Active Preservation of Luciano Berio's Audio Documents

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In December 2017 the project of restoring, digitizing, and cataloging the audio documents of Luciano Berio was completed after four years of work, leading to ca. 440 preservation copies.[1] The magnetic tapes generated by Berio over decades were originally stored among his private archives in various locations, e.g. at the Centro Tempo Reale in Florence or his home in Radicondoli. They contain his electronic compositions, concert recordings, audio sketches, and roughly 100 tapes with material recorded for the realization of *C'è musica & musica*, a television broadcast conceived by Berio and transmitted on Radiotelevisione Italiana (RAI) in 1972.[2]

The instability of magnetic tape as a storage medium has long been recognized and keeps archives busy around the world. Especially in the case of electronic or electro-acoustic works, where scores often do not exist, and audio sketches bearing portions of recordings in unfinished or discarded stages, the preservation of the material is crucial for a complete understanding of the working process. But although chemical and physical degradation of the carrier can be slowed down using optimized preservation strategies, it cannot be stopped entirely.[3] In consequence, the only way the information can survive is by abandoning its materiality and transferring the acoustic information onto new carriers.

Since the late twentieth century digitization has been considered the appropriate strategy for counteracting the inexorable degradation of audio

1 The project, commissioned by the Paul Sacher Foundation (PSS), was entrusted to the Centro di Sonologia Computazionale (CSC) of Padua University, and was coordinated by Sergio Canazza (CSC) under the musicological supervision of Angela Ida De Benedictis (PSS).

2 An earlier attempt at digitizing the Tempo Reale holdings proved fruitless owing to various technical and archival uncertainties. This made a new digitization unavoidable in order to ensure the archive's long-term stable preservation in keeping with PSS standards.

3 Federica Bressan and Sergio Canazza, "A Systemic Approach to the Preservation of Audio Documents: Methodology and Software Tools," *Journal of Electrical and Computer Engineering*, online journal (2013), 21 pp., esp. pp. 5–9 (doi.org/10.1155/2013/489515, article ID 489515, accessed on February 11, 2019).

documents.[4] But audio digitization has to become part of an *active* preservation process treated as a continuum in time, lest the information be exposed to the high risk of data loss or media obsolescence. Moreover, the simple transfer of audio signals as musical information to the digital domain will remain incomplete if it lacks the full metadata, i.e. the technical information on the original carriers and the recording and playback systems, plus a description of contents. Again, audio documents like those from the Luciano Berio Collection deserve special attention in this respect. Since such recordings are unique and resemble autograph manuscripts as primary sources, they were never edited and standardized for publication, and the bond between the recorded content and its carrier is indissoluble. Thus, the compound information packages needed to preserve a reel of tape in digitized form must contain the audio signal itself, the available technical and content metadata, and any kind of contextual information associated with the original object.[5] Examples from Berio's tapes show that this includes his manual annotations on the boxes and spools, and in some cases on the tape itself, indicating cuts or track breaks. Therefore the digitization process had to guarantee optimum preservation of both primary and secondary information.

Preservation Method

To fulfill these demands, the CSC adapted a method for the preservation and valorization of audio documents developed during fifty years of experience in the field of electro-acoustic music.[6] This active preservation method aims at producing a digital preservation copy that meets the criteria of authenticity, accuracy, and reliability. This is combined with an exhaustive documentation of the entire preservation process, including references to any restorative intervention performed on the original carrier.

The digitization of Berio's tape collection took place in three steps: carrier preparation, signal transfer, and data elaboration. Each step included several substeps involving different professions: engineers, audio technicians, musicologists, chemists, and archivists. Prior to the analog-to-digital (A/D) conversion, a complete photographic documentation was performed

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4 *The Safeguarding of the Audiovisual Heritage: Ethics, Principles and Preservation Strategy*, ed. Will Prentice and Lars Gaustad, IASA-TC 03 (London: International Association of Sound and Audiovisual Archives, 2005, [4]2017), available at www.iasa-web.org/tc03/ethics-principles-preservation-strategy (accessed on February 11, 2019).

5 See Carlo Fantozzi, Federica Bressan, Niccolò Pretto, and Sergio Canazza, "Tape Music Archives: From Preservation to Access," *International Journal on Digital Libraries* 18 (2017), no. 3, pp. 233–49.

6 Sergio Canazza, Giovanni De Poli, and Alvise Vidolin, "Visions of Sound: The Centro di Sonologia Computazionale, from Computer Music to Sound and Music Computing," in *Proceedings of the Sound and Music Computing Conference 2013*, ed. Roberto Bresin (Stockholm: KTH Royal Institute of Technology, 2013), pp. 639–45, online at smcnetwork.org/resources/smc2013 (accessed on February 11, 2019).

a)

b)

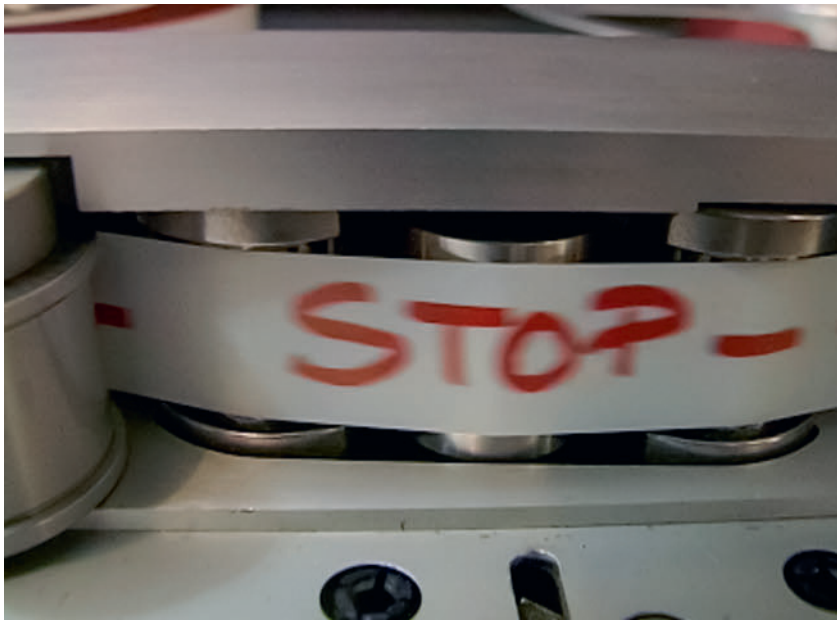

Plate 1: Still photos from the video documentation. a) visible damage of the tape, b) autograph inscription on the tape.

to provide evidence of the document's condition and to take note of all information related to the carrier, e. g. inscriptions on the tape or box, flange sizes, etc.

The correct recognition of degradation processes is complex, owing to the different chemical properties of each manufacturing material and brand. Taking this into account, it was necessary to document the preservation status of the objects beforehand and unwind all the tapes at low speed before processing the A/D transfer of the audio signal. This procedure is highly recommended, as it offered to recognize syndromes of tape binder breakdown.[7] In many cases, it was necessary to optimize the carrier, e.g. to repair defective splices or to substitute leader tapes. In addition, a video recording was made of the magnetic tape while unwinding during the copying process. This footage was integrated into the auxiliary information, completing the preservation copy for further studies by keeping track of corruptions or author's marks on the tape *(Plate 1, a–b)*. As many of Berio's tapes contain sketches and raw materials for his final compositions, it was not unusual to find multiple-speed recordings within the same tape, sometimes even differing between channels of the same tape portion *(Plate 2)*. Audio monitoring the entire transfer process was therefore crucial in order to recognize such events.

At the end of this stage, the preservation copies include the uncompressed high-quality audio file (wav file, 24 bit/96 kHz) and a full set of *technical* metadata, including the above-mentioned photos and videos, as well as a report on the condition of each tape.

Content Metadata and Access

Besides the general information on the respective archival provenance, all the *content* metadata had to be collected in an extensive research process. The goal was to combine all the technical and content metadata in a database in order to meet the conflicting demands of archive management and research interests with specific options for selecting and accessing the metadata and the digitized sound recordings. This database, specially tailored for the Berio tape digitization project, was implemented at the CSC in Padua and initially opened for the exclusive use of the specialists involved. They are currently inspecting and completing the data records on the digitized audio documents from various angles to ensure the consistency of the technical and content metadata, and to order the documents as accurately as possible within Berio's total œuvre. Once this stage is completed in 2019, the audio data and the associated metadata will be trans-

7 E.g. the soft binder syndrome and the sticky shed syndrome, which can be treated by baking the tape in a laboratory oven at 50–60 °C for a few hours. See Federica Bressan, Sergio Canazza, and Roberta Bertani, "'Honey, I burnt the tapes!' A study on thermal treatment for the recovery of magnetic tapes affected by Soft Binder Syndrome-Sticky Shed Syndrome," *IASA Journal*, no. 44 (January 2015), pp. 53–64.

Plate 2: Dynamic spectrum and analytical graph for recordings at different speeds and in different directions on one of the tapes.

ferred intact to the archival system of the Paul Sacher Foundation and made available to researchers in Basel.[8]

During the overall process of data acquisition, stable long-term archiving, and data provision, the audio archive of the Luciano Berio Collection will also be subordinated to the general archival strategy of the Paul Sacher Foundation. In this way the digital documents and associated metadata will be safeguarded and duplicated with the assistance of the Fonoteca Nazionale Svizzera (FNS) in Lugano, with all technical matters being entrusted to the FNS and all responsibility for content description remaining in the hands of the Paul Sacher Foundation. Researchers will then, for the time being, work in the archive using archival copies of the Berio audio data, as is the case with digitizations from all other collections. In the future, a server-based utilization system will render the use of intermediate media obsolete.

From this point, the archival and access technology might conceivably undergo further developments on which the CSC employees are already at work. For example, concepts might be developed to digitally simulate the technical and acoustic properties of historical equipment (such as multi-track tape recorders, record players, or tape decks) and to make them in-

8 The post-processing of the content metadata was carried out for the PSS by Claudia Vincis (Cagliari) on the basis of research findings from Angela Ida De Benedictis.

telligible on today's computer systems, mobile devices, or Web browsers.[9] As a technical foundation, the CSC is currently developing machine-learning algorithms for making specific properties of audio documents (equalization, editing on the tape, etc.) automatically recognizable in the future and to integrate them into the simulated analog playback instruments, with the long-term goal of reproducing the original analog listening experience as naturally as possible within the digital universe.

9 Sergio Canazza, Carlo Fantozzi, and Niccolò Pretto, "Accessing tape music documents on mobile devices," in *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, Special Issue on Smartphone-Based Interactive Technologies, Systems, and Applications, vol. 12, no. 1 (October 2015), 20 pp., online at dl.acm.org/citation.cfm?id=2808200 (accessed on February 11, 2019).