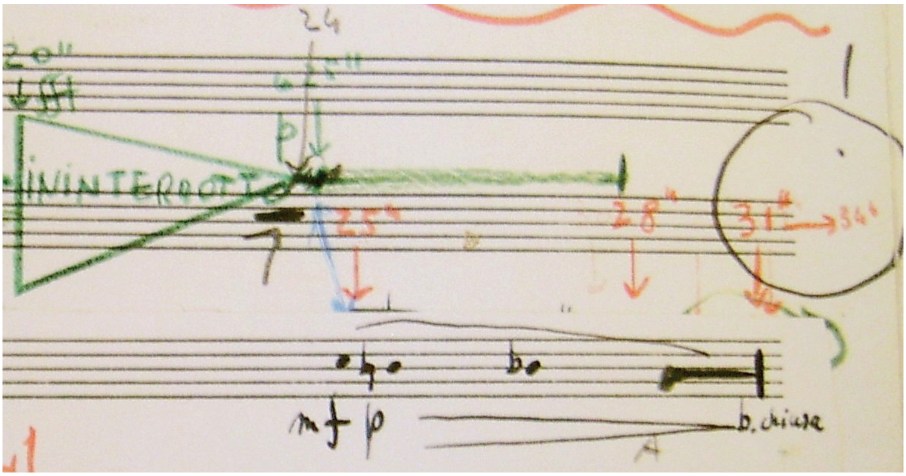

Figure 5. Basel manuscript: final draft. Picture taken from the photocopy kept at the Luigi Nono Archive in Venice.

Carla Henius later on wrote *C*. Nono approved this change as well, wrote a reference to *C* (black line, Figure 5) and transposed the notes in this passage downwards. As this point no reference was transcribed in the 1967 draft (Figure 6).

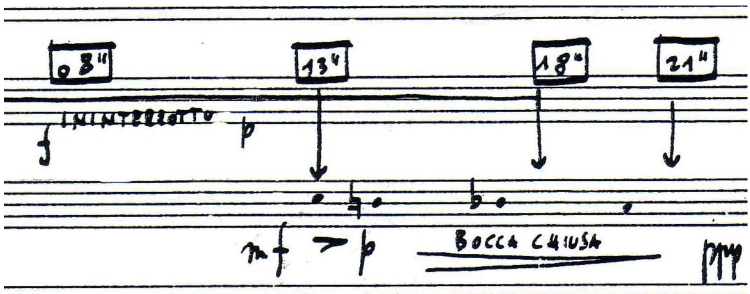

Figure 6. Reference to the tape at 7'10". Nono 1967.

The original structure of the whole phrase is fairly clear: the solo voice, with a chromatic scale, 'carries' the sound to the tape; the latter processes it and 'returns' it to the voice which – also with a chromatic scale – closes the musical phrase. This structure is completely lost in the manuscript for printing: the unisons between the dimensions which fused live voice and recorded voice become dissonant.

But where do the sounds that were heard and noted by Henius and which have caused so many problems come from?

If we study the development of the musical text in the problematic points, it becomes clear that almost all references are sharpened by one semitone, or little more,[14] and then, eventually, transposed by an octave. In the first case the notes were transposed by little more than one semitone; in the second case, conversely, by one minor third compared to the original reference on track 2, but by one semitone from the *B*♮ on track 4. The singer studied her part from copies of the original tape sent by Nono himself.[15] It is possible to explain this transposition of references assuming that Henius listened to the tape at a speed which was about 3-4% higher, sufficient to impose onto the recorded sounds a frequency shift which leads us to categorize them one semitone higher. The mono- or stereophonic mixdown,[16] moreover, merges

14 The sounds to which reference is made are almost always of vocal origin, often with a very wide vibrato; the intonation is therefore strongly fluctuating.

15 See Nono/Henius correspondence in Henius 1995.

16 It is unlikely that Henius had a quadraphonic reproduction and diffusion system available which allowed for playing 1-inch tapes with four tracks – at the time that was actually the only quadraphonic format in use at the Studio di Fonologia Musicale.

on the frontal plane the four sound sources which, with quadraphonic listening, are distributed around the hall. This could have led, in the second instance, to confusing the tracks and taking as reference track 4 instead of track 2.

The presence at Studio di Fonologia Musicale of equipment which was not properly calibrated, causing the tape to run slightly slower, a mixdown of the original tape (kept at the Luigi Nono Archive)[17] at a speed which is almost 1% higher, the tolerance by ±2% in the running speed on tape recorders for domestic use and – last but not least – the single direction of the transposition are all elements in support of the theory of listening at the wrong speed. Moreover it is unlikely that, in 1964 for a composition which was still strongly affected by serial influences, Nono would deliberately de-structure the piece adding dissonances where meetings in unison were intended. It seems more logical to conclude that, due to some serious discrepancies between the references noted and the sounds heard, to save the dialogue between the two dimensions, the author might have decided to change the score. The latter, which can be subject to interpretations and revisions, is changed according to the sound fabric.

'AUTHORIAL' ERRORS

Problems, however, arise not only in respect of the text traditions. Exactly because of the heterogeneity of composition strategies used by Nono, a set of inconsistencies between tape and solo part started to appear right from the origin of the work, and are already in the first drafts of the score and sound fabric.

The beginning of the *Finale* section, for example, includes an augmented octave interval between the recorded chorus on tape, *F♯*, and the live voice, *F* (Figure 7).[18]

17 See tape ALN 101 for example.

18 The composer's sketches, as well as the draft covered in the Basel manuscript, include a minor second interval. The latter was immediately transposed one octave downwards, which is how it has remained until the printed edition.

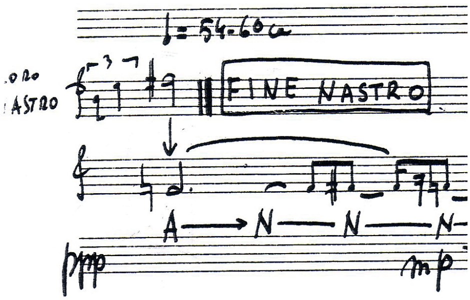

Figure 7. Beginning of the Finale *section: reference to the tape. Nono 1967.*

In the recording, however, the chorus sings all the passage transposed by one semitone downwards; the final note thus becomes a *F*. Intoning the melody as it is written, the solo voice would therefore be on the perfect octave in respect of the electronic part. Such a consonant interval would, however, be totally removed from the composer's intention who expected a strong dissonant clash here. A reference to *F*♯ is already in the composer's sketches with regard to the tape montage and, in the absence of preparatory audio materials, it is impossible to say exactly when this transposition was introduced.

One way to correct the error could be to change the recording, making sure that the intonation of recorded sounds matches the one noted on the score. However, a local correction intervention must be ruled out for several reasons: first of all the 'wrong' note is only one of the voices in a chorus, which means that it cannot be processed separately; it is also impossible to objectively choose where to start transposing – for example, should one limit oneself to the three notes on the score, or should the whole chorus part be changed? There are then difficulties, often unsurmountable, associated with segmenting the *continuum* of the sound fabric; finally, it is very likely that processing of the audio locally would lead to discernible artifacts. As a consequence, the approach which necessarily needs to be considered is regenerating the tape.[19] Here again, though, unsurmountable obstacles arise: the sound fabric is a result of the editing and processing of preparatory

19 For a regenerative approach see for example "The regeneration of the electronic part of *Jour, Contre-jour* by Gérard Grisey", in this book.

audio materials; almost all of them are now lost and, moreover, the composer's notes are insufficient to reconstruct the electronic and physical processing which led to the final editing phase. On the other hand, serious and well-founded doubts could arise as to the appropriateness of this operation: considering the tape wrong based on its description – and not prescription – in the score and, following this assumption, correct it, creating a sound fabric which never really existed. The solution therefore needs to be integrated with the interpretation: the singer needs to choose whether to respect the interval or the notated pitches. The clash could indeed be re-established if the singer intoned the passage one semitone lower. This solution seems sufficiently logical: the vocal dimension, in the continuous renewal of the interpretation act, may compensate any inconsistencies between written text and recorded sound fabric. It appears that Nono himself advised singers to listen to the chorus and intone the interval indicated on the score (see Cossettini 2010, 232).

If, however, the first note is intoned one semitone lower, the structure of the passage makes it necessary to transpose by one semitone lower also the rest of the melody, until the end of the piece. The succession of notes, indeed, is generated by a 'Latin square', found in the composer's sketches (Figure 8).

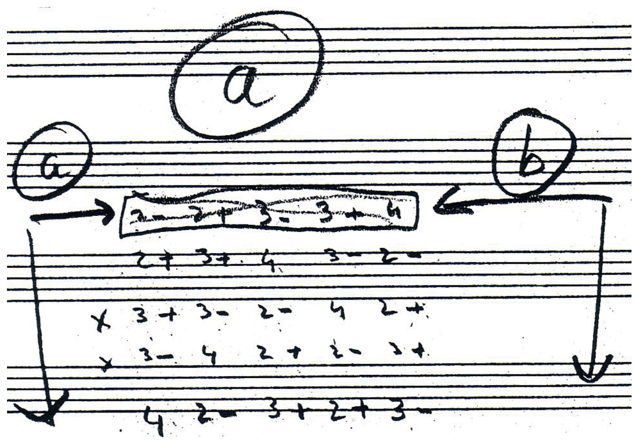

Figure 8. The 'Latin square' which generates the final melody. Picture taken from the sketches kept at the Luigi Nono Archive in Venice.

From the translations and permutations of this interval series, Nono created one long melody (Figure 9) from which he then extracted the notes which, combined with the text by Pavese, constitute the *Finale* of the work. Each note was thus related to the previous and subsequent one by a precise interval which cannot be changed. This composition strategy itself suggests that more importance should be given to interval relationships, rather than to the pitches of the notes: the *F*♯ on the tape is only the starting point which Nono chose to transform a succession of intervals into notes with a specific pitch. This is obviously not a mechanical choice dictated by the text: it is merely a solution based on formal elements. It is up to the performer's sensitivity to choose the interpretative solution.

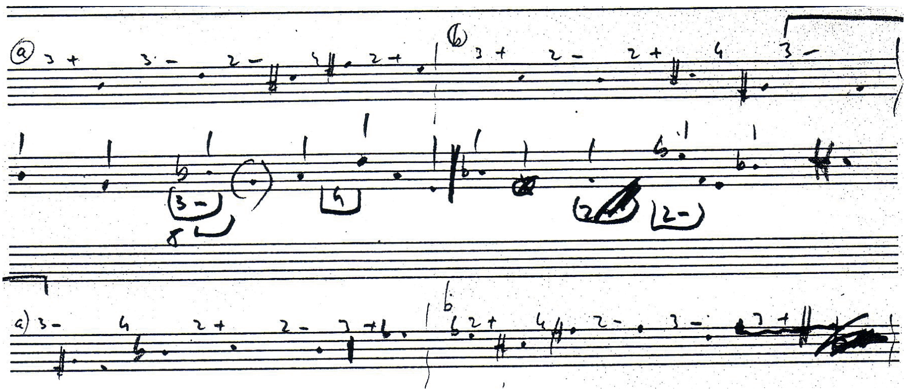

Figure 9. Development of the 'Latin square' from which the final melody will then be extracted. Picture taken from the sketches kept a the Luigi Nono Archive in Venice.

VARIANTS ON THE TAPE

Also the electronic part has been subject to an adjustment process, which was completed almost immediately with the acceptance of Q6 as document of its final form.[20] Also in this case, variants in the sound fabric are reflected in as many variants in the musical text.

In a letter to Henius, written on 6 January 1965, Nono wrote «Tonband von Paris sollte noch die alte ohne die Striche in Venedig gemacht» (Henius 1995, 51). The Luigi Nono Archive includes a tape with a mixdown of the electronic part alone, made before some definition work on the sound fabric was completed directly on Q6, and confirmed by the physical splicing. In one of these points, for example, the duration of the solo voice parts has been reduced by physically shortening the tape thus eliminating a sound fabric section. Even though in the Basel manuscript no clear correction work was done with regard to timing references to the tape in the musical text, at this point the correction – and the reduction – of a rest is clearly noticeable. Also highly significant is a quarter note rest added with a pen by Henius who, most likely, studied the dialogue on a tape created before the author added this variant to the sound fabric.[21]

PRAXIS AND WRITING

The examples examined above show that the movement of the text and the variants introduced by the author are a result of a retroactive process, triggered by the need to search for a balance in a system consisting of two subsystems: the magnetic tape and the score. This 'homeostatic' process was consolidated over time, and – in order to achieve it – Nono had to sacrifice some structural elements from which he had started.

20 This is clearly confirmed by the fact that on Q7 and E28, created during the first months of 1965, an electronic part is memorized which is identical to the one on Q6.

21 For details see "From the archive to the event", in this book.

The solution to the inconsistencies which arose needs to be searched for outside the texts, in the performance practice which, as always, is based on oral tradition, on the teacher-apprentice relationship. Nono, in actual fact, was in the habit of personally supervising each individual performance. He worked with the performers on the definition of the part based on the expressive potential of the individual voices, and he was in charge of sound direction. While preparing the concerts the author himself gave instructions which compensated for any textual issues. A small part of these instructions are available from the texts in the form of variants; most of them, however, was never set on paper; the 'non-written' component also includes sound direction instructions.

The fact that no important elements were set, as regards both the performance and also the text, creates serious interpretation difficulties today because, unfortunately, singers can no longer refer to the author for advice. In order to preserve the *nuances* of an execution practice which cannot be framed within classical stylemes, it is important not to interrupt the extra-textual tradition which – through the performers who worked alongside Nono – refers back to the author himself. As regards the texts, on the other hand, the only instrument for a well-founded interpretation of problematic points is the study of authorial variants: only by understanding how errors arise and develop it is possible to give back important details as to how the work was written; the latter may help suggest convincing interpretation approaches, or at least set the 'boundaries' within which one is being true to the text.

The problems encountered with this score are a clear indication of the difficulties, which were never totally overcome, for traditional notation in inventing *ex novo* a form of writing which could convey in an accurate way the dialogue between magnetic tape and live instruments, without necessarily sacrificing one dimension or the other. Already Liliana Poli, when she made a copy of the score for herself[22] transcribed very few references to the tape and never the chronometric division. This is because the sound fabric

22 Liliana Poli Private Archive.

was memorized to concentrate on the musical detail.[23] Nono himself, in the printed edition, being aware that the publication of the score would inevitably distance the performer from the author, made the writing of the solo part explicit; at the same time, however, since he could not be sure about the conditions of each individual performance, he simplified the writing of references to the tape, thus leaving the performer enough freedom – possibly too much? – to find on each occasion *ad hoc* solutions for the problems which would inevitably arise.[24]

The painstaking work done by Nono on the performing practice to the detriment of the text is already a sign of his mistrust with regard to traditional writing which led the author not to write complete scores for his subsequent electronic work (suffice it to mention as an example *A floresta è jovem e cheja de vida, Musica Manifesto N. 1, Y entonces comprendió*),[25] or to radically change the relationship between the two dimensions (as, for instance, in *Al gran sole carico d'amore*).[26] Entrusting more and more details to the memory of performers, Nono already consciously and voluntarily paved the way for oblivion of his music. However, in spite of the author's expectation, his music is still played and appreciated today. Now that new performers are approaching it, a careful review of the sources is even more important, in order to establish a solid foundation for understanding texts and sound fabrics and the creation process underlying each composition: in this way their performance will give back once again the interpretation richness and variety typical of the author-performer collaboration process which has resulted in most of Nono's music and has become apparent today after analyzing its variants.

23 The memorizing of the sound content on tape would deserve a separate analysis regarding the importance of the auratic moment, typical of a technology which Walter Ong defined as second orality (see Ong 1967).

24 It is not by chance that Nono, in the published score, adds to several synchronic indications the word «circa»: the precise chronometric division of times is actually not as important as the dialectic relationship tape/voice, which also includes normal oscillations in musical phrasing.

25 See "The critical edition of the electronic part of *Y entonces comprendió* by Luigi Nono", in this book.

26 See "Al *gran sole carico d'amore* thirty years on", in this book.

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S2: Basel, Paul Sacher Stiftung, Sammlung Paul Sacher, 1964. Autograph manuscript with annotations by Carla Henius, 5 bifolios of music paper, 14 August 1964. Privately owned by Henius until it was sold to the Paul Sacher Foundation in Basel in 1994.

S3: Venice, ALN 27.17.02/01-15, 196[5?]. Photocopy of S3 with autograph annotations, 16 unbound sheets on which Nono intervened in different moments.

S4: Milan, Biblioteca Nazionale Braidense, Archivio Storico Ricordi, 1967. Autograph manuscript, 5 bifolios of music paper with a smaller page glued to the verso of the title page. Consigned for publication in fulfillment of the composer's contract with Ricordi (signed 1 January 1967).

S5: Scandicci, private collection Liliana Poli, 196[5?]. Manuscript copy of S3 transcribed by Liliana Poli with annotations by Nono, 5 pages.

S6: Freiburg, private collection Susanne Otto, 198[9?]. Copy of S1 modified by Susanne Otto in accordance with the composer's instructions, 9 pages.

S7: Venice, ALN 27.17.01/01-15, [s.a.]. Color photocopy of the final version in S2. 15 unbound unnumbered pages of various sizes. Donated to the Luigi Nono Archive by Carla Henius.

S8: Villars-le-Grand, private collection André Richard, [s. d.]. Color photocopy of the final version in S2. 8 unbound unnumbered pages of various sizes. Donated to André Richard by Carla Henius.

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R3: Milan, RAI E28, 196[5?]. Magnetic tape, ¼", 15 ips, full track, monophonic.

R4: Milan, Ricordi 214, 196[7?]. Magnetic tape, 1", 15 ips, 4-track, quadraphonic.

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Al gran sole carico d'amore thirty years on

For a restaging of Luigi Nono's musical theater

Luca Cossettini

Al gran sole carico d'amore (azione scenica in due tempi per soli, piccolo e grande coro, orchestra e nastro magnetico) is an emblematic example of Luigi Nono's musical theater in the 1970s. The preliminary work for the new staging of the *azione scenica* at the Salzburg Festival[1] in August 2009 indeed raised wide-ranging interpretation issues as to the possibility itself of restaging this production today without its composer. As is well known, most of Nono's compositions are a result of the direct collaboration with their performers.[2] The musical theater has always been a vantage point for this active involvement which – in Nono's case – is reflected in the sources being essentially incomplete and ever-changing.

The political-historical attitude adopted by Nono when composing *Al gran sole carico d'amore* follows from an approach which is already clearly stated by the composer himself in a famous interview with Leonardo Pinzauti in 1970 regarding the incompleteness of sources in *Y entonces comprendió* and the future restaging of his work. To the question:

> Fra trenta o quarant'anni gli esecutori troveranno delle indicazioni sufficienti – un progetto, un grafico – per poter eseguire nel modo più ortodosso queste variazioni dei nastri magnetici della sua composizione?

1 The work was staged from 2 to 14 August 2009 at the Salzburger Festspiele after a critical review of the sources and audio restoration on behalf of Casa Ricordi completed by the team of the MIRAGE Lab at the University of Udine (Nono 2009). Conductor: Ingo Metzmacher, stage director: Katie Mitchell, sound direction: André Richard. See *Luigi Nono. Al gran sole carico d'amore. Salzburger Festspiele* 2009.

2 See "The critical edition of the electronic part of *Y entonces comprendió* by Luigi Nono" and "*Y entonces comprendió* by Luigi Nono: spatialization of sound and theatrical practice" in this book.

Nono answered:

> Ma fra trenta o quarant'anni ci sarà altra musica. Io lavoro per oggi, nei problemi di oggi: non penso mai alla musica del futuro, che credo sia un concetto ottocentesco, di quando si scoprì la 'storia' della musica. Questo della musica del futuro è un concetto che lascio volentieri ai visionari musicisti tedeschi; allo stesso modo credo che il continuo ritorno al passato, impostoci dal consumismo di oggi e dall'industria culturale, sia una sorta di bloccaggio per tentar di farci perdere il senso dei problemi della nostra epoca (Nono 2001b, 85-86).

The idea of 'musical repertoire' seems not to interest the composer; he rather considers artistic creation as a social act, always merging with the issues of daily life and political and human reality which brings it to life on each occasion. With *Al gran sole carico d'amore*, Nono fully expresses his concept of music as being part of 'the present day'. In what he calls 'azione scenica' (stage action) the narrative flow which characterized his earlier theater production, e.g. *Intolleranza '60*, is completely abandoned; instead the staging consists of a set of scenes which represent issues from civil and political life, voluntarily reviewed from a perspective which was topical at the time (for example the oppression of workers), alongside historiography and civil conscience questions. The protagonists are 'forgotten' women, whose life was actively connected to the birth and development of communism worldwide.[3] We therefore find here the Commune of Paris, with Louise Michel, the Cuban revolution and guerrilla in Bolivia, with Tania Bunke, the Russian revolution, with 'the mother', inspired by Maksim Gorkij, and working-class Turin as described by Cesare Pavese and personified by the prostitute Deola. Spanning one century, Nono thus connected the past to the historical moment when the work was composed and history to current affairs.

A musical theater work, regarded by Nono as 'stage action', can thus be faithfully performed only with the collective involvement of all those who play an active role in its production. The task of the composer is to draw up an outline; it is only during rehearsals that the texts are then performed as Work, thanks to continuous fine-tuning of the artistic features of individual

3 For a description of the work's narrative structure please refer to Stenzl 1987.

performers and in agreement with the conductor, stage director, choreographer etc. It is this lively and ever-changing historical involvement which every time renews and re-actualizes the aesthetic and political message of the composition.

In an interview with Sigrid Neef of 1974, the year before the premiere in Milan, Nono clearly explains how this creative work tales place and how this is reflected in the sources:

> [S.N.] *Tu hai dunque un materiale che deve essere fissato. Affidi questo materiale a un determinato collettivo di allestitori, che elabora il lavoro teatrale definitivo. Anche il tuo lavoro raggiunge quindi la sua conformazione definitiva solo attraverso l'accordo di determinati artisti in un tempo determinato. Puoi immaginare che altri artisti vogliano ripetere in una circostanza successiva questo processo creativo? Oppure, quando Ljubimov, Abbado, Borovskij, Jacobson avranno percorso una volta questo processo, ne deriverà una fissazione relativa anche della tua opera? Come potrà essere?*
>
> [L.N.] Questo è un problema. Per esempio, in partitura, per quanto riguarda la drammaturgia, ho segnato solo brevi indicazioni e assolutamente nessuna descrizione precisa del contenuto, che di solito è presente. Credo che potremmo o stabilire insieme in modo preciso (dopo la prima a Milano) la drammaturgia e il contenuto in modo che poi il lavoro rimanga così, o lasciare tutto completamente aperto, cosicché altri in seguito possano fare in modo molto diverso. Per quanto riguarda le indicazioni in partitura, sembra in ogni caso logico che la definizione venga da tutti noi. Di qui sorge naturalmente un problema. Ai successivi allestimenti toccherebbe soltanto più un processo di ricostruzione (Nono 2001b, 198).

RESTAGING THE WORK

The difficulties encountered in restaging work such as *Al gran sole carico d'amore* are thus twofold: alongside the issue of re-actualizing the political message there is also the question of interpreting the sources (scores and magnetic tapes).

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-edited', 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 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.

Bearing witness to the work done by Nono on *Al gran sole carico d'amore* today we have:[4]

- Two scores, of which the most recent and published refers to the 1978 version, the other – reprinted on purpose by Casa Ricordi for the preliminary study before the staging in Salzburg – contains traces of the first version and of the revision work which would then lead to the second;
- two different and authoritative versions of the tapes, one from the Archive of the RAI Studio di Fonologia Musicale in Milan and one from Ricordi Archive in Milan;
- a video of the 1978 staging;
- a set of preparatory materials from the Luigi Nono Archive in Venice;
- diagrams for sound diffusion in the hall, kept in the Archive of the Studio di Fonologia Musicale;
- copies of the electronic materials from various archives (Luigi Nono Archive, Ricordi Archive, Archive of the Studio di Fonologia Musicale);
- recordings of concerts.

4 See *Sources*, p. 366.

All these materials show some macroscopic variants, both as regards their musical text and their sound fabric, due to the stratification of the various revisions. The greatest difficulty, however, is due to the fact that the instructions in the two published scores as to which electronic parts should be used, their duration and at which point in the work their reproduction should be started are totally insufficient; furthermore, there is no indication regarding sound direction. More than thirty years after the first staging, it is fair to say that the interpretation tradition has been interrupted. This *impasse* is clearly apparent in a recorded edition issued by Teldec of a 1999 performance in Stuttgart, conducted by Lothar Zagrosek, where the electronic component is often almost unrecognizable.[5] More specifically, the reviewing and comparison work of the various audio recordings and reconstruction of synchronous points with the score is so complex that even director Katie Michell, who was in charge of the Salzburg staging in 2009, initially thought of entrusting the electronic part to a trusted sound engineer and have it rewritten from scratch.

At first glance, the most faithful – and easiest – solution would be to refer back to Nono's statement on *Y entonces comprendió* and give up the idea of a restaging. However, despite the difficulties in the sources, today *Al gran sole carico d'amore* is being restaged in prestigious venues: in 2009 alone it was performed both at the Salzburg Festival and at the Opera House in Leipzig, with two different productions. The reasons for such renewed interest are clear: apart from its undeniable musical value, this work has great documentary value because its staging includes a biographical research on female protagonists of communist history. Even though the socio-political framework in which it originated is now absent, it still has great aesthetic-musical value and as historic narration and testimony.

5 See, for instance, the whole *Scena VIII, muro dei comunardi*, track 9 on the Teldec 8573-81059-2 CD. The electronics used here seem to come from minute 1.10 of section ten on the RAI Q31 tape or from section seven on the Ricordi 212 tape, an intervention originally designed for *Scena VI*. The quality of the recording is insufficient for exact measurements and comparisons.

THE 2009 EDITION OF THE SALZBURG FESTIVAL

The critical work on audio and text sources

Due to the complex editorial issues involved, before the staging in 2009 at the Salzburg Festival, Casa Ricordi asked MIRAGE to critically review the sources and to find traces of a tradition which seemed to have been lost. A reconstruction procedure was thus necessary with regard to texts, sound fabrics and their interrelations, similar to what Nono mentioned in the interview with Neef.

Both the audio documents from the Archive of the Studio di Fonologia Musicale and those of Ricordi Archive consist of a series of recorded tape sections separated by leader tapes which – even in this case – constitute the various electronic interventions. The audio materials contained in these main sources are very different one from the other and, without specific instructions on the score, it is not always possible to say with certainty which intervention should be replayed and what are the possible synchronous points with the instrumental part. 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.

In an interview with Neef in 1974, Nono says about the tapes:

> In questo lavoro, soprattutto nella prima parte, sono impiegate molte musiche su nastro. Decideremo la durata di ogni parte di nastro solo durante le prove di scena, in quanto dipenderà dalle necessità di palcoscenico. Ciò significa che io offro a Ljubimov un materiale temporale. Lui lo ascolta e decide che cosa gli serve per la scena. Può prendere da questo materiale temporale due secondi o dieci minuti. [...] L'ultima decisione sulla durata del materiale temporale che ho predisposto viene presa solo durante le prove e collettivamente (Nono 2001B, 191-192).

This is probably the reason why in the score published by Ricordi in 1978 there is no precise trace of the entrances of the electronic parts.

An indispensable aid to define the relationship between electronic and instrumental parts comes from texts and audio documents used by Nono for the 1978 staging. The composer, who was personally in charge of sound direction, actually left a set of notes from which it is possible to determine the synchronous points between the two components: a draft for the score of the second version, kept today at the Luigi Nono Archive in Venice, shows the fine-tuning work as regards entrance indications on the tapes which is not included in the published score; on the tapes from RAI a set of measure instructions – revised several times – is provided directly on the carrier. These notes, although they are specific for the 1978 staging, today serve to show how the dialogue between the orchestra and the electronic part should be interpreted. As can be seen from the video of the re-recording operation[6] on tape RAI Q31, in the leader tape segment which comes before the second electronic part, there is an instruction for synchronization with the orchestra, originally intended on measure 35 of the score which was then moved by the author to measure 42 (Figure 1).

Figure 1. Above: magnetic tape Q31 (R1). Below: published score (S1), measures 34-43. Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy.

6 For the video-recording of the tape flow during the preservative re-recording procedures, please see "From the archive to the event", in this book.

The relationships between tape and orchestral element and their variants become clear only by referring to the performance scores kept in the Luigi Nono Archive. 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 radically manipulated recording of the performance following editing work – 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.[7]

A review of the sources was thus indispensable to provide accurate texts and tapes for the staging. There still remained the issue of re-actualizing the political message. This is where the choices made in terms of direction for the Salzburg edition come into play.

The staging in Salzburg

The director of the Salzburg production, Katie Mitchell, decided to focus on the historical-political value of the work, re-interpreting Nono's stage action as a documentary, with the resources of a multimedia staging which was very innovative at that time (Figures 2 and 3). The projection of a video documentary, filmed (partially) in real time on the stage while the play was in progress, depicts the life of the female protagonists of the work, resulting in a sort of inclusive-exclusive circularity of the theatrical action which, crystallizing in the dimension of the new medium, leaves margins open for a meta-historical interpretation (Figure 5).

7 The tapes from Ricordi Archive, for example, include a recording of some spoken choruses, which were performed live during the 1978 staging.

Figure 2. Al gran sole carico d'amore. *Salzburg 2009. Whole scene with orchestra, choir, actors and projection.*
<http://59productions.co.uk/project/al_gran_sole_carico_damore>

Figure 3. Al gran sole carico d'amore. *Salzburg 2009. Whole scene with orchestra, choir, actors and projection.*
<http://59productions.co.uk/project/al_gran_sole_carico_damore>

Figure 4. Al gran sole carico d'amore. *Salzburg 2009. Live video recording. © Stephen Cummiskey.*

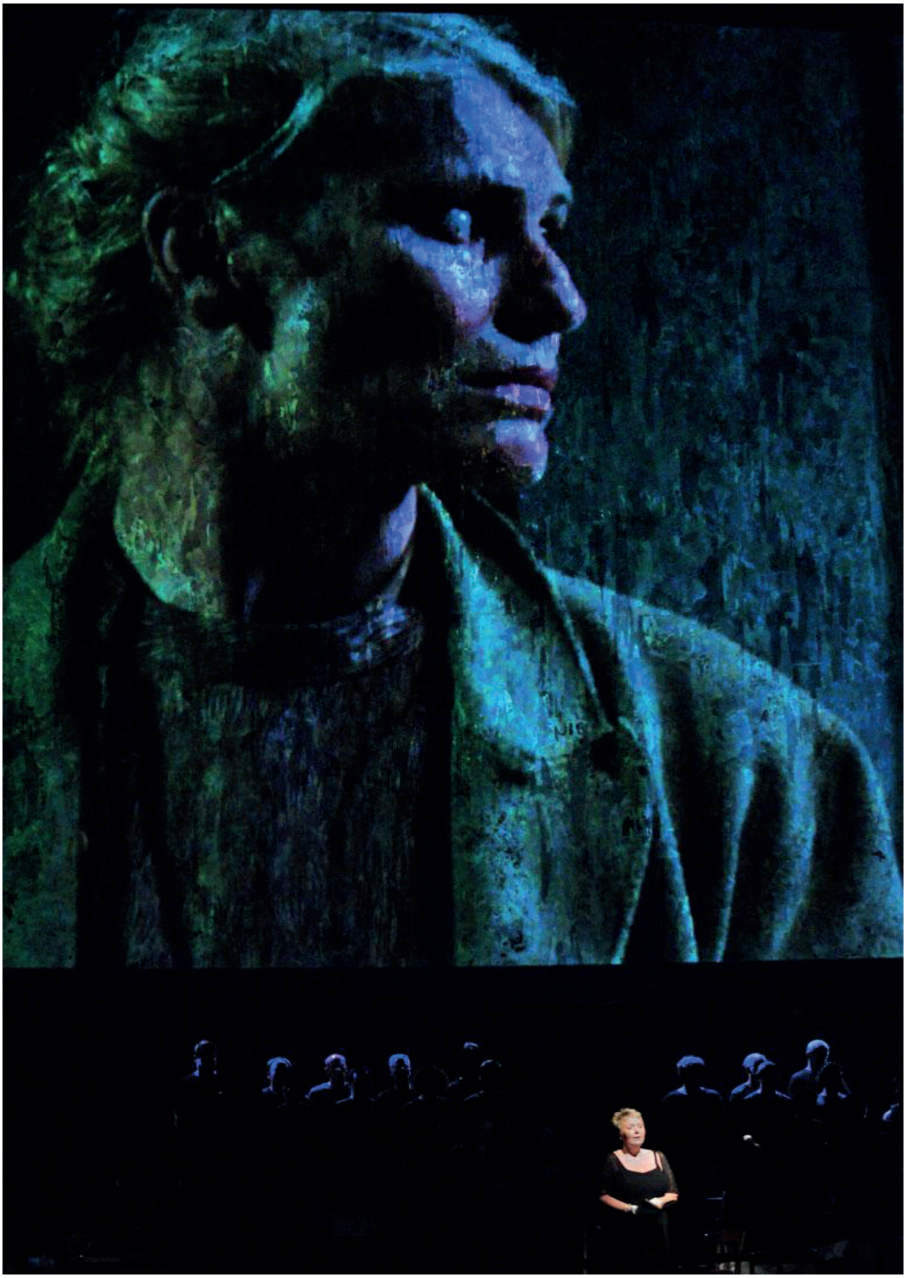

Figure 5. Al gran sole carico d'amore. *Salzburg 2009. Singing and 'mute narrating'. © Stephen Cummiskey.*

The staging by Katie Mitchell was innovative in several respects, not only as regards scenography, see for example the idea of having a woman walk round a museum with remains and documents of the most salient phases in the history of communism, materialized in the objects belonging to the historical figures who are the protagonists of this work. A new character, our contemporary, therefore has the task of re-contextualizing the stage action and updating it as regards its historical-documentary content. It is the visit to this museum that today conveys the images which Nono put into music: the visitor on stage becomes a sort of 'mute narrating voice' whose purpose is to research and recreate the historical distance of events (Figure 5). Such a choice, however, introduces a sort of guiding thread in the narration which is absent in the original playwright's concept, and the video projection further enhances this feeling of being spectators of a documentary film.

The legitimate question arises as to the meaning of this operation, especially if we take into account Nono's approach to musical theatre, expressly reiterated starting from his famous *Appunti per un teatro musicale attuale* in 1961 (Nono 2001a, 86-95). Most notably with regard to *Al gran sole carico d'amore*, in fact, the author openly said the following to Neef in 1974: «nel teatro bisogna usare dialetticamente ogni elemento formativo e non collegarli tra loro in un rapporto causale lineare» (Nono 2001b, 197). The conceptual distance from Nono's reflection and aesthetic approach is clear.

The audio restoration of the concert tape

The distance between Nono's original *Al gran sole carico d'amore* and its 'modernized' staging also affects the issue of restoration and re-mediation of electronic parts: such a hiatus between the original playwright's concept and the restaging is allowed, but what is the margin of action on the audio signal? What is left of the expressive tension, which features so prominently in Nono's work, when the electronic component reaches an audience whose acoustic sensitivity has drastically changed due to the daily immersion in new sound diffusion technologies? Taken to the extreme, these doubts finally confirm that the director's initial idea of redrafting the electronic part from scratch is justified and consistent. However, to avoid such easy shortcuts, disregarding the significance of the work and the author's efforts, the issue of changing medium and sensitivity should be brought to a critical level from a systemic perspective: it is necessary to study the original production system, seen as interaction between composer – Nono –, lab technician – Marino Zuccheri – and technology used – the equipment available at the time in the RAI Studio di Fonologia in Milan (see Caciotti 1950, Burzatta 1986 and Rodà 2009) – then compare and contrast this with the system used today for restoration (new sound processing and diffusion techniques, new theories and sensitivities as regards restoration, etc.). From this dia-systemic perspective,[8] the question is therefore as follows: how to preserve the constraints with the original sound fabric set on tape by Nono, while having to readjust it to the new media? What are the limits of a re-mediation process?

In this case, again, sources criticism clearly shows the limits of re-mediation. It reveals the constraints of the system, those aspects of Nono's electronic composition, his 'sonorities' – if they might be called thus – which are essential for the work's identity and composer's style. In a natural development of both composition and acoustic sensitivity, reviews have brought into the modern day and age a live trace of Nono's stage action which thus paved the way for its re-actualization.

Again in the interview with Neef, Nono also touches on the issue of tape interpretation.

> [S.N.] *È però ugualmente problematico anche nel caso che venga tramandato soltanto il materiale di partenza. Infatti per la prima esecuzione sei tu stesso presente, puoi quindi relativizzare e cambiare molte cose, e prendi parte responsabilmente alla realizzazione del tuo lavoro. Questo verrà a mancare in produzioni successive. Un pericolo accentuato dal fatto che molti credono che la musica fissata su nastro sia una musica che non richiede più l'intervento del compositore o del direttore.*

8 Regarding the application in the area of restoration of the dia-sytemic concept, introduced by Cesare Segre, see Orcalli 2007, Orcalli 2013 and "Towards a systemic approach to the critical editing of music at MIRAGE", in this book.

> [L.N.] Esatto. A questo proposito bisogna osservare una cosa importante che di solito non viene compresa. Riguarda la musica elettronica. Un nastro di musica elettronica, quando viene prodotto, non è affatto stabilito definitivamente. Ci sono compositori che sostengono questa idea. Per me è diverso. La dinamica e il carattere della mia musica, anche di quella elettronica, dipendono dalle condizioni date della sua esecuzione, dalle reazioni dell'ascoltatore e degli interpreti, e io stesso devo poter reagire a questo. Con diverse orchestre, a seconda delle diverse condizioni, regolo il nastro elettronico in modo diverso. Sono contro l'industrializzazione della musica promossa dall'editoria e dalle nuove tecniche di incisione del suono (Nono 2001B, 193).

In the radically changed media context of the digital age, as a matter of fact, the signal contained on the tape necessarily needs to be transferred onto the carriers used in concert halls today (CD, DVD, audio files, etc.). It then needs to be restored and adjusted to the change in medium and sensitivity: the clicks, excessive noise, impulsive disturbances at low frequencies would actually lead us to hear the presence of the 'magnetic tape' medium very clearly, something which we are no longer used to perceiving, distracting attention from the sound fabric set by Nono.

After the re-recording process and the creation of the preservative copy,the MIRAGE team proceeded to remove or attenuate the audio signal disturbances caused by alterations of the original carriers and malfunctioning of the equipment used for the production process of the sound fabric. Moreover, the signal to noise ratio has been further improved, with a view to producing a version suitable for concert reproduction and performance using modern-day sound reproduction and diffusion systems. Attention was paid to preserving the 'acoustic nuance' of time, which gives the recorded audio its character as historical document; nevertheless a sort of acoustic anachronism was avoided which would clearly be out of place in a re-actualized staging. In actual fact, no interpretation elements were added to the sound fabric associated with personal taste and made possible by current treatment technologies of the audio signal which would have limited the margin of action for the sound director (for example interventions related to dynamic compressions/expansions, new equalization, 'enhancers', artificial reverberations, etc. have been avoided).

The documentary approach chosen by MIRAGE thus focused on the transparency of the new *medium*, even though consideration was given to the technological level of the time during which the original document was created.

Finally, in line with Nono's position, the 'sound' in the electronic part needed to be fine-tuned during theater rehearsals, based on the actual staging conditions. And the same as in Nono's time, also for the Salzburg staging in 2009 it was a case of collective effort: the comparisons with the published scores and sketches kept in the Nono Archive were completed in collaboration with André Richard; having decided which parts should be restored, the work on the recorded audio was then done at MIRAGE by the whole team; during the rehearsals in Salzburg, with the conductor Ingo Metzmacher, decisions were made as to the final details on entrances and durations, and some sections of the electronics parts were edited due to staging requirements or aesthetic-musical choices: more specifically it was necessary to intervene on some electronic parts to synchronize them with the video durations.

CONCLUSIONS

In conclusion, *Al gran sole carico d'amore* can survive today, in a radically changed social and media context, only if it is re-mediated, i.e. re-interpreted and re-contextualized from both a narrative and technological viewpoint. In Salzburg the new media totally absorbed and internalized the historical distance, to transform a stage action into a sort of documentary film; this probably became necessary taking into account the changed taste of the audience and to 'update' Nono's work. It is indeed true that, in the Salzburg staging, the new audiovisual media and the new 'narrator' take on a prominent role between the audience and the stage. By distancing the action, they actually neutralize the original political stance. Nevertheless the possibility of historical awareness raising should not be ruled out. The issues can thus be summed up in a single question, which is probably common to all music written in the past – like *Al gran sole carico d'amore* – «per oggi, nei problemi di oggi»: might the restaging of a production originally designed as active and disruptive expression of a protest act, so closely connected to its socio-political context and which used past history and new media as means for raising awareness in what was then contemporary society, possibly be different in the final analysis?

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SOURCES

Textual sources

S1: Nono, L. (1975), *Al gran sole carico d'amore*, Milan, Ricordi. Reissue 2007 for studying purposes of the draft for the first version of the work.

S2: Nono, L. (1978), *Al gran sole carico d'amore*, Milan, Ricordi. Published score of the second version of the work.

S3: Venice, ALN 40.17.01, score 51, 1975. Copy of an autograph with autograph annotations.

S4: Venice, ALN 40.17.02, score 42, 1975. Copy of an autograph with autograph annotations.

S5: Venice, ALN 40.21.03, score 18, 1975. Copy of an autograph with autograph annotations. Score of *Coro I* from *Da un diario italiano* with many annotation concerning Act 1, Scene 3 of the first version of *Al gran sole carico d'amore*.

S6: Venice, ALN 40.21.06, score 53, 1975. Print + copy of an autograph with autograph annotations. Score of *Ein Gespenst geht um in der Welt* with many annotation concerning Act 2, Scene 5 of the first version of *Al gran sole carico d'amore*.

S7: Venice, ALN 40.23.01, score 38, 1975. Copy of an autograph with annotations by an employer of Ricordi + incomplete autograph score of the first version of *Al gran sole carico d'amore*: Act 1 'Come preludio', Scene 1, Scene 2, a first draft of Scene 3, Scene 4 with few annotations on form and tapes.

S8: Venice, ALN 40.23.02, score 163, 1975. Copy of an autograph with autograph annotations and annotations by an employer of Ricordi + working score of the first version of *Al gran sole carico d'amore*; with projects for Act 1, scene 3 and corrections. On the last sheet: «15-8-74».

S9: Venice, ALN 40.23.03, score 153, 1978. Copy of an autograph + final score of the new version of *Al gran sole carico d'amore*; with a large amount of annotations on the sound direction. Probably this score was used during the first staging of the second version of the work.

S10: Venice, ALN 40.23.03 [sic. duplicated cat. n.], score 81, 1975. Copy of an autograph with annotations by an employer of Ricordi.

S11: Venice, ALN 40.23.04, score 64, 1975. Copy of an autograph with annotations by an employer of Ricordi.

S12: Venice, ALN 40.36, score 148, 1978. Copy of a printed score and of an autograph. Score of the first version of *Al gran sole carico d'amore* with a large amount of corrections and annotations concerning the second version of the work.

S13: Venice, ALN 40.42, score 5, [1986]. Printed score with autograph annotations.

Audio sources

R1: Milan, RAI Q31, 1975 - [1978?]. Magnetic tape, 1", 15 ips, 4-track, quadraphonic. Electronic parts for the first act.

R2: Milan, RAI Q32, 1975 - [1978?]. Magnetic tape, 1", 15 ips, 4-track, quadraphonic. Electronic parts for the second act.

R3: Milan, Ricordi 212, 1975 - [1978?]. Magnetic tape, 1", 15 ips, 4-track, quadraphonic. Electronic parts for the first and the second act.

R4: Milan, Ricordi 213, 1975 - [1978?]. Magnetic tape, 1", 15 ips, 4-track, quadraphonic. Electronic parts for the second act.

CD1: Nono, L. (1999), *Al gran sole carico d'amore (Azione scenica in 2 tempi)*, Hamburg, Teldec, 8573-81059-2.

The regeneration of the electronic part of *Jour, Contre-jour* by Gérard Grisey

Luca Cossettini, Angelo Orcalli

When our laboratory was asked to restore the electronic part of *Jour, Contre-jour* by Gérard Grisey this composition had virtually disappeared from the scenes. As well as specific synchronization defects of the electronic part with the instrumental section, it was certainly also affected by degradation and corruption issues typical of the audio documents Casa Ricordi used to rent out. At first glance, the technical risks inherent in the project proposal by the Publisher appeared to be limited to the usual operations related to recovering analog tapes and installing a re-recording system suitable for transfer to the digital domain; these actions were expected to be followed by work on the audio signal based on a documentary approach. It was our intention to write a report to be licensed with the restored audio tracks: a few pages of information for the benefit of sound directors who would then be in charge of reproducing the music directly during a concert. However, just after we had started working in the laboratory we became aware that the multiple components of the work were so interconnected that they all needed to be retrieved and none deserved to be abandoned. Grisey had completed an extraordinary synthesis whose re-editing required a long and complex path, considering first of all the genesis of this work. Casa Ricordi was informed of this and immediately advanced the necessary travel expenses. Technische Universität in Berlin, GRM-INA in Paris and Paul Sacher Stiftung in Basel were our obligatory stops. Finally, *Jour, Contre-jour* was played again in front of an audience, based on the work of the MIRAGE team, on two prestigious occasions: the Salzburg Festival on 31 July 2014, as part of a series of concerts organized as a tribute to Pierre Boulez (Klangforum Wien, conductor Sylvain Cambreling) and Milano Musica Festival on 4 November 2016 (Ensemble Orchestral Contemporain, conductor Andrea Pestalozza).

Due to the mixed nature of the composition during our work we were faced with two issues: the first, a real hindrance, was associated with the very bad preservation state of the two magnetic tapes owned by the publisher: chemical-physical corruption processes[1] had jeopardized readability and quality of the recorded signal. Support was given by the Elektronisches Studio at Technische Universität in Berlin where Grisey with the sound engineer Folkmar Hein had created the version of the electronic part licensed in 1981.[2] Thanks to the generous collaboration of the Berlin institute, MIRAGE was able to acquire a digital copy of the tapes in their archive to complete the study of the tradition of the electronic part. The review and digitization phases of the audio recording were followed by comparison work, aimed at selecting authorial copies and interpreting the noises. The quality of the audio recorded in the Berlin sources and the authorial nature of the original archive – combined with the presence of enlightening documents as to the origin of the electronic part – were essential factors for the success of our project. A second provider of valuable support was GRM-INA which helped our survey with extremely useful live recordings.

1 More specifically the open reel magnetic tapes preserved by Casa Ricordi (4-track, ½ inch) were severely affected by 'sticky shed syndrome', i.e. chemical decomposition of the 'binder' components which makes it impossible to reproduce the tape because the magnetic coat comes apart, causing a deposit on the tape recorder heads while they are running. It was thus necessary to dry them at controlled temperature (50° for 12 hours) so that the water deposits could evaporate. The procedure was successful on one of the tapes (R4, see *Sources*, p. 386), but unsuccessful on the other (R5), for which no preservative copy could thus be produced. The signal was digitally re-recorded by letting the tape run with the magnetic coat towards the outside, to avoid any friction between the latter and the heads. The signal thus obtained was poor in terms of quality, though sufficient to identify the contents and for a *collatio* with the other sources.

2 Numerous evidences confirm that a first version of the tape was probably produced at the Institut International de Musique Electroacoustique in Bourges. To date, however, it has not been possible to find any audio source with the electronic part alone. Nevertheless there are recordings from two concerts held in Paris at the time (in 1979 and 1980 respectively), kept at the Institut National de l'audiovisuel (INA) in Paris, where this first version of the electronic part is used. Listening to these recordings it become clear that the first version was very similar to the Berlin version: it has the same sound materials and seems to be derived from the same composition model. Unfortunately the overlapping of instrumental parts with electronics makes an analytical comparison impossible.

The second issue pertains to the interpretation of the tape/score relationships. The presence of misalignments in respect of the score made all the 4-track copies available unsuitable for publishing purposes. Pre-existing literature does not help in this regard (see Baillet 2000 and Cohen-Levinas 2004); indeed it has often been misleading from an analytical perspective, as well as offering no relevant clue in respect of the electronic part. It has thus become necessary to review the notes and calculation by Grisey at the Paul Sacher Stiftung in Basel to get a clearer view, recognize the deep structure and the model underlying the whole form of this work.

THE MODEL IS THE MESSAGE

After having completed *Modulations*, part four of the large cycle called *Les Espaces acoustiques*, in 1978 Grisey composed *Sortie vers la lumière du jour*, for electric organ and 14 musicians, followed by *Jour, Contre-jour*, for thirteen musicians, electric organ and 4-track magnetic tape. As confirmed by the author himself, the two compositions share the same underlying inspiration: a reading of the *Book of the Dead* by the ancient Egyptians (see Barguet 1976, Kolpaktchy 1979). The similarity between the two scores thus leads to conclude that the two compositions are the result of the same project. On the other hand, the choice of adding an electronic component recorded on tape, makes *Jour, Contre-jour* a different piece precisely as regards the salient aspect of timbre structuration.

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 1). In *Jour, Contre-jour* 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 magnetic tape.

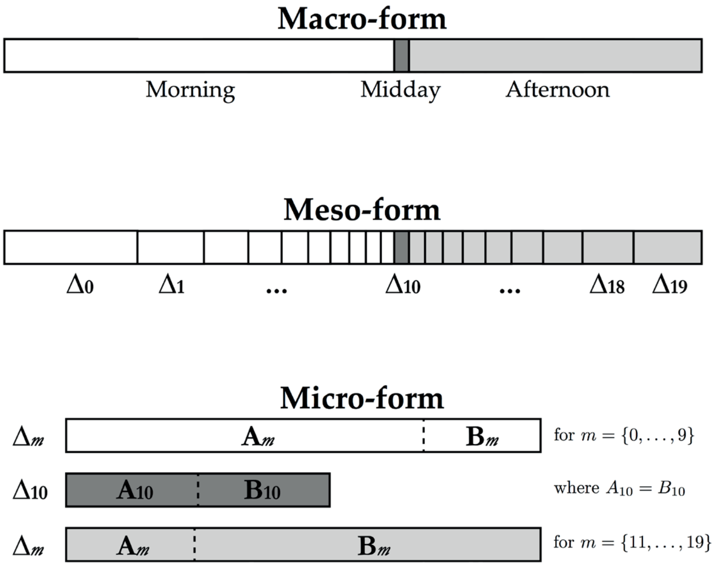

Figure 1. Structure of the work.

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 $x_{m,n}$ for parts A_m and $y_{m,n}$ for parts B_m) are determined by a table of coefficients ($k_{m,n}$ where $m=\{1,\ldots,19\}$, $n=\{1,\ldots,10\}$),[3] preordained by the composer in his sketches (see Table 1). Figure 2 shows the development of the partial sums of the coefficients:

$$F_m(i) = \sum_{n=1}^{i} k_{m,n} \qquad \text{for } i = \{1, \ldots, 10\}$$

The straight line $F_{10}(i) = 2i$ representing section m=10 (midday) is highlighted with dots.

3 The first section ($m = 0$) of the work is dealt with specifically (see Cossettini, Orcalli 2017).

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

Table 1. Coefficients $k_{m,n}$ (first section $m = 0$, $\Delta_0 = 240$ is not present). Re-elaborated version of the sketches. Paul Sacher Stiftung, Basel.

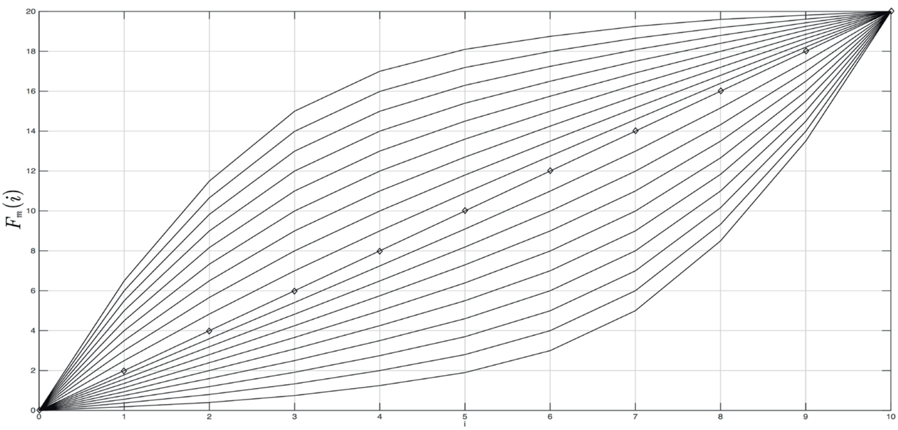

Figure 2. Development of the partial sums of the coefficients.

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

$$x_{16,n} = \frac{A_{16}}{20}\sum_{n=1}^{i} k_{16,i} \qquad \text{for } i = \{1, \ldots, 10\}$$
$$A_{16} = 13$$
$$\mathbf{x}_{16} = [0.49, 1.04, 1.63, 2.28, 2.99, 3.9, 5.2, 7.15, 9.75, 13]$$

In the score, time values are then represented – and approximated – using traditional music notation (Figure 3).

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

$$y_{9,n} = A_9 + \frac{B_9}{20}\sum_{n=1}^{i} k_{9,i} \qquad \text{for } i = \{1, \ldots, 10\}$$
$$A_9 = 12$$
$$B_9 = 12$$
$$\mathbf{y}_9 = [13.07, 14.158, 15.247, 16.346, 17.456, 18.596, 19.796, 21.095, 22.495, 24]$$

The sounds are to a large extent recorded on magnetic tape. For the editing work, Grisey includes the values obtained from the model in a preliminary project for the production of the electronic part (Figure 4).

The analysis of the four-track master copy recorded by Grisey in 1981 at the Technische Universität in Berlin (R2), however, shows some differences compared to theoretical time values (Figure 5). What happened between he definition of the model and its implementation?

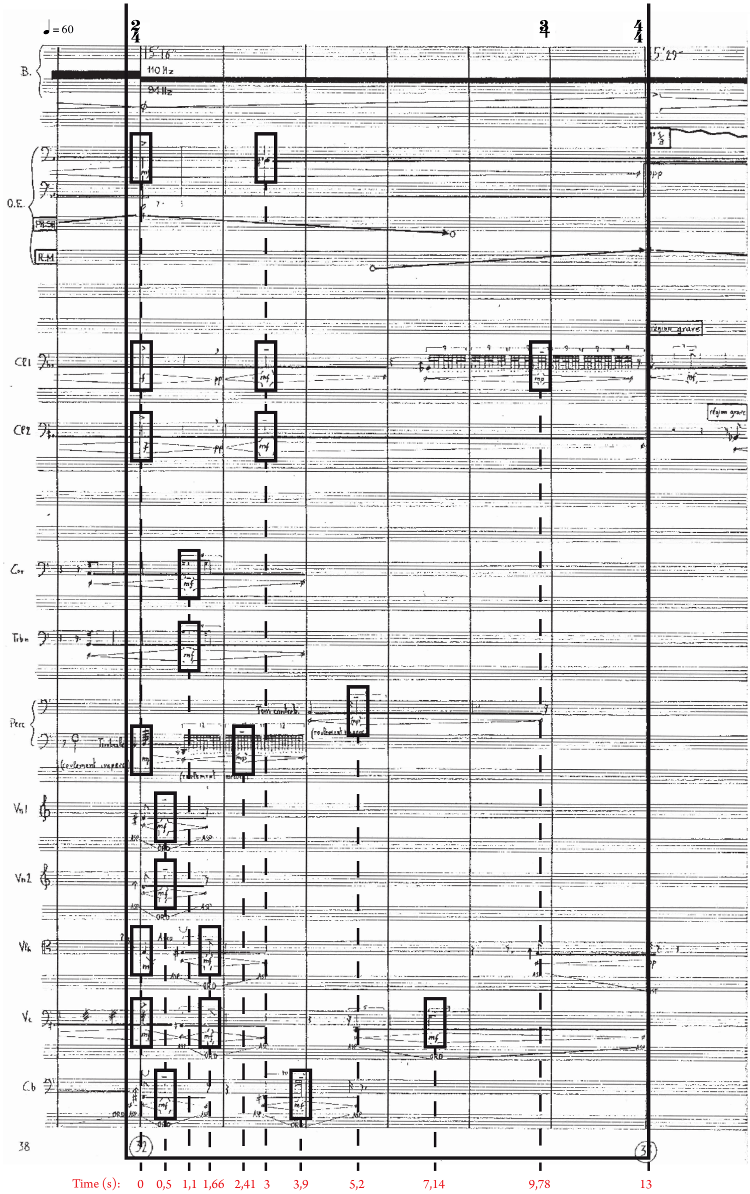

Figure 3. Distribution of intensity peaks in the score (in seconds, red): section 16, number 32, metronome: ♩ = 60. Source: Grisey, G. (1981), Jour, Contre-Jour, *Ricordi, Milan, p. 38. Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy.*

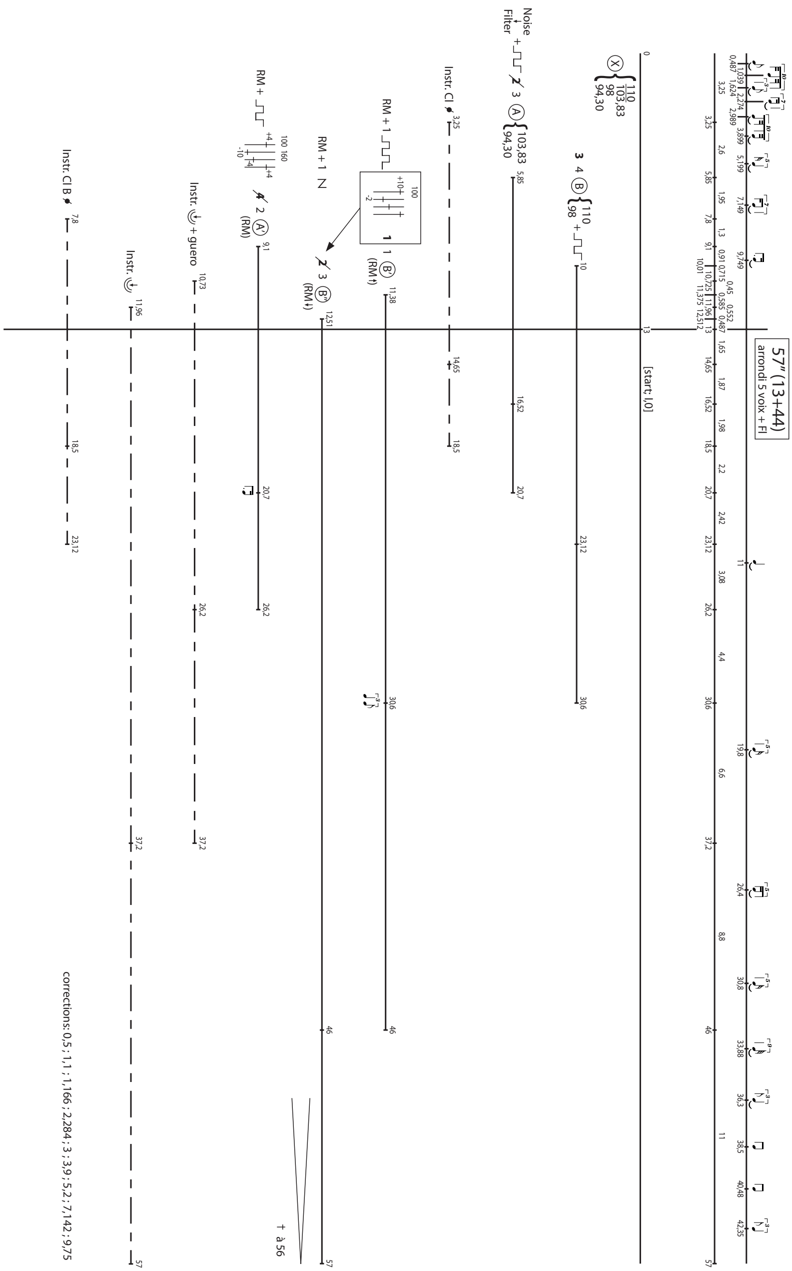

Figure 4. Transcription of the preliminary project for the production of the electronic part (kept at the Paul Sacher Foundation in Basel).

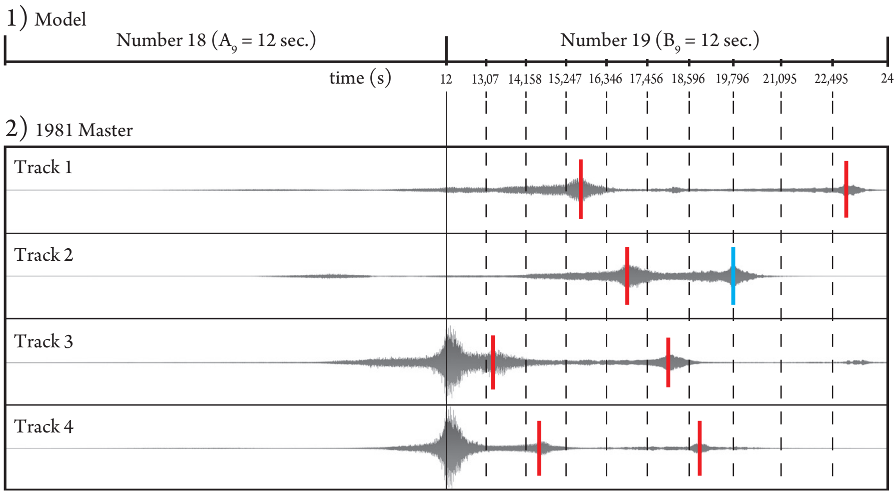

Figure 5. Electronic part: synchronization of events according to the model (section 9, numbers 18-19, duration 24 s.). 1) theoretical distribution of instants (in seconds); 2) master tape realized by Gerard Grisey and Folkmar Hein (Berlin 1981).

THE ELECTRONIC PART

For the restitution of electronic and mixed music it is necessary to have methodological and technical tools available for *recensio* and *collatio* which are able to compare heterogeneous sources (audio, scores, instruction sheets for mixing, programming files), because the relationships between documents constitute the primary information element. A comparison of the witnesses available serves to highlight any invariants in the transmission process. The formal analysis, on the other hand, is focused on the constraints of the compositional model and on their violation.

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 audio sources, but rather they are elements constituting the basic audio materials for the electronic part. Non-linearity of the equipment, noise, performance imprecisions (both instrumental and technological) became 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 8-track tape kept in the archives of the Technische Universität in Berlin which includes a pre-mix of preparatory audio materials (R1). As confirmed by Hein, this was the source used to produce the quadraphonic tape to be used during concerts through mixing and dosing work 'in real time' on the tracks (Figure 6).

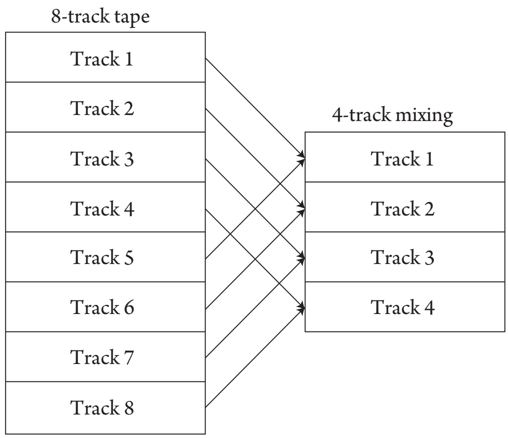

Figure 6. Mixing scheme: from 8-track preliminary tape to 4-tracks master tape.

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 8-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 7).

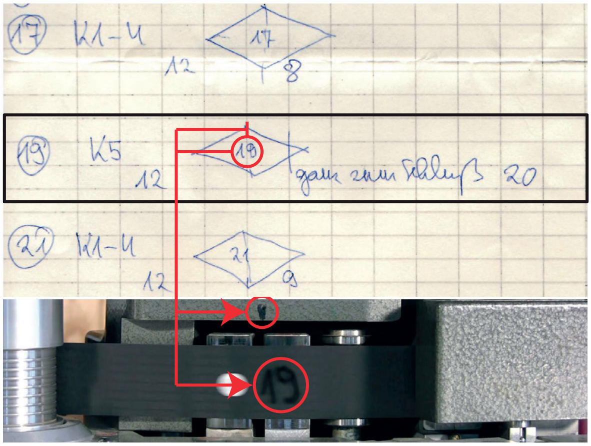

Figure 7. Mixing instruction. 8-track alignment and envelope (section 9, numbers 18-19, duration 12+12 s).

Any numerical value without further indications refers to the *Eckmiller* W85 mixer sliders 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.)[4].

In 1981 the quadraphonic mixdown, delivered to the publisher for performance (R2) 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%,

4 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 slider scale thus corresponds to the absence of attenuation by the amplifier, therefore to an increase by 12 dB.

with an inevitable impact in terms of the duration and pitch of the recorded sounds. Between the composition model and its performance, a distance is created which cannot be reduced, caused by the specific characteristics of the technology used.

The message (or the model) encoded directly in the abstract (algebraic) form had undergone a set of changes during the transmission phase via channels (recordings). The 'noise' in the channels, caused by mechanical tolerances and production defects, have altered the original organization of the message. In this way the 'instantiations' on tape of *Jour Contre-jour* fail to adhere to the general constraints established by the composer. Between the composition model and its performance in studio, a distance is created which cannot be reduced, caused by the specific characteristics of the technology used.[5] Nevertheless, the compositional model sets the invariants that vouch for the identity and recognizability of the work.

The irreversible nature of mixing processes and the poor quality of 4-track audio recordings have made a reconstructive approach using 4-track impossible. It has therefore become necessary to use a new strategy, which we call *regenerative*.

THE REGENERATIVE APPROACH

Referring to Communication Theory, the composition model developed by Grisey can be interpreted as a message produced by a 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 (see Wiener, 1950). In this case, Grisey treats separately a source and two different channels: score and magnetic tape. On the one hand we thus have a notational system, and on the other an analog sound recording system. Figure 8 shows the two

5 The study of the relationship between composition model and its implementation in a musical score deserves to be discussed separately, not as part of this paper. Reference can be made to Cossettini 2013.

different transmission channels for *Jour, Contre-jour* using a representation of the Shannon's model standardized into blocks.[6]

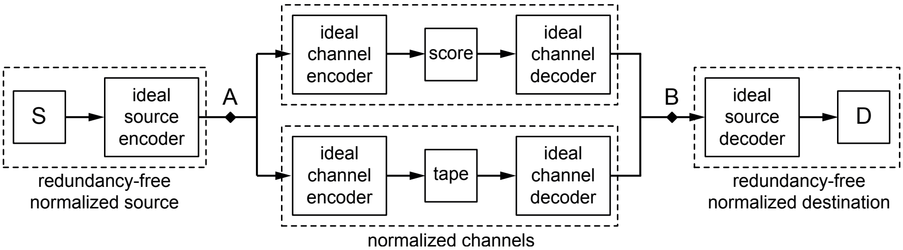

Figure 8. The two different transmission channels for Jour, Contre-jour.

The term *regeneration* is based on a concept express by Gérard Battail in *An Outline of Informational Genetics* (Battail, 2008), 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. 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.

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. More specifically, for the electronic part there are two channels in series, the first is the 8-track recording, the second the 4-track mix. The 'noise' in the channels has different origins; in this case it is caused by mechanical changes and production defects which have altered the organization of the message. MIRAGE thus served as an agent to correct this error based on

6 See "Toward a systemic approach to the critical editing of music at MIRAGE", in this book.

the model represented by the algebraic encoding of the musical theory by Grisey (Figure 9).

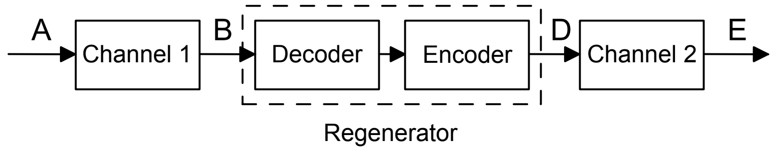

Figure 9. Regeneration process. A: input of the message (composition model used for Jour, Contre-jour*), Channel 1: recording on eight tracks; regeneration work was completed by MIRAGE between B and D; Channel 2: new version on four tracks.*

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 where, by virtue of the presence of a composition model which can be formalized, restoration can be done on an analytical basis.

The regeneration of the electronic part of *Jour, Contre-jour* is made possible: a) by reconstructing the theoretical model according to Grisey's sketches; b) by the mixing patterns provided by Folkmar Hein; c) by the 8-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 according to 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 4-track version using the original 8-track.

In operational terms, the audio content of the 8-track tape was digitally remastered; the resources of digital editing were thus used to synchronize sound events with the 'timing' taken from the model. Mixing work was then realized on the tracks based on the handwritten instructions by Hein (Figure 10).

As further control element, the new mix was compared with the one realized in Berlin in 1981 (R2), which contains interventions not included in the handwritten instructions, but aimed at highlighting intensity peaks of the recorded sounds (Figure 11). We are facing an emerging property of the work: uncodified musical gesture, most likely improvised 'live' during the mixing process to obtain a better (in a purely aesthetic and musical sense) fulfillment of compositional thought. Based on an intervention by the author, these 'musical 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 the model was found, in order to comply with a source approved by the composer (R2), the collation method was used and the reconstructive procedure followed.

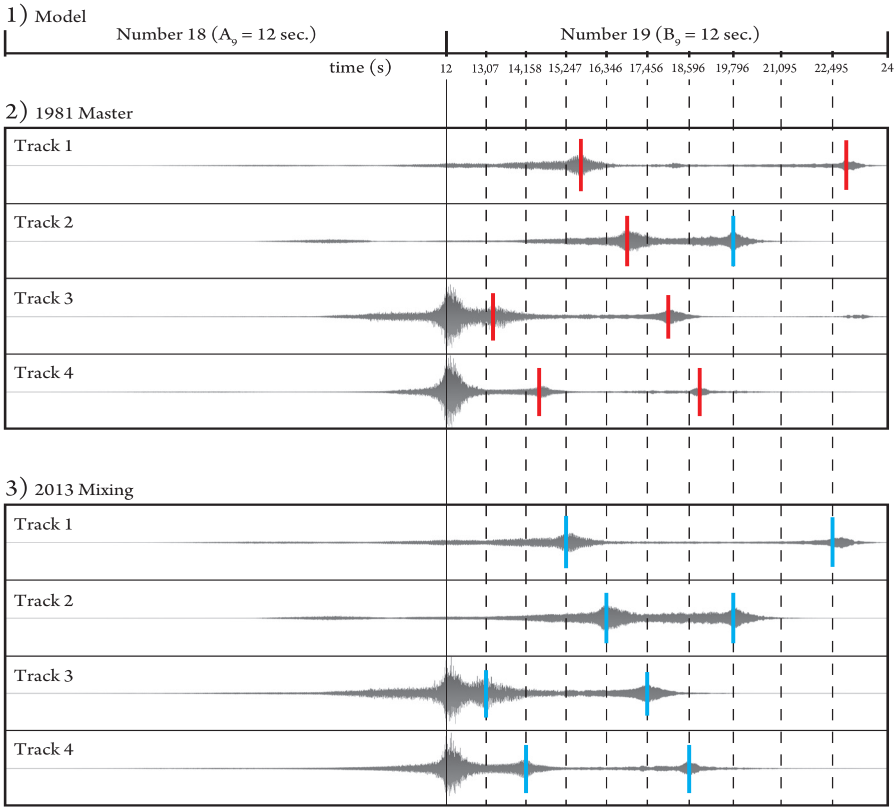

Figure 10. Electronic part: synchronization of events according to the model (section 9, number 18-19, duration 24"). 1) theoretical distribution of instants (in seconds); 2) master tape realized by Gerard Grisey and Folkmar Hein (Berlin 1981); 3) master realized by MIRAGE *(Udine, 2013).*

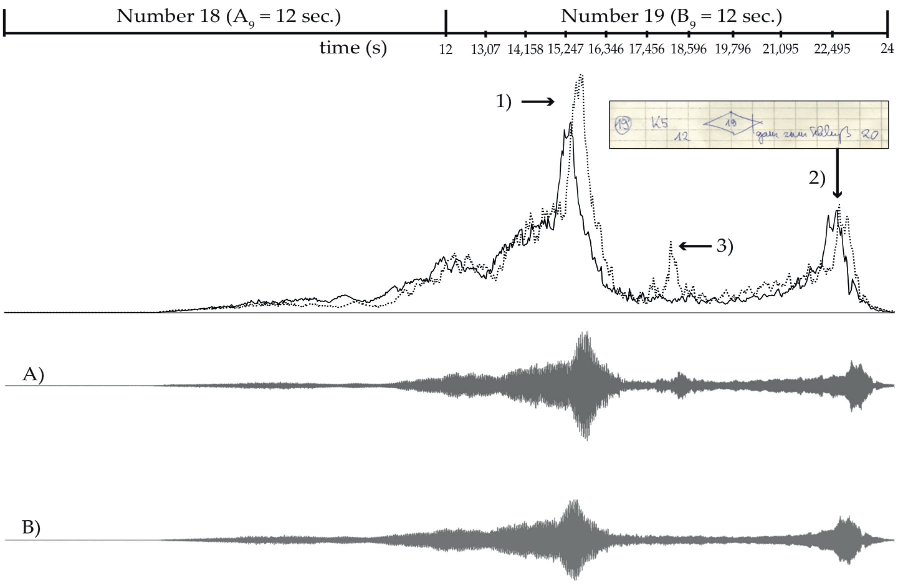

Figure 11. Gestures. 1) difficult to describe: an improvised musical gesture? 2) codified gesture; 3) crosstalk. Dotted line, waveform A: Berlin master; solid line, waveform B: MIRAGE *restoration (section 9, numbers 18-19, duration 24").*

The regeneration of non-codified gestures has shifted restoration to a different level: re-establishing the weights of the sound materials (what Grisey would have called 'the flesh of time', see Grisey 1987). That was still not enough, though the technological distance which separates the moment of creation of the electronic part involves becoming aware of the change in *media* and listening habits, because there is no access to the audio signal apart from an interface. Asperities such as impulsive, stationary or global noises, classifiable as production or transmission defects of the tracks over time, undermined the smoothness of the sound fabric, a typical aesthetic feature of this work. It was thus necessary to implement removal and/or attenuation strategies of disturbances typical of audio restoration (*declick, denoise,* local re-synthesis) (see Grisey 2014).

The work completed on *Jour, Contre-jour* highlighted the importance of the analysis not only in order to better understand and perform the work, but also as a guide for critical editing; it also restated the role of audio restoration as analytical tool.

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The performance edition of *Poème électronique* by Edgard Varèse

Luca Cossettini

INTRODUCTION

Poème électronique is a piece of electronic music composed by Edgard Varèse for the Philips pavilion at the Universal Exhibition in Brussels in 1958. For its diffusion within the architectural space (designed by Le Corbusier and Iannis Xenakis) a 35mm 3-track perforated magnetic tape was used. The sound was projected inside the room and amplified using an array of loudspeakers placed along the walls of the structure. A video and games of light, both designed by Le Corbusier, accompanied the music reproduction. It was a one-off event: after the pavilion was taken down at the end of the exhibition, the work has been disseminated exclusively through monophonic or stereophonic reductions, on record or reproduced during concerts.[1]

As is well known, however, a few years ago the publisher, Casa Ricordi, decided no longer to rent *Poème électronique*. The reasons for such a drastic choice are complex, certainly not due exclusively to the poor quality of the copies circulating; they are also associated with the nature of the work itself and with its performance methods: having been designed as *ante litteram* 'multimedia production', closely associated with the venue and architectonic structure for which it had been conceived, how can it be restaged today, in other settings and different contexts?

1 Only recently have some reconstruction projects attempted to reintroduce the original experience taking advantage of the virtualization potential of IT tools.

MUSIC AND SPACE

Much has been written about the origin of this work.[2] Recently Kees Tazelar, in a volume dedicated to Philips and to the origins of electronic music in the Netherlands (see Tazelaar 2013) goes through the stages which led to designing the project, all the way to its studio production and setting up of the work in the pavilion, also underscoring the role played by the Philips technical experts who worked with Varèse (Willem Tak, Simon Leo de Bruin, Jan de Bruyn, Anton Buczynski, at al.). The genesis of *Poème électronique* was complex. More specifically the task of defining the spatialization of sound has been long and complicated, because it was closely connected to the architectural framework within which it had to be completed and to technological conditions at the time.

The first tests to assess the possibilities of sound spatialization were completed in early 1957 by Willem Tak alone, in a garage of Strijp III at Philips, set up for the occasion with loudspeakers directly on the walls; these architectural conditions were extremely different from those envisaged by Le Corbusier and Xenakis. The first ideas by Tak therefore differed greatly from what was actually implemented. For example mention is still made of walls, ceiling and roof (in striking contrast with the characteristics of the facility with hyperbolic paraboloids which Xenakis was designing) or of stereophonic sound; however at least two pivotal elements in the final version of the work are already present: 1) the sound movement through an exceptionally large number of loudspeakers placed along both axes – horizontal and vertical – made possible by a rotary switch, and 2) artificial reverberations (see Tak 1957 quoted in Tazelaar 2013, 121-122).

In September 1957, Varèse traveled to the Netherlands. He immediately enquired about the sound diffusion conditions in the pavilion and the possibilities of spatialization. At the Paul Sacher Stiftung in Basel there are production notes, drawings, templates and sketches which reveal the various ideas assessed by the author to compose the movement of sound in space. Mention is made of different loudspeakers for low and high frequencies – the former

2 The bibliography on the Philips pavilion and on *Poème électronique* is too extensive to be reproduced within the space of this paper. Please refer at least to Treib 1996 and Tazelaar 2013.

integrated within the walls and the latter, 400 in total, placed all along the facility –, of full-range loudspeakers placed in an 'antiphonal' position at the entrance and exit of the pavilion, as well as of spatial movement lines for the diffusion of the three tapes on which he was working. One note is worth quoting in its entirety:

> Point A projection: Route du son - perspective of sound - very remote, far away, outside - coming closer and closer - at a certain moment its presence in the hall - suddenly runs any route - remain at a chosen point (entrance or exit) and from there goes out again fading out.
> Point B projection: A certain sound, very special - one route parallel differentiated - Mercurial effect, mysterious stereophonic effect - location pure1y individual and subjective - at a certain moment you feel the sound inside of you - slight pause - new projection (any one).
> Point C projection: Sound in the hall - impression of dimension of the hall - same sound in which reverberation is introduced and the dimension of the hall increases (expands) comes back to normal - finishes.
> Point D projection: Jumping of sound - jumping - independent of each other - Loudness restricted.
> Point E projection: Echo effect - mixed with jumping and reverberation - all combinations possible on the 3 tapes = any choice.
> Point F projection: rain - a kind of falling counterpoint of the three tapes.[3]

As is understandable in the world of electronic music, the musical concept chosen by Varèse would then need to fit within the technological system which would make it possible. Presumably due to technical difficulties, the analog real-time reverberation and the relevant stereophonic spatialization envisaged by Tak were never used; instead the choice was made to integrate the effects directly into the electronic part: with the help of Anton Buczynski, the sound events to be 'effected' were cut from the three monophonic tapes originally intended for diffusion on three separate audio lines, then these parts were replaced by leader tape; following the application of reverberation and spatialization they were assembled on a stereophonic tape at a position in time corresponding to the original monophonic tapes. In this way four tapes were created which could be synchronized during reproduction.

3 Note preserved at the Paul Sacher Stiftung in Basel.

This latter operation was completed aurally by applying tape sections containing impulse signals before the beginning of the recording. The result was then re-mixed on the three tracks of the 35 mm perforated magnetic tape intended for reproduction inside the pavilion (Tazelaar 2013, 151). The master copy was thus ready. It was now a matter of managing sound projection.

Tak's original project was ambitious and its technology pioneering. In the end the number of loudspeakers was reduced and the sound 'routes' were redefined by Xenakis and physically installed in the architectonic structure only in early 1958. This meant that they were working 'blindfold', without any possibility of carrying out tests on the actual operation of the spatialization lines and their sound impact within the real acoustic space. Once this work had been completed, a control room was set up, which included a reader for the 3-track perforated magnetic tape and a 15-track system to manage control signal linked to a selective amplifier. The latter controlled arrays of loudspeakers or the rotary switch in charge of sound movement. It was thus the control room which finally made *Poème électronique* actually possible by mechanically performing it inside the pavilion.

VIRTUALIZATIONS

Poème électronique, in the form for which it was intended, only existed from the 20th of May to the 19th of October in 1958. Then, as already mentioned, the Philips pavilion was taken down and never rebuilt again. A thorny question already arose at the time with regard to the work's survival: how could the memory of such an experience be passed on to future generations? Varèse came up with a 'musical' solution by curating an edition on LP record of *Poème électronique* (see ED1): a stereophonic mix from the original tapes to which reverberation was then added, possibly to compensate for the lack of real 'space'. This was not enough, though: as one of the most celebrated pieces of electronic music in history, *Poème électronique* soon started to feature also in the concert programs dedicated to contemporary music.

Its performance in concert, however, taken outside its original context and placed on a stage, radically upsets the original underlying composition idea and drastically changes its conception. This issue has always been clear to everyone, which meant that the first suggestions to find a solution started to be made, aimed at a reconstruction – though virtual – of space. More specifically, over the past few years, thanks to digital audio systems and most notably due to recent developments as regards virtual reality, some ambitious projects have been undertaken aimed at reproducing the experience of *Poème électronique*. This means that not only spatialized listening, which can already be – and has often been – simulated with careful sound direction, but also projection, colors and the architectural environment could be virtualized. Alongside a number of initiatives which could be classified as amateurish, the VEP project achieved significant results, also because of the funding it received from Culture 2000:

> The goal of the Virtual Electronic Poem (VEP) project is the realization of a virtual reality (VR) environment that aims at reproducing the total experience of the dismantled masterpiece through an accurate philological reconstruction of the original installation and a technologically innovative implementation with the VR techniques. [...] The expected concrete results of the project are a VR installation that allows a renovated fruition of the *Poème électronique* and an interactive application in 3D computer graphics that provides an access to the virtual scenario and the audiovisual show through the www, in order to yield a wide dissemination of the project results.[4]

As part of this project mention should be made in particular of the review completed mainly by Kees Tazelaar on the Dutch audio sources of the work. This led to conclude that the tapes produced at the Philips studio, in 1960, were transferred to the Institute of Sonology archives of the Utrecht State University. The Institute of Sonology moved to the Royal Conservatory of The Hague in 1986 with its archives, where Tazelaar found the production tapes of *Poème électronique*: these are 3 monophonic tapes and the stereophonic tape used to produce the 3-track master on the 35 mm magnetic perforated tape. Thanks to these valuable high quality documents (assessment made in terms signal/noise ratio) it has been possible to follow the traces of editing and mixing operations and to regenerate the three-track master tape.

4 From the official presentation of the project.

As for the reproduction of the audio part, Tazelaar was faced with a problem typical of montage operations with analog magnetic tapes, which has a substantial impact also on the structure of the work: the loss of synchronization due to tolerances in calibration of the tape recorders' running speed. «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)» (Dobson, ffitch et al 2005, 39).[5] To reinterpret the correct alignment of the sound events it was thus necessary to use other multi-track sources: the perfo-master, the mono soundtrack of the video copy of the film supplied by the Philips Company Archives, and the Columbia Gramophone record.

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? Tazelaar, being aware of this question, chose to rely on the recorded version authorized by the author himself.

Thanks to work completed by a multi-disciplinary team – musicologist, cinema experts and IT engineers – which was called upon to restore the audio part, the video, the light games, as well as for the modeling of acoustic and architectural space, projects such as VEP today have returned to us a virtualization of what might have been experienced by the audience at the time. The demand for concert performances, in any case, never waned. The contemporary music public asks for *Poème électronique*. It therefore becomes necessary to find publishing solutions which are, at the same time, mindful of the work and meeting its performance requirements.

5 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 state 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, 2015, 78).

FOR A PERFORMANCE EDITION

In 1961 Frits Weiland started working as technician at the studio for electronic music at the Plompetorengracht in Utrecht (later to become the Institute of Sonology), where the master tapes of *Poème électronique* were kept at the time. It should come as no surprise, therefore, that the solution he suggested regarding the performance of this work was actually one of the first, based on his dual training as sound engineer and composer. In the 1960s, Weiland used the three separate tapes to produce a quadraphonic version of *Poème électronique* with new spatialization consistent with the technological conditions for diffusion at the time. This version «was from then on referred to as "the master" of *Poème électronique*» (Dobson, ffitch et al 2005, 30). Unfortunately this 'rewriting' project undertaken by Weiland was not very successful for concert performing in its original quadraphonic form; on the other hand, it was used as master to produce stereophonic versions, then transferred to the archives of production centers and publishers. Casa Ricordi, in particular, owns two copies which were used for many years to be rented on the occasion of concerts: R231 (R2) – where track 1 and 4 of the quadraphonic version are transferred to the left channel and track 2 and 3 to the right channel – and R165 (R3) – where track 1 and 3 are transferred to the left channel and track 2 and 4 to the right channel. It is from the latter tape that the recent digital version originated. Moreover the version by Weiland was used to produce, in stereophonic mixdown, the versions on record after the one curated by Varèse for Columbia. It is worth mentioning in particular the Decca box-set which contains two CDs with the whole of Varèse's production (see ED2 record). The stereophonic mixdown versions by Varèse-Weiland are therefore the ones which, after the Philips pavilion was taken down, had the largest diffusion. As often happens in the dissemination of electronic music we are faced with a scenario where the original version of the work differs from the successful one in the performance tradition and published version.[6] Given the characteristics of the original multimedia project, this gap is due to

6 See "The quest for *Ages*, the radio-drama by Bruno Maderna and Giorgio Pressburger", in this book.

changed technological conditions for reproduction, but also to the change in the purpose for which the music was used.

Apart from constituting the forerunner of what could be considered a vulgate stabilized over the years, the version by Weiland is also a valuable source because it is still well suited today for concert diffusion. Take for example the section from 32" to 40" (time measured from the first sound event in the work), of which a multi-track visualization in time/amplitude is shown in Figure 1.

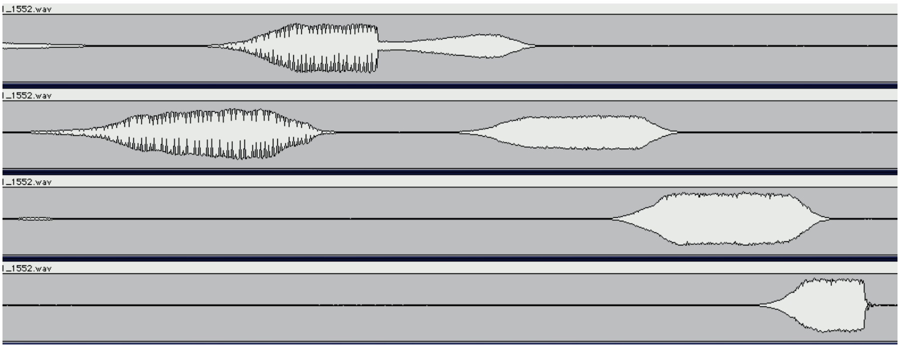

Figure 1. Poème électronique*, quadraphonic version by Weiland (from 32" to 40"). Sound spatialization.*

Here we see the spatialization of two sounds. The first is moved from track 2 to track 1, while the second is moved from track 1 to track 4, through the other tracks. If you listen to the work in quadraphonic diffusion with the loudspeakers placed around the audience (channels positioned clockwise starting from the first one on the front left), the result is first of all a shift on the frontal plane from left to right, then a clockwise revolving motion which surrounds the audience. A similar processing, obviously impossible in the original version with three channels, perfectly reproduces the spatialization practices in use at that time. Also for this reason, when Casa Ricordi entrusted MIRAGE the task of studying a publishing solution for the performance issues of *Poème électronique* we immediately thought that a restored re-edition of the Varèse-Weiland version could be a valuable suggestion, in line with the performance practice. We thus digitized the copy kept in the publisher's archives (Ricordi R230, R1),[7] which had been filed for copyright protection, and conducted its audio restoration. The excellent preservation conditions of this tape made it possible to reproduce a signal whose quality actually far exceeded that of any other source available so far. On the other hand the high quality of the audio signal clearly revealed the construction defects of the original tapes: low frequency impulsive noises due to splices and malfunctioning of recording equipment at the time, discontinuity in background noise, excessively perceivable *hum*, plus other disturbances whose origin may be traced back to the preparatory tapes undermined the transparency of the medium and distracted attention from the sound fabric. In agreement with the publisher we therefore opted for a restoration approach of an aesthetic nature,[8] aimed at eliminating also these corrupted elements, in order to reveal the potential of the original sound fabric and, subsequently, of the work in relation to its performance during a concert.[9]

Since it was produced starting from three original tapes by Varèse, the quadraphonic version by Weiland includes no reverberation. This was another decisive factor in choosing the publishing strategy. The absence of effect overlapping with sound fabric actually offers the sound director an opportunity to adjust the reverberation according to the characteristics of the hall where it will be reproduced and to individual performance choices.[10] This means that space is not frozen in the electronic part and can be recreated with each performance. *Poème électronique*, now seen as electronic music work and no longer as multimedia experience, will thus come to life again for concert performances.

7 For the digitization of the audio signal we used: a customized *Studer A80MKII*, *PrismSound* ADA-8XR converter, 2 *Mac Pro* workstations with firewire and AES-EBU connections (*RME HDSPE*), *Adobe Audition*. For a description of MIRAGE re-recording protocols, please refer to "From the archive to the event", in this book.

8 See "Recorded music: from the ethics of preservation to the critical editing", in this book.

9 For further details on the restoration work see Varèse 2017.

10 The sound director can also opt for a mix of tracks two by two, thus producing a stereophonic version which is perfectly in line with the performance tradition.

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R1: Milan, Ricordi 230, 1973. Magnetic tape, 1", 4-track, quadraphonic. Copy of the "Master tape B" kept by the Studio voor Electronische Muziek Rijksuniversiteit in Utrecht.

R2: Milan, Ricordi 231, 1975. Magnetic tape, ¼", 2-track, stereophonic. Stereo mixdown of the "Master tape B" kept by the Studio voor Electronische Muziek Rijksuniversiteit in Utrecht.

R3: Milan, Ricordi 165, 1984. Magnetic tape, ¼", 2-track, stereophonic.

ED1: Varèse, E. (1960), *Music of Edgar Varèse*, Columbia, New York, CBS-S75 695, LP.

ED2: Varèse, E. (1998), *The Complete Works*, Decca, Londra, 4754872, CD-A.

Coda

Towards a systemic approach to the critical editing of music at MIRAGE

Luca Cossettini, Angelo Orcalli

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 concepts. The abrupt extension of organology from its acoustic dimension to new forms of sound production, then projected writing beyond its flat graphical dimension; 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 Nelson 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» (Goodman 1984, 190).

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» (Goodman 1984, 191). Even though the electronic music composer intends to 'autographically' fix the first 'instance' of the work on an audio recording, 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 carriers 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.

> 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* (Schaeffer 1970, 27).

This feedback action seems to be the result of a transformation process, where Schaeffer points out the aspects related to the 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 he 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.

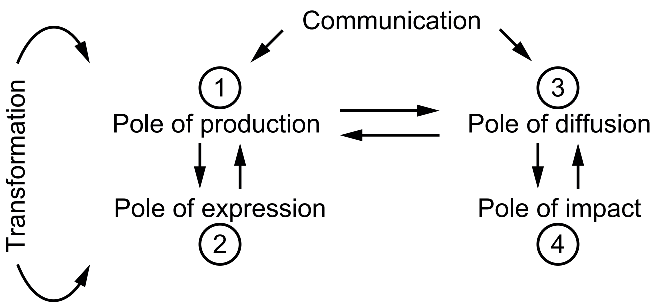

Figure 1. Schaeffer's Communication Model.

Schaeffer thus posed the semantic question of communication at systemic level, as opposed to a semiological approach, with three underlying elements: composer, performer and audience. It is the system through its historically given context which transforms the meaning of communication, in the sense that it transforms the very concept of sound and music production.[1]

During the 1960s 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 experimentation forms; 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 of this has been 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

1 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.

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 (Grier 1996, 6).

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 (Grier 1996, 4).

Based on this perspective centered around production systems, according to Grier, publishing and sound recording are on the same level (Grier 1996, 6-7). 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» (Grier 1996, 23). From the point of view of the issues involved in critical editing of electronic and mixed music this means that for an editor the review of audio sources is a fundamental moment. On the other hand, traditional musical philology has not deemed it necessary to develop suitable methods for these new recording forms which have now become a primary source as regards the tangible and intangible assets of twentieth century music. The bias on the part of philologists towards new forms of representation and reproducibility of knowledge is indeed nothing new: the awareness which has led philologists to analyzing with special care all paleographic and codicological elements of a manuscript, has not meant that the same level of attention was paid to the bibliographical and bibliological aspects of printed matter. Only during the early decades of the twentieth century, in the Anglo-Saxon area, has the practice become widespread of taking into account the specificity of printing processes and of individually assessing each printed copy in respect of any information which could be derived from analyzing the physical and textual aspects of a book. As regards audiovisual sources, the success of critical editing is still hindered today not only by new intellectual biases, but also by the fact that the 'observation' of sound recordings requires operational knowledge of the technical means for audio reproduction and analysis. As a consequence, the editing of audiovisual recordings is 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 account is taken of the media framework created by the new possibility of accessing sound.

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 separates source and receiver in terms of time: the carrier 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 information theory 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 carrier 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.

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:

> From the point of view of the cryptanalyst, a secrecy system is almost identical with a noisy communication system. The message (transmitted signal) is operated on by a statistical element, the enciphering system, with its statistically chosen key. The result of this operation is the cryptogram (analogous to the perturbed signal) which is available for analysis. The chief differences in the two cases are: first, that the operation of the enciphering transformation is generally of a more complex nature than the perturbing noise in a channel; and, second, the key for a secrecy system is usually chosen from a finite set of possibilities while the noise in a channel is more often continually introduced, in effect chosen from an infinite set (Shannon 1949, 685).

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):

> There are a number of difficult epistemological questions connected with the theory of secrecy, or in fact with any theory which involves questions of probability (particularly *a priori* probabilities, Bayes' theorem, etc.) when applied to a physical situation. Treated abstractly, probability theory can be put on a rigorous logical basis with the modern measure theory approach. As applied to a physical situation, however, especially when 'subjective' probabilities and unrepeatable experiments are concerned, there are many questions of logical validity. For example, in the approach to secrecy made here, *a priori* probabilities of various keys and messages are assumed known by the enemy cryptographer – how can one determine operationally if his estimates are correct, on the basis of his knowledge of the situation? (Shannon 1949, 664).

From our point of view, the actions aimed recognizing the value of a recording and at restoring and critical editing 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 carrier – regardless of the content of the document, or of its establishing and historical origin – has been the greatest watershed which divided the theory of restoration according to Dietrich Schüller from what could be defined as Bayesian approach. The possibility of decrypting the format of a recording 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 critical editing of music first and foremost as the *collatio* of documents, then as content analysis process. The possibilities of restoring recorded music for reproduction purposes are essential based on individual documental evidence, as well as on a subjective assignment of conditional probabilities.

INSTALLING THE DIA-SYSTEM

Transcribing onto another carrier electronic music originally intended for recording on an analog carrier creates a connection between two systems: the historical, analog, system which produced the document in question, 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 (Segre 1981).

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 edited using instruments consistent with the original format, restored and reproduced using signal processing and data treatment techniques related to the audio tracks. 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 recordings 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.

An audio document consists of a several information items related to its creation process, essential for the transfer of its audio content. A number of aspects comes into play to form a document unit:

1. The material structure of the item: the set of its physical-chemical components, technology, production system, format;
2. primary information related to the message contained in the recording;
3. secondary (or ancillary) information: signals specific to the recording system;
4. the reproduction and listening system: amplification, diffusion;
5. any metadata: labels, storage notes, writing on the tape, etc.;
6. its transmission history: forms of archiving, duplication, re-mediation, etc.

The information theory, 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 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:

1. The analog document with its reading system;
2. 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 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 (see Atlan 2006 and Foerster 1960).

THE FEEDBACK PRINCIPLE: CRITICISM OF CRITICISM

The scientific contribution from 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 transmission process and analysis of current recorded traces. From the moment that surviving data become the subject of recognition, their knowledge takes place through analysis systems 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. 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 recording. 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.

ENCODINGS

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 (see Orcalli 2013). In some cases, the presence of a composition model for the music in question, can provide 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 critical editing 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 peculiarity 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.[2]

COMMUNICATION MODELS MADE VISIBLE

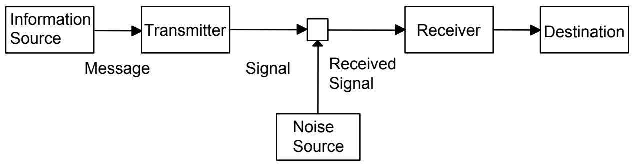

Figure 2. General communication system (Shannon 1948, 381).

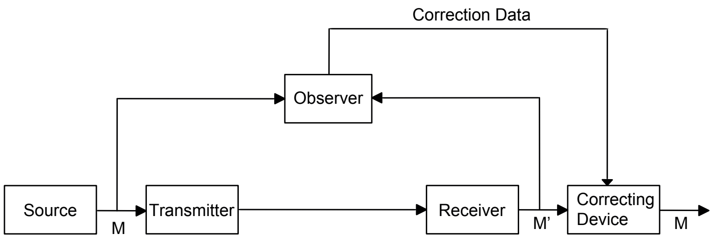

Figure 3. Schematic diagram of a correction system (Shannon 1948, 409).

2 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. 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 (see Battail 1997; Hamming 1986).

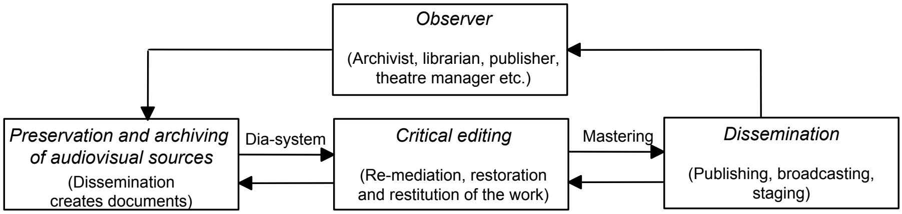

Figure 4. Critical editing of audiovisual sources.

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 the composition *Jour, Contre-Jour* by Gérard Grisey clearly shows the need for a theoretical approach;[3] 4) finally, the critical editing of Bruno Maderna's music paves the way for a new reflection on restoration. The continuity in his 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 (see Cossettini, Orcalli 2015).[4]

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 (see Grier 1996). The difference between the critical

3 See "The regeneration of the electronic part of *Jour, Contre-jour* by Gérard Grisey", in this book.

4 See also "Towards an electronic 'global work'", in this book.

editing of scores 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 of recorded music cannot neglect the knowledge of technical instruments and of their history.

The example presented in this book show the tools that the critical editing of recorded music must include: a spectromorphological analysis supported by time/frequency and time/amplitude representations, a survey of the physical editing cues on the original carriers, a historical reconstruction of the 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 recorded music cannot be directly traced back to Shannon's communication model: Sender → Channel → Receiver. 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.

The model proposed by 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).

The task of critical editing is to bring musical works back to life (both for publishing and performance). As a consequence critical editing 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 historical differentials, and discovers continuity and singularities. From a historical perspective:

1. *Production* becomes the history of the systems of production, reproduction, and publishing;
2. *diffusion* materializes itself in the documents, and becomes critical knowledge;
3. *expression* in time becomes the evolution of musical theories, of techniques and compositional forms and of style;
4. *impact* of diffusion on the end-user becomes Reception History and Music Listening History.

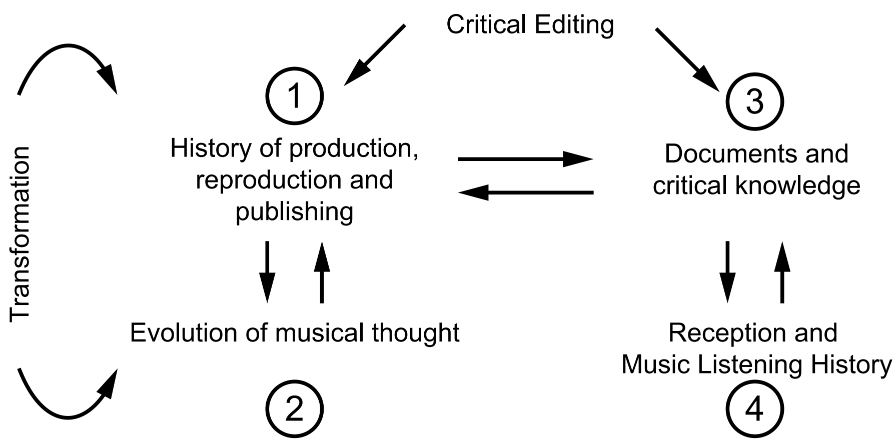

Figure 5. Towards a systemic approach to the critical editing of music.

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Between spectrum and musical discourse

Computer Assisted Composition and new musical thoughts in *EnTrance* by Fausto Romitelli

Alessandro Olto

In the 1980s and 1990s musical research at IRCAM focused most notably on computer assisted composition (CAC). A multitude of programming languages, sound control and synthesis systems were developed at the Paris research center to provide composers with tools and software environments conducive to experimentation with the new organology, thus expanding the boundaries of musical writing. All this paved the way for the important era of personal computer assisted composition, supported by the general belief that developments in the engineering field and processor miniaturization, with the shift from large data processing systems (for example the computer *PDP-11*) to visual programming software developed for *Macintosh* platforms (*Patchwork*, to mention but one),[1] would inevitably lead to a change in paradigm as regards composition approaches.

In 1990 Fausto Romitelli started working at IRCAM, first as a student of the *Cursus international de composition et d'informatique musicale* (1990-1991) and then with a grant as *Compositeur en recherche* (1993-1995). At the Paris center, Romitelli was directly confronted with the world of digital sound synthesis and its computer-based control. *EnTrance,* for soprano, ensemble and electronics is the most significant outcome of this period, most notably because it includes traces of a personal approach to timbre, developed as part of a debate which was all the rage in those years on the European music scene.

1 *Patchwork* is a visual programming system which makes it possible to graphically manipulate objects. It provides a graphical interface for the Common Lisp (and CLOS, Common Lisp Object System) programming language on which it is based. The functions written using LISP can be translated into interconnected graphical objects which are then organized resulting in what is known as 'patch'. The aim of a visual patch is to define a computational model where individual items take on a functional role (see Malt, Roads 1996).

This reflection on timbre, which indeed characterized the last few decades of the twentieth century, on the one hand resulted in a mature attitude to spectral aesthetics among composers of the Itinéraire group (see Orcalli 2013), on the other side it led to its integration within 'musical discourse' as suggested in 1985 by Boulez (see Boulez 1987): the latter entailed the need to define structural relations in the organization of timbre and encouraged composers to look for new categorizations which could reinstate the hierarchical system abolished by serialism (see Barriére 1991). The concept introduced by Boulez was also taken up by Romitelli, who interpreted it personally at the beginning of the 1990s.

In *EnTrance* there is an undeniable influence from spectral theories, most notably as regards Tristan Murail's spectralism, which appeared to create a possible bridge between processual spectralism as theorized by Gérard Grisey and functional spectralism (see Orcalli 2013). Through the new forms of writing and representation of sound, however, as well as with the opportunity offered by the digital domain of extracting parameters from the analysis of the acoustic phenomenon, it became possible for composers to treat spectra not only in their qualitative dimension, but also from a discrete parametric perspective. Romitelli therefore brought together combinatorial rules, clearly derived from his studies with Franco Donatoni, and the spectral techniques made popular by composers of the Itinéraire group.

NEW COMPOSITIONAL PERSPECTIVES

During his time as *compositeur en recherche* within the *équipe de représentation musicale* directed by Gérard Assayag, Romitelli carried out a personal research on possible organization criteria for musical material. Already in the presentation for *La sabbia del tempo* (1991-92) and *Les idoles du soleil* (1992), he wrote:

> Gli oggetti evolvono in uno spazio di transizione tra armonia e timbro: le strutture timbriche sono legate ai processi di fusione percettiva di tutte le componenti in singole immagini sintetiche, quelle armoniche sono legate ai

processi di separazione (parsing processes) che permettono la riconoscibilità di ogni singola componente intervallare. I processi di fusione e fissione percettiva sono legati all'interazione complessa di fattori quali l'armonicità, la sincronia nell'attacco, la coordinazione nella modulazione d'ampiezza e frequenza, la densità spettrale ecc. (Romitelli in Arbo 2009, 341-342).

These few lines include, on the one hand, concepts such as 'perception thresholds', 'harmonicity', 'modulation', 'spectral density', which highlight the interest with regard to spectralism; on the other side, expressions such as 'timbre structures', 'objects', show that Romitelli immediately adopted the approach developed at IRCAM.

An unpublished paper, *Pertinence du timbre*, drafted between 1992 and 1995 and kept in the private collection of Laurent Pottier, clarifies the composition approach which the author developed during those years. It includes some examples of the new composition techniques drafted in particular for *Mediterraneo I – Les idoles du soleil* (1992).

In this paper Romitelli consistently uses the word 'aggregate' to define a chord. The definition of a discrete set of aggregates paves the way for a possible timbre categorization. The example suggested by Romitelli is as follows: the basic material consists of three aggregates, which differ in terms of number and quality of the intervals, as well as of density and register (Figure 1):

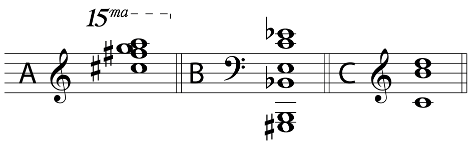

Figure 1. The three basic aggregates A, B and C.

Each aggregate is manipulated by drawing from a repertoire of combinatorial rules which makes it possible to generate three set of objects **A**, **B** and **C**. As can be seen in Figure 2, the rules chosen to transform basic aggregates differ from time to time:

- Aggregate **A** undergoes processing which, through twelve steps, brings it from high to low pitch. From **A1** to **A3**, as also from **A5** to **A6**, in each step only one of the four notes is moved downwards, while the other three remain fixed; the transition from **A3** to **A4**, on the contrary, is characterized by the transposition by a minor ninth of all the aggregate: **A3** and **A4** thus preserve all internal interval relations; between **A4** and **A5** there is a compression of the intervals; finally the transitions described so far are reproduced, in reverse order, from **A7** to **A12**;
- the work done on aggregate **B** results in producing four other aggregates, each of which is calculated starting from **B1**. This procedure is based on reversing a gradually increasing number of intervals and its final outcome is a complete reflection of **B1** in **B5**;
- aggregate **C** produces twelve objects, generated exclusively through inversion of intervals or transposition.

In this way three separate sets are formed which include the initial aggregate and its combinatorial transformations (Figure 2).

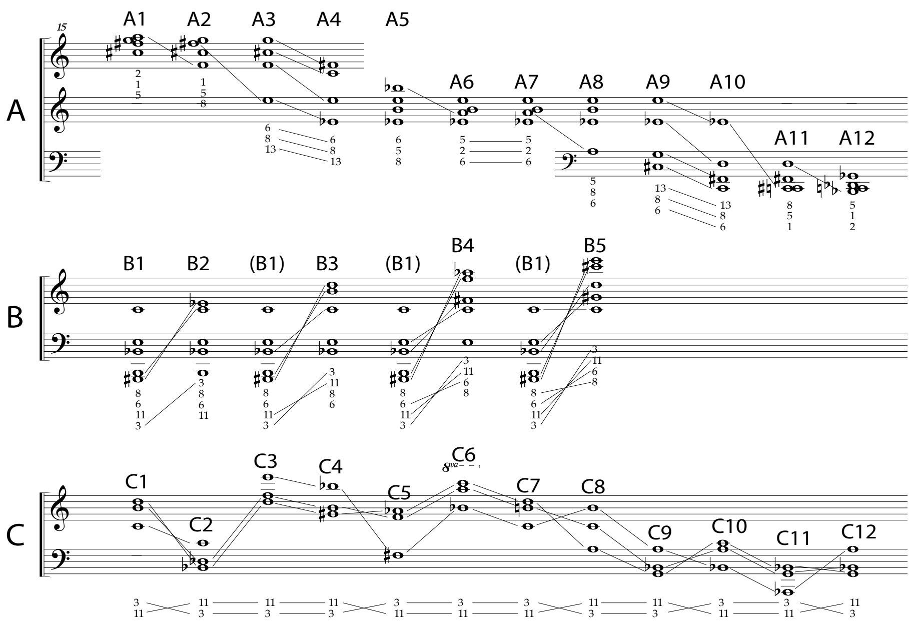

Figure 2. Rules for aggregate transformations.

Once the combinatorial calculation for the production of the new material had been completed, Romitelli started analyzing the possible pathways between one aggregate and another. The following set of rules is thus defined:

- A transition between two aggregates is possible provided that there are at least two consecutive intervals in common, even if in inversion;
- by the same token, a transition is possible if there are at least two pitches in common;
- each aggregate, defined by the sets **A**, **B** and **C**, cannot be associated with more than two other aggregates. In the event that several connections are possible, the order in which they appear in the combinatorial calculation should be followed;
- each set should be read from left to right.

For example, **B1** can match other four aggregates: **A3**, **A4** – two consecutive intervals in common, in inversion in this case – as well as **C2** and **C10** – two notes in common (Figure 3).

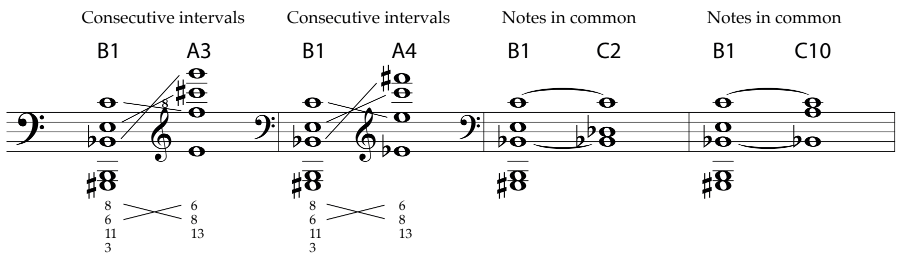

*Figure 3. Connections between **B1** and the aggregates from **A** and **C**.*

The rules laid down make it possible to select aggregates which are more or less similar – perceptively the common-note connection is much stronger than those for common intervals –, it is also true that, in order to extend compositional possibilities, it is necessary to work by contrast too. In this way a hierarchical system is created which allows the composer to produce a 'tension curve' in the harmonic domain.

Romitelli then moves one step from interval relations to timbre space:

> Nous allons les considérer pas plus comme des produits d'une logique combinatoire, des objets discrets constitués à partir de l'articulation réglée d'éléments abstraits et relationnels, mais comme des ensembles de fréquences qui tendent à la fusion perceptive dans des images synthétiques: des timbre placés à l'intérieur d'un espace multidimensionnel[2] comme produit d'un transition entre modèles opposés (Romitelli [s.a]).

The aggregates in each group are thus analyzed in search of an implicit fundamental frequency where the notes in the 'chord' can be regarded as overtones. For example the notes in **A6** correspond to partials 5, 7, 8 and 11 of a harmonic spectrum on the note *B1* (Figure 4). The result of this procedure, applied to sets **A**, **B** and **C**, is shown in Figure 5.

It is therefore possible to define further transitions on a spectral basis: new relations can be established when the implicit fundamentals of two or more aggregates belong to the same imaginary harmonic spectrum (Figure 6).

The categorizing of timbre led Romitelli to developing a new system which was expected to guide the formalizing of musical structures. The medium in this case is computer science: «l'objectif est alors de déterminer des représentations informatiques dans lesquelles cette opposition peut être pensée et contrôlée» (*Rapport* IRCAM *1993*, 46).

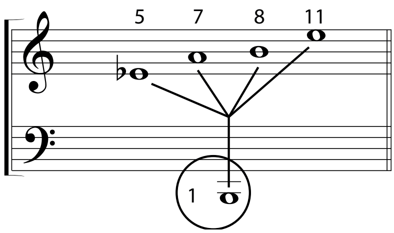

Figure 4. Defining a common fundamental.

2 The multi-dimensionality of timbre space mentioned by Romitelli is linked to a concept outlined by Jean-Baptiste Barrière and quoted by the composer: «un espace de timbres est déterminé à partir d'un choix de modèles. Ceux-ci sont distribués en fonction d'une catégorisation psychologique arbitraire projeté dans un espace à x dimensions» (Barrière quoted in Romitelli [s.a.]).

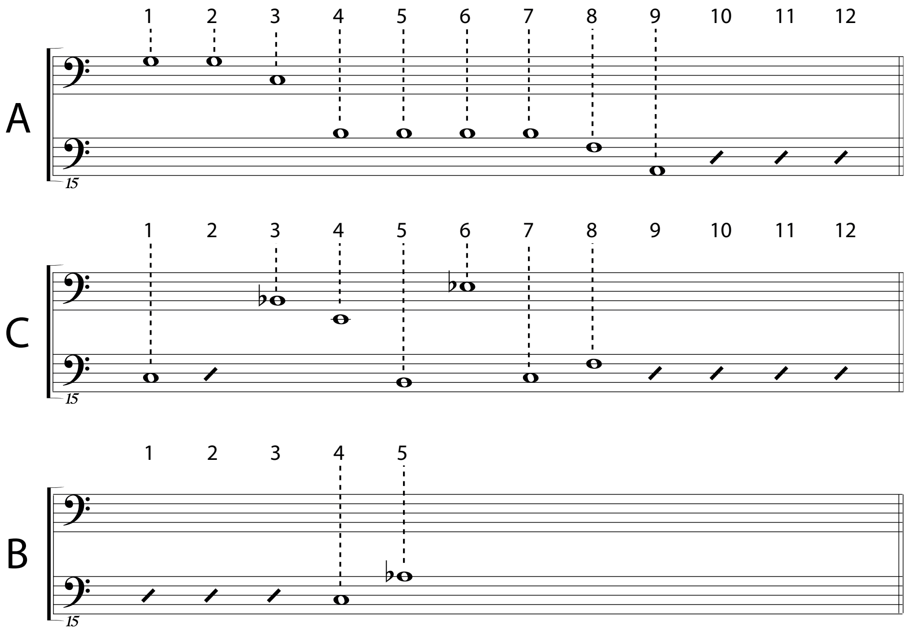

*Figure 5. Definition of a implicit fundamentals for each aggregate in sets **A, B** and **C**.*

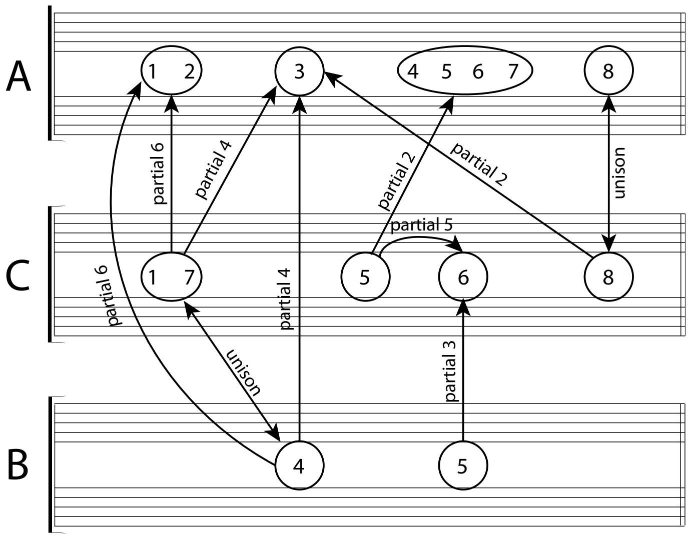

Figure 6. Possible spectral transitions.

As an aid to composition, Romitelli thus produced a software prototype which allowed him to build the timbre space establishing relationships among the various aggregates and spectra:

> A partir des paramètres fixés de l'un ou de l'autre type, le système construit un réseau de contraintes qu'il cherche à résoudre en produisant tous les objets compatibles (i.e. moments spectraux contenant les bons intervalles). Une interface *Patchwork* permet de diriger les solutions vers une représentation en notation musicale ou vers la génération de script de synthèse pour *Csound* (*Rapport* IRCAM *1993*, 46).

Based on the developments of CAC, Romitelli translated his theoretical-musical reflection into LISP programming language, then possibly by implementing the *Patchwork* graphic environment.[3] The composer used one file, 'lispdef', originally created for the composition called *Natura morta con fiamme* (1991-1992)[4] and preserved at IRCAM: this set of libraries, from 1991 to 1995, was stratified with new functions aimed at implementing new composition strategies. The 'autograph' comments are enlightening, for example:

> Data una lista di liste d'intervalli, li trova all'interno di uno spettro, nell'ordine stabilito dalla lista, e li fa apparire cancellando le note dello spettro estranee agli intervalli [...].
> Data una lista di intervalli, li integra in spettri distorti abbassando il coefficiente; è possibile definire quanti degli intervalli della lista devono essere obbligatoriamente presenti nello spettro e in quale densità minima rispetto al numero complessivo degli intervalli dello spettro.

The comments include: a) the connection between intervals and spectra; b) the hierarchy among intervals, aggregates and the selection of possible pathways; c) the definition of transition rules. All these elements laid the groundwork for writing *EnTrance*.

3 The development of a personal library with *Patchwork* by Romitelli is also confirmed by Gérard Assayag, director of the *équipe de représentation musicale*. Unfortunately it has not been possible to trace the original *Patchwork* library.

4 *Natura morta con fiamme* was composed during the *Cursus international de composition et d'informatique musicale* and premiered on 19 March 1992 at the Espace de Projection at IRCAM.

ENTRANCE

EnTrance is a 'mixed' composition for soprano, ensemble and electronics. It was composed in 1995, then performed for the first time on 26 January 1996 at Espace de projection at IRCAM (Ensemble InterContemporaine, soprano Françoise Kubler, conductor Ed Spanjaard). The voice and the woodwinds, brasses, strings, percussions and piano ensemble, are complemented by electronic devices which include the following: a synthesizer, a sampler and a digital quadraphonic studio recording to be played during the concert. The heterogeneous nature of the instrument list thus makes the definition of extended organology appropriate (see Stiegler 2003).

The study of the sources

The study of composition sketches and drafts is a valuable resource to reconstruct the origin of this work. The analysis of these sources is essential, nevertheless it is not sufficient when dealing with mixed music which actually involves other forms of writing. Studying this repertoire, indeed, means analyzing sound synthesis systems, sound production and reproduction techniques, software for computer assisted composition and new organology.

In the case of *EnTrance*, computer patches, libraries and the software itself which were used play a pivotal role for understanding the creative process. Already in 1991, for the composition of *Natura morta con fiamme*, Romitelli had experimented with sound synthesis using *Csound* and with its control by means of LISP;[5] during his stay as *compositeur en recherche* he also worked with the *Patchwork* environment. The survey therefore needs to start from

5 In *Natura morta con fiamme* sounds have been obtained using *Csound*. *Csound* allows for synthesis, starting from basic operators, for example oscillators or filters, which in turn can be described by means of several parameters (start, end, amplitude and frequency envelope, phase, bandwidth etc.). To produce complex sounds it is therefore necessary to manage a large amount of data. Romitelli has overcome this difficulty by developing a control program written using LISP which he called 'WORKLISP': by defining specific functions, this program allows for substantial reduction of the amount of data to be manipulated, as well as for categorizing the type of sound to be obtained.

heterogeneous sources, found today in the Ricordi archive, at IRCAM and kept by Pottier, Romitelli's musical assistant for the composition of *EnTrance*.

The underlying idea

The underlying idea of the work, as the title suggests, is a ritual whose aim is to induce a state of trance. The reference text for the soprano part is a fifteen-syllable mantra from *Bardo Thodol*, the Tibetan book of the dead: *om a yu vse sa ra ha ra ka ra re sva re hûm p'at* (Romitelli 1996). In the vocal part the composer used breathing in/breathing out techniques while at the same time turning one's head, almost hieratically:

> La voix fait alterner inspiration, dans un microphone situé à gauche du visage, et expiration, dans un autre situé à droite. Ce mouvement, inspiration-expiration de paroles sacrées monosyllabiques, son accélération et les rotations de la tête dont il s'accompagne, rappellent les rites de certaines musiques traditionnelles qui favorisent l'entrée en transe en s'appuyant aussi sur des facteurs d'ordre physiologique, telle l'hyper ventilation durant l'accélération de la respiration, autrement dit une oxygénation maximale du cerveau (Romitelli 1996).

In order to emphasize this ritual, two microphones placed on the side of the face help amplify and carry the sound of the voice in different ways: breathing out is carried frontally and treated using ordinary reverberation; breathing in, on the contrary, is carried at the back of the hall and treated using long, unnatural reverberation and with a slight echo effect.[6]

The voice is the pivotal element and driving force in the composition, because its breathing rhythm marks the harmonic rhythm of the instrumental part, as well as the transformations in terms of density and volume.

6 The amplification of the instrument ensemble, on the other hand, is of the ordinary type which means that dynamic levels and any reverberations should be established depending on the acoustics of the hall.

Formal articulation

The composition, according to Romitelli, follows a cyclical form and involves the repetition of three states:

1. Respiration lente et régulière, polarisation harmonique, registres instrumentaux gelés, fusion : situation homéostatique, immobile, suspendue. Souffle;
2. respiration accélérée, temps d'inspiration toujours plus bref, crescendo dynamique et agogique, croissance exponentielle de la densité et des volumes, accélération du rythme harmonique et de distorsion, accentuation des transitoires d'attaque au point de produire une perturbation et une distorsion dans la perception des hauteurs;
3. articulation rapide et violente, fin du mouvement inspiration-expiration dans la voix, nouvelle polarisation et régularité extrême du rythme harmonique devenant presque hypnotique, aucune fusion des instruments mais un unique geste furieux (Romitelli 1996).

The phases of the breathing cycle are repeated three times within the composition, which means that it is actually tripartite. There is a *coda* at the end of the piece. The three states are clearly recognizable in the first two parts of the composition, where the linearity of the process leaves no room for doubt. Part three, instead, appears to be more articulated.

Following the categorization suggested by Pottier (see Pottier 2009), the three states described by Romitelli have been assigned the letters **A**, **B** and **C**, to indicate staticity, acceleration and 'rapid and violent' articulation respectively.

The type **A** sections can, in turn, be divided into two sub-sections. The first (**A'**), serves as a sort of prelude (harmonic material with few notes, fixes instrumental register, total staticity). The introduction of the electronic part marks the beginning of the next subsections, **A''.**

A process of constant and gradual timbre transformation is thus started, where the different chord aggregates are perceptively very similar to one another. In spite of the slightly increased sound density (Figure 7) the feeling of immobility still remains.

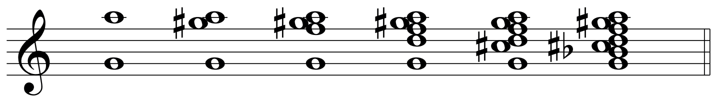

Figure 7. Gradual increase with regard to harmonic density in section A'' of part one.

In the B-type sections, very short breathing-in phases are followed by a strong, assertive vocal articulation, which triggers rapid movements in the instrumental ensemble, such as arpeggios and *glissandi*. These phases alternate with others where individual sounds, without their attack transition, fuse together with more contained dynamics. Global dynamics therefore range between *sforzato* and *pianissimo*; the sound density is high. The harmonic aggregates are clearly differentiated and inserted within a time compression process. Distortion, considered both harmonically and as a synonym of saturation – in the electronic part there are actually distorted sounds of electric guitar and electric bass – is used systematically.

The 'rapid and violent' articulation mentioned by Romitelli becomes apparent in the C-type sections. The rhythmic component is highlighted, to the detriment of sound density, which tends to become rarefied. The harmonic rhythm is once again eliminated, the timbres of individual instruments emerge clearly while in the vocal part, if present, individual melodic cells are repeated almost 'compulsively'. To counteract the rapid articulation of the ensemble there are synthesis sounds recorded in the electronic part and the distorted sound of an electric guitar produced by a sampler. The violent character of C sections is indicated by means of agogic indications such as 'furioso', 'con estrema violenza', 'molto ritmato', 'martellato', 'sempre ***f***', 'brutale'.

The formal specificity of part three

The structure of the first two parts of the composition is A (A'+ A''), B, C; the internal articulation of part three, on the other hand, is unusual, both because of the introduction of new sections and of the fragmentary features of C (C', C'' and C'''). There are actually: a sort of interruption in the process

(R) in the place of A'', a hybrid section characterized by elements from both A and B (AB) in the place of B, a constant *crescendo* (D) to separate C'' from C''' (Figure 8). It is within this framework that Romitelli's words become particularly significant:

> On cherchera en vain dans cette pièce élégance et harmonie de proportions, équilibre formel et transformations graduelles et linéaires. En revanche, j'ai exhibé l'aspect obsessionnel et violent, répétitif et visionnaire, oscillant entre une extrême densité et une extrême raréfaction (Romitelli 1996).

The composition ends with a *coda* with dynamics ranging between ***p*** and ***ppppp*** and the ensemble and electronic parts totally merge. A sequence of chords is gradually flattened here, leading the final two strings of the double bass being out of tune, in a process which gradually leads to silence in the final measure.

In summary, the structure of the composition can be drawn as follows:

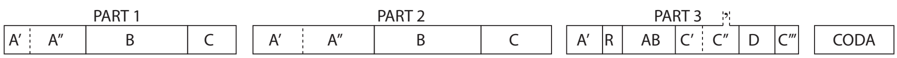

Figure 8. Macro-structure of EnTrance.

ANALYSIS OF SECTION 1B

Computer-based sources, more specifically *Patchwork* patches, make it possible for the analyst to follow the creative process and thus survey in detail the harmonic structure of the composition.

An example of this is section 1B. The analysis of the files on a CD preserved at IRCAM[7] shows that the harmonic component has been calculated starting from a melodic line:

7 Paris, IRCAM, 1996. Cd *Philips* CD-R 74, file system: Mac OS standard [HFS], created on 15 February 1996. It includes heterogeneous sources used for the first performance of *En-Trance* on 26 January 1996: electronic part, *SampleCell* sampler and *Yamaha SY99* synthesizer patches. It also contains files used for the composition of the electronic part.

Figure 9. Basic melody for section **1B** *with the relevant frequencies.*

Following a strictly spectral procedure, each note becomes a fundamental within a spectrum consisting of 30 partials which shall be called **S**. The spectra, however, are not harmonic because they are distorted with different coefficient (Figure 10), perfectly in line with the procedures described by Murail to outline his idea of *harmonie fréquentielle* (Murail 2004, 204).

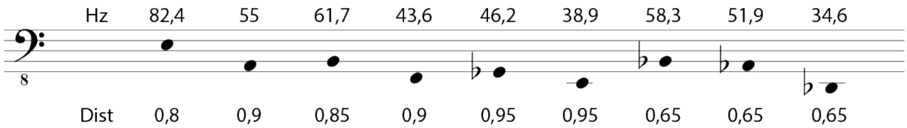

Figure 10. The same melody with detail of distortion coefficients.

To calculate the frequencies in the spectra, Romitelli probably used the following function written in LISP language:[8]

```
(defun dist(part freq dist)(let ((res))
(dotimes (n part res)
(setf res (cons (* freq (expt(+ n 1) dist))res)))
(reverse res)))
```

Figure 11 is a transcript in musical notation of the first two spectra (**S**^{1} and **S**^{2}) obtained by Romitelli (30 partials).

The spectra are thus orchestrated in the score, producing an effect of timbre merging and reminding us of the spectral instrumental synthesis technique.

8 Definition of the function 'dist'. 'part' is the number of partials, 'freq' the fundamental frequency, 'dist' the distortion coefficient.

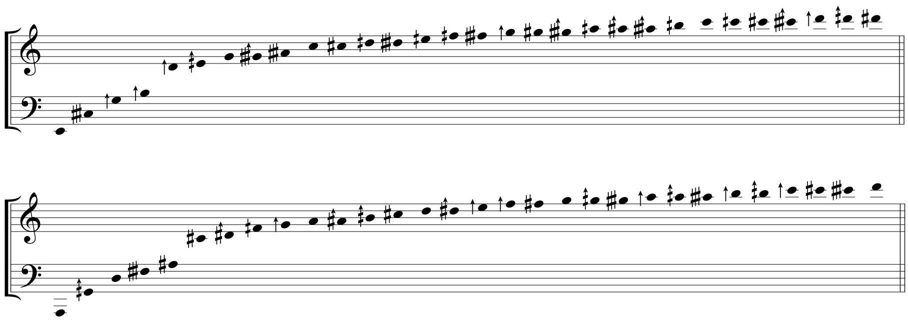

Figure 11. Distorted spectra **S** *starting from E1(*$\mathbf{S}^1$*) and A0 (*$\mathbf{S}^2$*). The frequencies have been approximated in traditional notation (eighth-tone resolution).*

Section **1b** is divided into nine subsections, equal to the number of distorted spectra **S**. Figure 20 at page 438 shows the first ten measures in the section (measures 41-50 of the score), corresponding to the first subsection. Here, the orchestration of $\mathbf{S}^1$ can be found in measures 46-50, and is shown in blue.

To understand how Romitelli worked in the first five measures of the example (41-45), a *Patchwork* patch, 'chds-secT', can be helpful (Figure 12). This patch, although quite straightforward – being a concatenation of chords – provides a set of nine aggregates (to which the letter **T** has been assigned)[9] that anticipate the basic spectra **S**.

To shed light on the techniques used to produce these new aggregates from basic spectra, reference should be made to the hard copies of composition sketches preserved by Pottier. An example of this is subsection two, defined by the distortion of the spectrum on *A0* ($\mathbf{S}^2$). The composer has chosen some partials taken from the reference spectrum: partials 6, 9, 10, 12, 15, approximated to the semitone (Figure 13, step 1). On the first interval, C♯4 - G4, Romitelli set a symmetry axis which divides the tritone in half; the axis is thus on E4. At this point there is a reflection of the intervals (step 2). Finally, the new notes are transposed two octaves upwards (step 3).[10]

9 It is worth mentioning that the letter **T** is also used by Romitelli to indicate the whole section of the electronic part corresponding to **1b**.

10 This system is not strictly applied for the construction of all nine aggregates in section **1b**. There is indeed noticeable freedom in positioning the symmetry axis, as well as the 'selection', 'discarding' and 'addition' of notes.

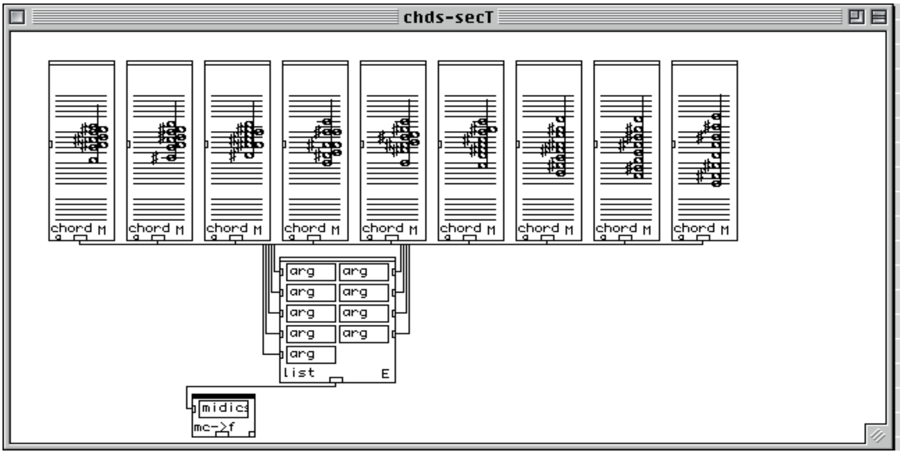

Figure 12. Patchwork *patch with nine aggregates* **T** *used in each subsection.*

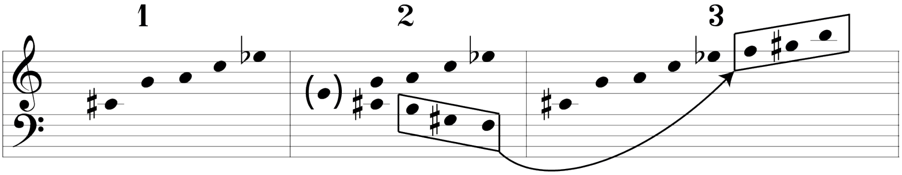

Figure 13. Procedure to create the aggregate $\mathbf{T}^2$ *starting from* $\mathbf{S}^2$*. Step 1: choice of partials; step 2: interval reflection on E4; step 3: upwards transposition of the notes obtained.*

The nine aggregates **T** were obtained using combinatorial techniques similar to those introduced in the case of *Pertinence du timbre*. They are directly related to the respective distorted spectra **S**, anticipating them (the aggregate $\mathbf{T}^1$ is highlighted in red in Figure 20), but the underlying composition idea is very distant from spectral aesthetics.

The nine subsections of 1B can in turn be regarded as bipartite: the aggregate **T** obtained through interval procedures and the spectrum **S**. The transition between these two harmonic situations is made smoother by the notes in common, most of which are played by brass instruments.

There are still other aspects to be clarified. The articulation in measures 44-47 of marimba, keyboard II and violins, highlighted in green in Figure 20, reintroduces aggregate $\mathbf{T}^1$**.** The individual notes, though, are exposed both to the pitch defined by aggregate $\mathbf{T}^1$ and transposed sometimes up to three octaves upwards. The interval relations between notes are thus not preserved.

Mention should then be made specifically of the arpeggios and *glissandi* found in measures 41 and 43, which are highlighted in yellow in Figure 20. Here the basic materials, also from aggregate $\mathbf{T}^1$, undergo a further combinatorial procedure: by placing a symmetry axis on the first of the aggregates, Romitelli produced by inversion a new reserve of sounds (Figure 14).

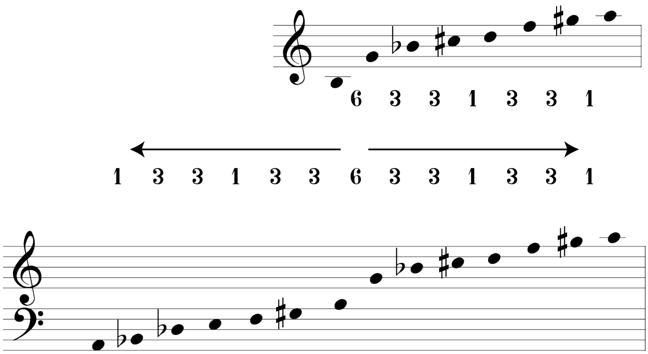

Figure 14. Interval inversion of aggregate T^1.

In measure 43, the arpeggios played by woodwinds draw directly from this material, as can be seen from Figure 15; brasses and strings play *glissandi* whose origin and destination is in the notes just selected.

The procedure chosen for the composition of arpeggios in measure 41 is similar to the one described above, except for an upwards transposition. This is done in such a way as to hit *F* on the last note of the arpeggios (Figure 16).

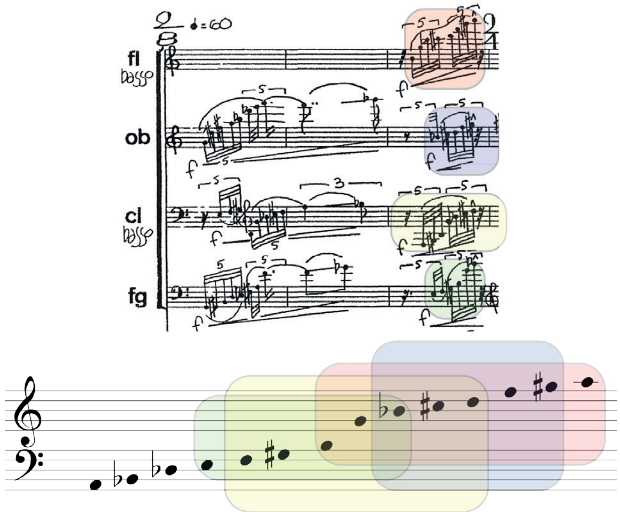

Figure 15. Detail of the source of arpeggios by wood instruments in measure 3: bass flute (red); oboe (blue); bass clarinet (yellow); bassoon (green).

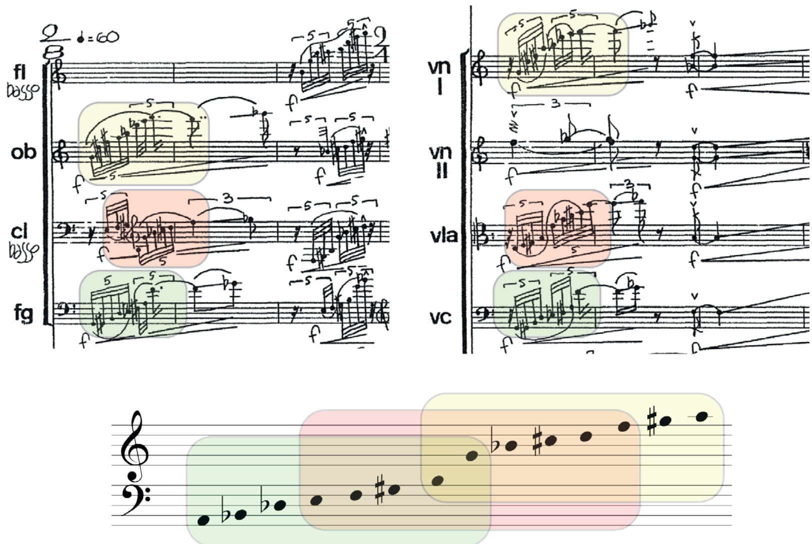

Figure 16. Detail of the arpeggios in measure 41: oboe and violin I (yellow) are transposed by a minor sixth upwards; bass clarinet and viola (red) are not transposed; bassoon and cello (green) are transposed by a major second downwards.

Also the soprano part which triggers the whole section 1B (Figure 17) is related to a transformation of the aggregate $\mathbf{T}^1$. In actual fact, eliminating the lower note from aggregate $\mathbf{T}^1$, the *B*3, and transposing the two higher notes one octave lower, *G#*5 and *A*5 – that is to say compacting the melodic material within the octave – the result is precisely the soprano part (Figure 18).

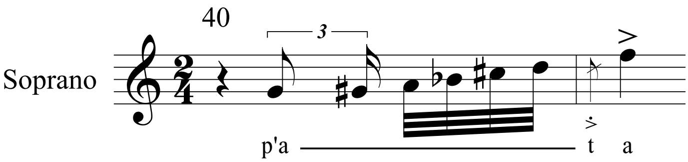

Figure 17. Soprano. Measures 40-41.

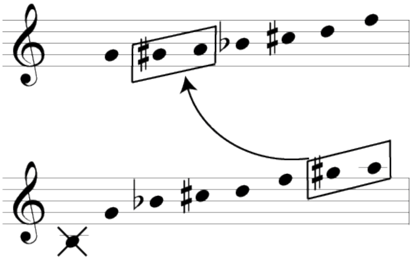

Figure 18. Combinatory procedure for the scale sung by the soprano.

To sum up, the whole section 1B can actually be seen as consisting of nine subsections, one for each note in the germinal melody. Each of these subsections, in turn, is then divided into two: aggregate **T** with its transformations which is followed by the distorted spectrum **S** from which it was generated. After these nine subsections there is a final *codetta*. The harmonic component is part of a time compression, therefore acceleration, process (Figure 19).

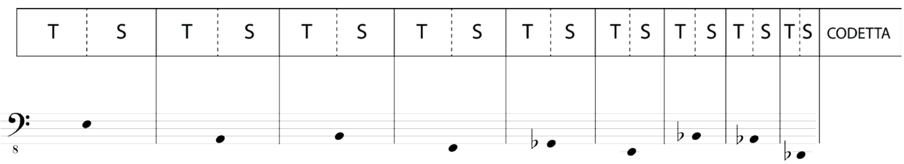

Figure 19. Formal articulation of section 1B.

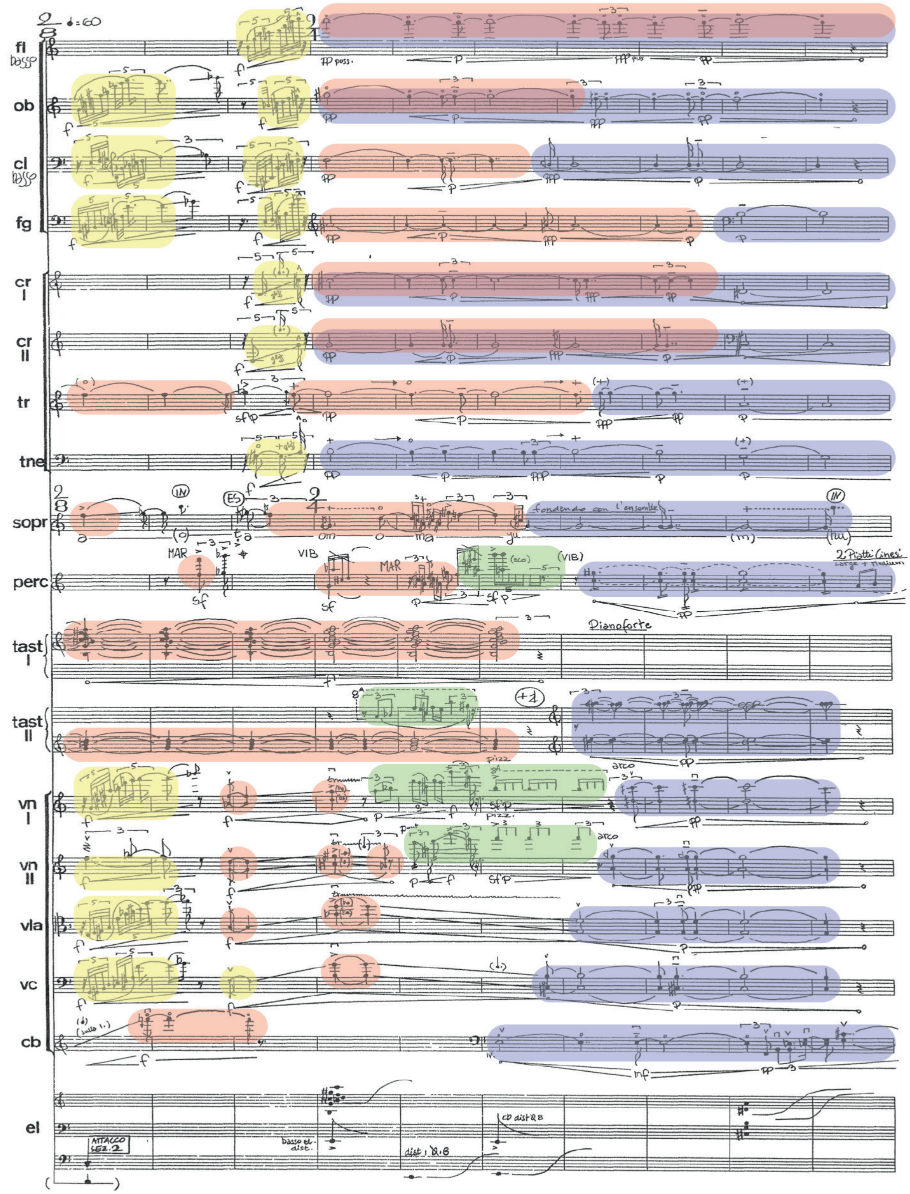

Figure 20. Fausto Romitelli, EnTrance*, p. 5, measures 41-50. In blue, the orchestration of the spectrum* S^1*; in red the aggregate* T^1*; in green, octave transpositions of the notes in aggregate* T^1*; in yellow, arpeggios and* glissandi *produced by reversing aggregate* T^1*. Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy.*

THE ELECTRONIC PART IN SECTION 1B

The electronic part in section 1B consists of percussive sounds (*pizzicato*) and dual-hairpin enveloping sounds (*crescendo-diminuendo*), both recorded and synthesized.[11] Romitelli and Pottier used three techniques for sound generation: sampling, FOF (formant wave-function) synthesis and variable wavetable synthesis. The parameters for sound synthesis have been processed through the *Patchwork* environment.

Sampling

The samples used in the part under examination derive from the recording of an electric bass played by Kasper T. Toeplitz. The instrument, treated with distortion, was played traditionally with the fingers or using 'picks' and 'bows'. The sounds were then edited in the electronic part; the fundamental frequencies of the electric bass correspond to the fundamental frequencies of **S** spectra.

FOF *synthesis*

This type of synthesis has generated sounds of a percussive nature called 'datachantfof-cb'. The FOF synthesis used for *EnTrance* is based on a *pizzicato* double bass resonance model, originally developed in *Chant* by Jean-Baptiste Barrière. However, it was altered:

> Seuls les partiels d'une largeur de bande inférieure à 1,5 Hz – c'est-à-dire ceux qui ont les durées de résonances les plus longues – ont été conservés et leurs largeurs de bande ont été multipliées par trois pour augmenter les durées de résonances. Chaque résonance a été dupliquée et transposée au quart de ton supérieur pour enrichir le modèle (Pottier 2009, 188).

11 An important contribution to understanding the nature of these sounds comes from Laurent Pottier's PhD thesis, where ample space is dedicated to the various synthesis techniques which he used with Romitelli (see Pottier 2001).

This model has been adjusted using the possibilities offered by *PW-chant*, a *Patchwork* library which is able to provide a visual graphic interface to the *Chant* synthesizer. Unfortunately, tough, in this case it was not possible to access the patches.[12] To analyze the sounds based on FOF synthesis and understand their connection with the harmonic model, there are two different paths: reading score annotations and analyzing individual sounds.[13] On the score, Romitelli noted the percussive sounds, highlighting their fundamental frequency – using traditional notation – and spectral distortion coefficient (Figure 21).

Figure 21. Fausto Romitelli, EnTrance*, p. 5. First subsection (measures 41-50). The percussive sound based on the resonance model of a pizzicato double bass is highlighted in red (Cb). The distortion coefficient is also indicated (0.8). Copyright Casa Ricordi – Courtesy of Hal Leonard MGB, Italy.*

The FFT analysis of synthesis sounds shows good approximation of the frequencies calculated for distorted spectra **S**. The sound frequencies in Figure 22 belong to the *E*1 spectrum (**S**¹). This is further evidence that also FOF synthesis-based sounds are anchored to the various spectra **S** underlying section **1B**.

12 The *PW-chant* library was created for *Patchwork* versions developed for *Apple* systems using *Motorola* processors of the 68k series. When PowerPc microprocessors, incompatible with the 68k technology, became widely used (1994) *Patchwork* had to be totally rewritten together with the various libraries. The same is not true in the case of *PW-chant*, which remained anchored to the previous architecture. It has not been possible to find a compatible and sufficiently performing workstation which could correctly execute the software.

13 The CD kept by IRCAM contains most of the synthesis sounds which were then edited in the electronic part.

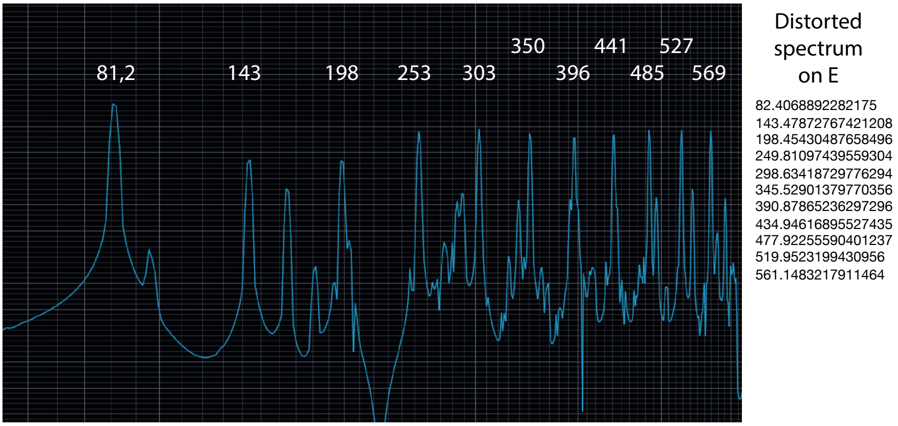

Figure 22. FFT analysis compared with the frequencies obtained by distorting the spectrum **S**[1]. *Analysis conducted with* iZotope RX 4. *Window "cos3" of 32768 samples.*

Variable wavetable synthesis

This type of synthesis makes use of the possibilities offered by digital oscillators of generating a complex sound starting from a single oscillator. The digital oscillator, in actual fact, repeatedly reads a table of values which describes the period. In the variable wavetable synthesis the oscillator table changes over time, in a gradual transformation process from an initial to a final form. The transition between two tables occurs by interpolating the numerical values of individual points. In *EnTrance* this synthesis is entrusted to *Csound*, but in order to facilitate manipulating the various parameters Pottier used the *Patchwork* environment with *SpData*[14] and *Csound/Edit-sco* libraries.[15]

14 *SpData* is a *Patchwork* library used for reading, writing, transforming and studying digital data from different software products which are dedicated to the spectral analysis of sound – *AudioSculpt*, to mention just one (see Pottier 1997).

15 The *Csound/Edit-sco* library, developed by Laurent Pottier and Mikhail Malt at IRCAM, and introduced in 1993, provides a set of modules for *Patchwork* aimed at generating *scores* for *Csound*. It makes it possible to take advantage of the algorithmic and graphical capabilities of *Patchwork* to manipulate the data used for synthesis, such as frequencies, amplitudes, durations and tables (see Malt, Pottier 1996).

In 1B, the variable wavetable synthesis has been used to generate three types of sounds, respectively named 'celldist', 'V91' e 'V04'.

'celldist' sounds. The synthesis of 'celldist' sounds is based on an acoustic sound of a cello. The waveform table actually derives from the analysis of its first 10 partials. The goal was not merely re-synthesizing the cello sound, but rather to generate a sound at the same time complex and distant from the perception reference of the acoustic instrument: «chaque son synthétisé était destiné à être employé comme un son partiel faisant partie d'un son plus complexe» (Pottier 2009, 186). The final sound is obtained by taking each of the 30 partials of the distorted spectrum **S** as the fundamental frequency for controlling the synthesis table. Unlike mere additive synthesis, obtained through the overlapping of simple sinusoids, the wealth of harmonics provided by the processed sound of a cello creates a complex spectrum, in a procedure which is very similar to the instrumental synthesis spectral technique.

To generate the synthesis parameters, Pottier created a *Patchwork* patch (Figure 23). Unlike in FOF synthesis, in this case accessing the patch did not create any difficulties: the *SpData* and *Csound/Edit-sco* libraries have been developed for the *PowerPC* architecture, still available on workstations which are old-fashioned but functioning or which can be emulated. The first highlighted box in Figure 23 shows the incoming variable '*distchds*', a result of a spectrum distortion function evaluation in LISP. The second box shows the cello sound analysis reading using *SpData*: the 'const' module calls back the file 'cello-add-extt1sec.format', which includes the harmonic analysis obtained with the *Diphone* software.[16] The third box includes module 'edit-sco-obj', whose task is to aggregate all calculated parameters and write the *score* file for *Csound*.

Pottier also kept the individual *score* files. Their analysis is evidence that also sounds of the 'celldist' type, such as those already generated by FOF, are produced on the basis of distorted spectra **S**.

16 Communication with Laurent Pottier.

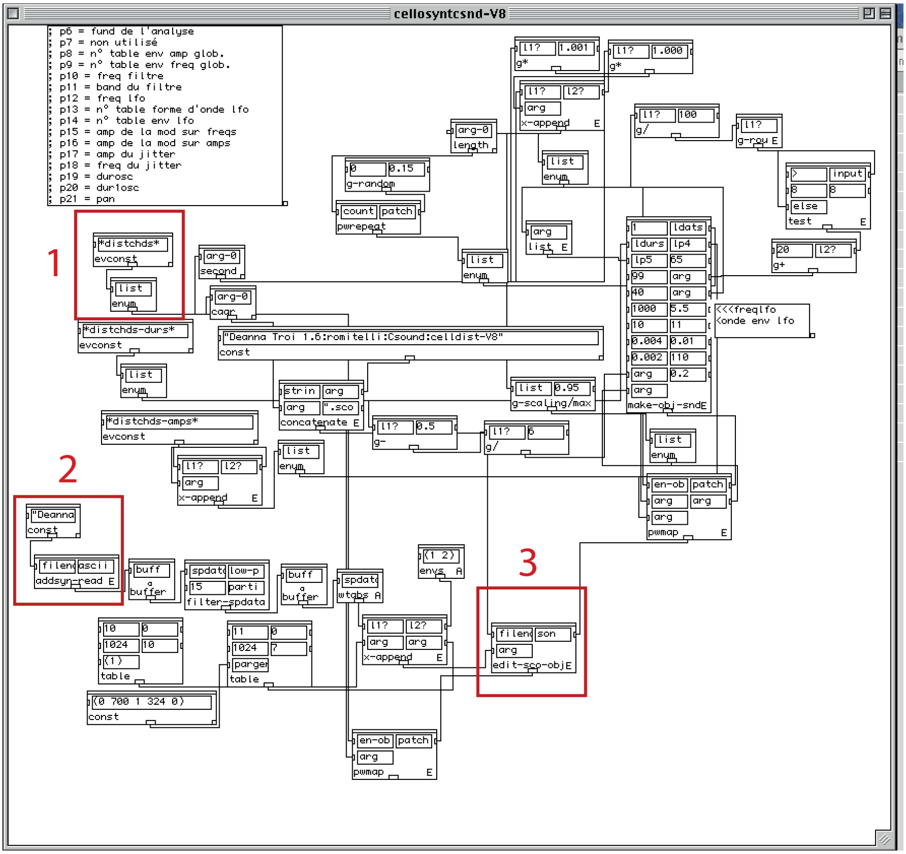

Figure 23. *'celldist' sounds. Patch to generate score files for* Csound. *Boxes 1 and 2: incoming data; box 3: file writing.*

'v91' sounds. Also sounds 'v91' and 'v04' were produced by variable waveform synthesis in the *Patchwork-Csound* environment. In these cases, however, no instrumental model has been used. The study of the patches and *Csound* files helps clarify their actual harmonic content.

'v91'-type sounds are anchored to the frequencies defined by aggregates **T** (Figure 12). The *Patchwork* patch used to produce them (detail in Figure 24) shows that the frequencies of aggregate **T** undergo multiplication by two different factors: 1.0006 and 1.001 (modules highlighted in blue).

The *Csound* score file generated thus include:

- The frequencies of the aggregate **T**;
- the same, multiplied by 0,0006;
- the same, multiplied by 0,001.

All this results in a complex and rich sound.

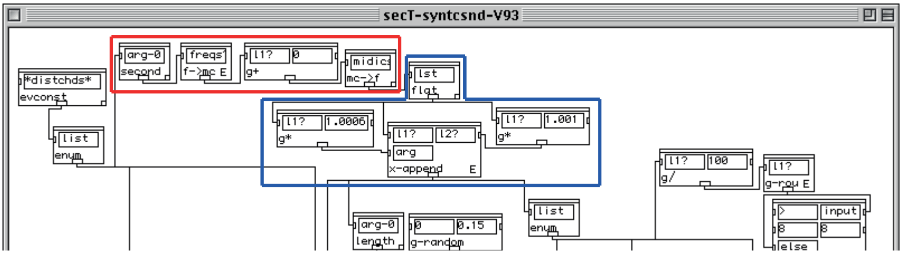

Figure 24. Patch for writing Csound *files for 'v91'-type sounds. Detail.*

To produce the audio file a *Csound* code was used, originally developed in May 1992 by Pottier and changed for the occasion in 1995. The resulting sound is defined by the sum of seven separate oscillators. It is interesting to note how the frequency of individual partials which make up the sound is 'disturbed' by an aleatory component and by a low-frequency oscillator (LFO) which in this case produces both a *vibrato* and a *tremolo* effect.[17]

In the folder of the CD kept by IRCAM which includes the 'v91' files there are, however, 18 score files, which generate two sounds for each subsection, differentiated exclusively by the transposition by one eighth-tone. How does this transposition occur? With regard to the patch in Figure 24, it is worth mentioning that there is one block dedicated to interval transposition in cents (highlighted in red). It is sufficient to enter the value 25 (one eighth-tone in cents) and revalue the whole patch to generate other score files. Sounds with frequencies derived from the model and transposed sounds will then be overlapped, as described later, during the final editing phase, to produce beats.

17 An LFO can control different parameters such as frequency (producing a *vibrato* effect), amplitude (*tremolo*), filter (*wah-wah*) etc.

'v04' sounds. By contrast, the harmonic materials of sounds 'v04' comes from a selection of frequencies taken from the distorted spectra **S**:

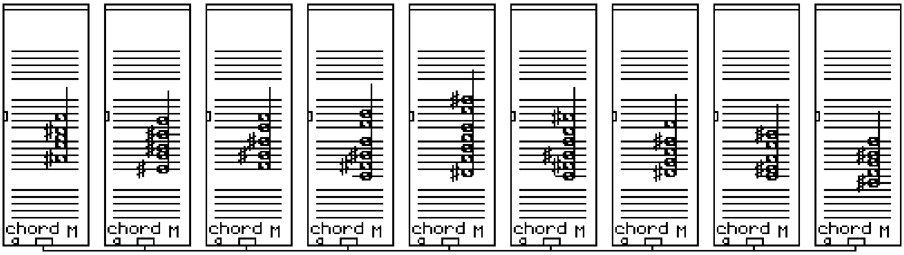

Figure 25. Selection of components of the nine spectra **S***, approximated to the semitone.* Patchwork *patch.*

The sounds 'v04' are produced by the same underlying code which is used for sounds 'v91', with a few further added modifications. More specifically, the synthesis here is limited to the sum of three oscillators. Also in this case, beats can be expected. Here, however, the latter are not generated during the final editing phase, but rather created directly within the *Patchwork* patch used to generate score files. As can be seen clearly from Figure 26 (part highlighted in blue), similarly to what happens with sounds 'v91', also here the selected frequencies from the spectrum **S** are subject to multiplication, to generate other components enhancing the sound. In this case there are three factors involved: 1.0003, 1.001 e 1.01. The latter, in particular, produces frequencies which, when overlapping with the original sound, are perceived as beats.

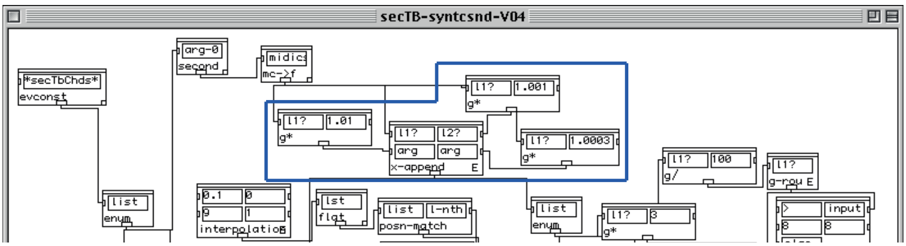

Figure 26. Patchwork *patch for writing score files for sounds 'v04'. Detail.*

Pro Tools *editing*

Also for the study of editing practices, reference can be made to the sources on paper kept by Laurent Pottier: some screenshots of the editing sessions in *Pro Tools*, which led to producing the final mix, shed light on the organization of the individual sounds described above. They include the positioning of sounds in the multi-track project and the volume automations. It is worth mentioning that there are sounds which are doubled and overlapped with themselves with a slight time lag. As already mentioned, these are 'v91' and 'celldist' sounds. In the case of 'v91' the aim of the overlapping is to produce beats; the time lag, on the other hand, serves a dual purpose: increasing the duration of the sound, especially in the case of 'celldist', then transform it through a *comb* filter. Once a single track has been produced, the latter is spatialized in the four channels used in concert.

SIMULATION OF THE EDITING PROCESS

The comparison between the electronic part licensed by the composer and the audio files included in the CD, supported by information about the *Pro Tools* sessions, has made it possible to simulate in a different technological environment the editing and mixing process of the electronic part in section **1B**. Figure 27 shows a reconstruction of the section with *Adobe Audition*.

Figure 27. Simulation of the editing process of section **1B** *with* Adobe Audition.

The possibility of studying the individual sounds provides the analyst with an exceptional opportunity. The irreversible nature of mixing processes, in actual fact, does not make it possible to discern constituting elements exactly, which means that their precise selection and analysis is impossible. The new editing, on the other hand, allows for a survey not only on the nature of individual sounds, but also on the relations between the electronic part and the score. More specifically it is possible to shed some light on the notes which Romitelli added to the system dedicated to the electronic part transcription. There is a perfect match between the notes produced using *Patchwork* and those written on the score (Figure 28).

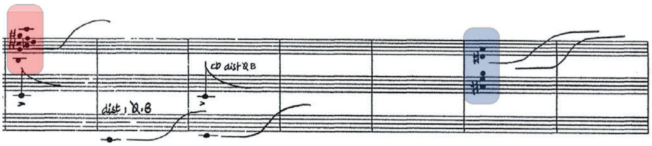

Figure 28. EnTrance*, p. 5. Measures 41-50. Electronic part annotations. In red the aggregate* $\mathbf{T}^1$ *('V91' sound), in blue the selection from the distorted spectrum* $\mathbf{S}^1$ *('V04' sound).*

On the other hand, analyzing the position of sounds, some inconsistencies immediately become apparent in the whole of section **1B**. It actually appears as if the position of all sounds 'V91' and 'V04' has been reversed (Figure 29).

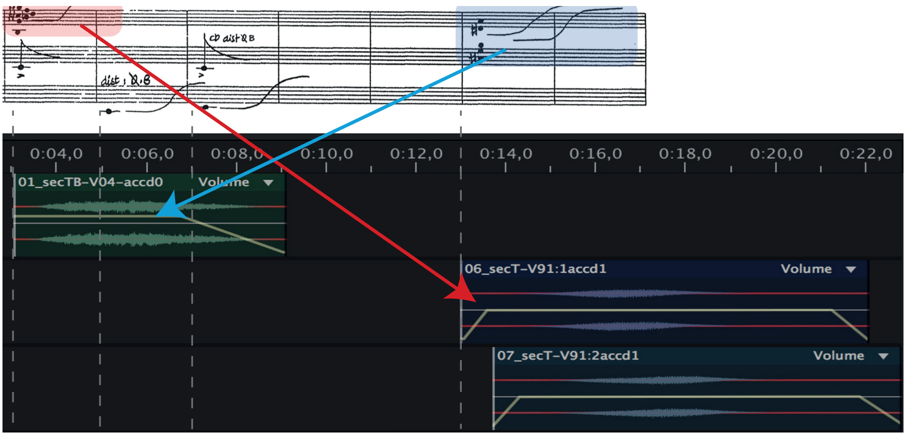

Figure 29. Reversal of the position of sounds 'V91' and 'V04' during editing.

How can such a deviation from the compositional model be explained? There are only two possibilities: second thoughts or editing error. In the first case the scenario would be that Romitelli, after adding the electronic references to the score, decided to reverse the sounds, based on listening and (possibly) by the better acoustic effect after editing.[18] It is necessary to keep in mind, however, some elements which make this hypothesis hardly plausible. First of all the study of notated sources – and most notably of stratifications in the scores kept as IRCAM – leaves no doubt as to the fact that any references to the electronic part were added in a highly advanced stage, when *EnTrance* was almost ready to be licensed. More specifically the scores preserved at IRCAM and used for the first performance are totally devoid of references. Moreover, in his writings and in his presentations of *EnTrance* the author always underlined his search for a perfect harmonic coherence between voice, ensemble and electronic part. More specifically, the presentation text for the composition reads as follows:

> En ce qui concerne la relation entre la voix, les instruments et l'électronique, nous avons, d'une part, une parfaite cohérence du point de vue du matériel harmonique, les fréquences étant les mêmes dans les sons de synthèse et dans l'ensemble (Romitelli 1996).

There is no denying that the reversal of sounds during editing undermines this harmonic coherence in the whole of section **1B**. Should one therefore start looking for an explanation of this inconsistency due to a material error in the course of editing?

18 This would be hardly surprising. The recording studio radically changed the relationship with writing music: the composer has become part of a complex system, in the position of performer and listener in his or her own respect, an active observer who determines constraints and adds emerging properties with a retroactive effect on the parts. These are properties which can be observed only empirically, not directly deductible from the reductionist study of individual parts and their relations, nor is it always possible to predict them based on preparatory materials, sketches, drafts and score (see Cossettini 2013).

CONCLUSIONS

EnTrance is the point of arrival of Romitelli's work at IRCAM, where the various composition techniques, used for previous compositions such as *Natura morta con fiamme* and *Mediterraneo I. Les idoles du soleil* with an approach which could still be regarded as experimental, become fully mature, as well as finding the possibility to coexist within an organized and original musical approach.

At IRCAM Romitelli tried to mitigate the opposition which had always existed in all musical writing, but which synthesis techniques (be they electronic or instrumental) and mixed music had made apparent: on the one hand the concurrence of simultaneous and continuous entities leading to a perception of timbre based on a categorization and projection process in the acoustic space, on the other side the sequence of entities characterized by discretization and hierarchical organization of discourse (see *Rapport IRCAM 1993*). This is, therefore, why *EnTrance* is so important: it is a demonstration by Romitelli from a musical perspective of how his aesthetic approach totally rejected this dichotomy. The solution for making sure that the two conceptual universes could coexist came exactly from CAC systems. Also through the development of original code, Romitelli created his own computer 'tool set' which combined analysis, manipulation of parameters and synthesis in a single modular environment, as well as directly conveying composition solutions both in musical notation and towards the scripts for sound generation. Thanks to the possibilities offered by modern CAC Romitelli produced a system which is at the same time conceptual and operational, allowing for harmonic fields rooted on dual control of the materials: the timbre is defined on the one hand by spectral procedures, on the other side by interval relations subject to combinatorial rules, the aggregates. This system builds a network of constraints which can determine the level of compatibility of timbre items, their 'proximity' measured also in aesthetic terms of continuity or clash (contemporary interpretation of classical concepts of tension and resolution), thus outlining possible pathways for their organization. In *EnTrance* the spectral moment precedes hierarchical structuring and provides basic material for the definition of aggregates. In this way, joining the two moments, the instrumental synthesis techniques adopted become part of musical discourse in their own right; being consistently integrated within the system, they are just one extra possibility.

In conclusion it is fair to say that, at IRCAM, Romitelli conducted an admirable synthesis between spectralism and combinatorial rules, to develop a totally personal composition system, mirroring his aesthetic approach, where constraints and possibilities assertively reaffirm freedom in artistic choices.

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Index of Names

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