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Seizing the ephemeral: Recording Luigi Nono's *A Pierre Dell'azzurro silenzio, inquietum*, *a più cori* and *Post-Prae-Ludium per Donau* at the Banff Centre

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Nisi enim ab homine memoria teneantur soni,
pereunt, quia scribi non possunt.
(Isidore of Seville 622-633)[1]

questa concezione spaziale della musica
si rifà come principio alla scuola veneziana
del'500 sopratutto ad Andrea e Giovanni Gabrieli.
(Nono 1959, [2001; 435])

Objective

The goal of this interdisciplinary project (in musicology, acoustics, and computer science) is to make a digital recording of two late compositions by Luigi Nono (1924–90) involving live electronics: *A Pierre. Dell'azzurro silenzio, inquietum. A più cori* (1985) for contrabass flute in G, contrabass clarinet in B-flat and live electronics, and *Post-Prae-Ludium per Donau* (1987) for tuba in F (and live electronics). We intend to capture, for conservation, transmission and study, those aspects of Nono's late work that can not be notated conventionally. The project consists of two phases:

1. The production of a digital recording, capable of reliably reproducing the three-dimensional reality of the listening experience. This recording provides data for the second phase.
2. The study and interpretation of the acquired dataset with which we hope to better understand the sound field created by the work. The data will be analysed using traditional musicological methods, as well as using computational techniques, and will yield interpretive audiovisual representations of the performed works.

Problems and the objects of study

When embarking on a study of Western art music, we usually assume that this will involve an examination of a score. Our work will focus on musical works for which the score is an inadequate or incomplete source of information. Since the middle of the twentieth century, both popular and art music involving improvisation, aleatory techniques and the electronic manipulation of sound has been composed in ever-increasing quantities. The actions required to produce this type of music are described in the score, often in great detail, but in many cases the musical consequences of performance actions and techniques cannot be read in their entirety from the score. Many musicologists and theorists prefer to simply ignore this problem and concentrate on composers whose concepts and compositional techniques correspond to their tried and true analytical methods. This may explain, at least in part, why the work of composers such as Elliott Carter and György Ligeti has received more academic attention than that of Nono and Bruno Maderna. This paper looks at approaches that we believe will provide ways and means to overcome this problem: sketch studies on the one hand and the use of digital recording technology on the other.

A Pierre and *Post-Prae-Ludium* involve real-time manipulation of sound, producing micro-tonal variation and spatial distribution of sounds and, as noted above, these aspects have the effect of short-circuiting traditional musicological analysis. The musical scores provide reliable information for the preparation of a performance, however, as the editors admit "the acoustic and dynamic result [of a concert performance] will not correspond to the graphic notation" (Richard and Mazzolini 1996; xiv).

Sketch studies and the philology of electro-acoustic music

Not long after the dawn of the electro-acoustic age, Umberto Eco noted that the comprehension and interpretation of an artistic form can best be achieved by examining the formative process: "to trace the work in all its trials and interrogations of matter, in its response to and the choice of cues, in its intuition of what the inner coherence of the work wants to be" (Eco 1962 [1989; 163]). Referring to problems entailed in the analysis of new music composed during the second half of the twentieth century, Gianmario Borio (1999; 5–6) has observed that the study of the composer's working documents has become the sine qua non for the posing of valid analytical hypotheses. The compositional techniques, strategies and work concepts of much of this music are often neither audible in performance nor legible in the published score. Gaining access to these aspects of the work is essential if we are to come to a proper understanding of it and it is for this reason that the composer's working documents can be so vitally important. Of course, even when conserved in optimal conditions, these documents (sketches, drafts, plans, schemata, recorded material, verbal texts, etc.) always constitute a fragmentary source that is usually difficult to interpret. The creative process can never be reconstituted in its entirety. Nonetheless, through careful study, the scholar can extrapolate and generalise fundamental criteria, some of which may have left no visible trace (Decroupet 2004; 146–147). Thus the painstaking examination of the composer's working documents can open a window, which otherwise would remain closed. In a recent series of publications, Laura Zattra (2008, 2007, 2006) has successfully identified the scope, goals and methods of the philology of electro-acoustic music.

The Archivio Luigi Nono, established in Venice in 1993 by the composer's widow, Nuria Schoenberg Nono, conserves a well-catalogued collection of the vast majority of the composer's working documents. The study of surviving sketches

[1] Isidore of Seville, Etymologiarum sive originum libri xx, "De Musica XV." Unless sounds are remembered by man, they perish, for they cannot be written down. Isidore of Seville (cited in Strunk 1950; 93).

of *Quando stanno morendo. Diario Polacco N. 2* (1982) for two sopranos, contralto, bass flute, violoncello and live electronics has conclusively demonstrated that these documents do provide indispensible information, not only for a deeper, better-grounded interpretation of the composition, but also for an examination of Nono's evolving work concept, which underlies both his innovative notation and his experimental performance practice (Sallis 2006).

Phase 1: Digital recordings of Luigi Nono's works

The digital recordings of Nono's works will take the form of a multi-track collection that can be played back to reliably reproduce the spatial reality and listening experience of the original performances, and also provide data for the second, analytical phase of the project. We will record audio and other types of data (control data, video) in various stages of the acoustic and electro-acoustic chain, to allow: (a) a study of the sound transformation, and (b) reliable reproduction of the listening experience in time and space.

We aim to reproduce the concert environment of these works in two ways: by recording and reproducing the sources of the sound field in the concert hall (the sound emitted by the musical instruments and the loudspeakers), and by recording and reproducing the sound in the concert space using surround sound techniques.

Phase 2: Study and interpretation of recorded data

The acquired dataset will be analysed: (a) by traditional musicological (human) methods, (b) using computational (digital sound processing) techniques, and (c) using a combination of the methods, i.e. human ad hoc analysis with the help of facts discovered by computational processing of the data.

Discussion: Sound transformation, spatiality, and mobility

A performance of a late work by Nono (such as *A Pierre*) entails numerous interrelated sound sources: direct sound of the instruments, amplified sound of the instruments played back through multiple loudspeakers, amplified sounds processed by live electronics, and acoustical contribution of the concert hall (reflections, reverberation).

The processing of the sound and the loudspeaker configuration are prescribed in the score and performance notes. Electronic processing, amplification, and interaction among the sound sources lead to the following effects:

Sound transformation: Sound picked up by microphones is transformed through live electronics in time (delaying), in pitch (harmonizing), in timbre (filtering), and through reverberation.

Sound spatiality: A mix of direct sound and processed sound is diffused in space, that is, distributed to loudspeakers positioned in various places in the hall.

Sound mobility: The volume levels (dynamics) of the instruments and the sound played by the loudspeakers are independently controlled during the performance, as prescribed by the score. Consequently, the sound sources are mobile, that is, they dynamically change their perceived position in space.

Based on the published score and performance notes, we believe that the sound sources in *A Pierre,* together with the effects of the concert hall, create a full or half-sphere periphonic sound field, implicit in the composer's concept of the work. A height element is intentionally present in *Post-Prae-Ludium*: notes in published sketch facsimiles indicate that two out of four loudspeakers are positioned at a "normal" height, while the other two are "hoch" (high).

Recording: Groups of data tracks

The digital recording will be made of numerous tracks, synchronized in time, recorded and analysed in four groups:

1. **The initial sound sources** — the direct sound of the instruments. This group of tracks provides grounds for analysis of the instrumentalists' performance and comparison with the notated score: how the notated gestures, extended instrumental techniques, and options for free (improvised) interpretation of the score relate to the artists' rendering during performance. A supplemental video track that will aid the analysis of the instrumentalists' performance will be also made.
2. **Audio signals in various stages of the electro-acoustic chain.** We will record line levels of input signals, signals before and after signal processing units, and control (automation) signals. Analysis of this group will help us understand the process of sound transformation, i.e. how the component sound layers contribute to the ultimate audible result.
3. **The sources of the sound field in the concert hall:** the instruments and four loudspeakers. The tracks in this group can be used to reproduce the performance in the original hall, or in a similar space, by placing additional loudspeakers instead of performers and playing back the recorded tracks. Listeners could then repeatedly experience the concert event, or at least a close approximation of the sound environment.
4. **A quality surround sound recording**. A surround sound reproduction will be used to validate the re-created experience. A surround sound recording will presumably be closest to the listener's memory of the concert. This recording will provide an important source against which other data and partial reconstructions of the performance can be compared.

Surround sound and sound field recording

Our goal is to capture the sound events intended by the composer, not to reconstitute a listener's experience of those events which would have to take into account psychoacoustics and individual perception of music. We will focus on recording of one particular performance (instantiation) of the works, in the form of an authentic record of the original spatially distributed sound, in the concert environment intended by the composer.

We have examined the following techniques for surround (spatial) sound recording:

1. Binaural recording (using a dummy head, *kunstkopf*) records two tracks of audio signal with time, level, and spectrum differences to provide spatial cues. The recording must be played back through headphones (not through loudspeakers), the listener cannot change his position or orientation, and the recording does not allow computational analysis of the sound field. *Consequently we do not feel that this method would be useful for our purposes.*
2. Wave Field Synthesis (WFS) technique (also called *holophony*) records sound waves by a large array of microphones positioned on a defined spatial boundary. During playback, a similarly positioned array of loudspeakers resynthesizes the sound waves, and thus recreates the original sound field. This recording technique captures, theoretically, the most authentic image of the spatial sound. Computational analysis is possible. *However, the large required number of microphones and loudspeakers makes this technique impractical*.
3. Surround sound microphone arrays and sound field microphones — small arrays of microphones or microphone capsules. Surround sound microphones typically map each individual capsule to the audio channel that will be played back by a specific loudspeaker. Sound field microphones are symmetrical assemblies of almost coincidental capsules, not directly mapped to loudspeakers. *We believe that the soundfield recording technique is appropriate for this project.*
4. Current literature also reports on experiments with various custom microphone arrays (Grenier and Guillaume 2007). Custom arrays consist of a larger number (approximately twenty to fifty) omnidirectional microphones in various spatial configurations. The diameter of the required space is determined by the wavelength of the lowest frequency which needs to be recorded (approx. 30 cm for 1 kHz). *Although we believe that such a technique would be beneficial, its experimental nature goes beyond our current expertise.*

We will record the performances both by a commercial surround sound array (provided by the Banff Centre), as well as by a soundfield microphone (Soundfield MKV microphone from the University of Calgary) that will produce an ambisonic recording suitable for computational analysis.

Analysis of the recorded data

We plan to use various computational methods in support of more traditional musicological analysis:

Spectrum analysis and pitch detection (producing spectrograms), to assist with transcription of the recorded sound into a notated form.

Correlation of signals, in the form of spectrum or amplitude images of the recorded sound, to search for common or repeated patterns. In particular, we plan to develop and use a technique based on self-similarity matrices (Jehan 2005, Orio and Zattra 2008).

Sound field mapping, to detect mobile sound sources and visualize their trajectories through space in time.

These methods will be applied to recorded groups of data tracks, respectively:

1. **Instrument sound and instrumentalists' performance:** Like Renaissance and Baroque tablature systems, the scores of *A Pierre* and *Post-prae-ludium* carefully prescribe in traditional notation what the instrumentalists must do, with annotations that indicate a range of extended techniques to be used, such as multiphonics, harmonics, whistles, etc. Recording of the direct sound will allow us to produce an augmented score (that is, a visual, symbolic representation) that will show the full range of sounds that were produced by the instruments. Spectrograms can help the transcription of recorded sound to a score, especially in those cases in which pitch content is manipulated microtonally, and cannot be represented using conventional notation.
2. **Transformed signals within the electro-acoustic chain:** The sound signals recorded (probed) in various points of the sound transformation chain: variants of the original sound transformed in time, pitch, frequency spectrum, etc. Spectrograms and self-similarity matrices of the signals in various resolutions will help us to identify patterns in the signal, such as musical phrases or motifs.
3. **Sound supplied to the hall:** This group of tracks will allow playback of the performance, through loudspeakers in the same positions as they were in the performance; in the original hall, or in a similar space. Listeners can thus repeatedly experience the work.
4. **Recorded sound field:** The recorded ambisonic sound field data will be used to produce sound field maps, graphically representing distribution of sound energy, its spectrum, and its evolution in space and time.

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