Issues of Ubimus Archaeology: Reconstructing Risset's Music

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ABSTRACT

This paper discusses questions of ubiquitous music archaeology within the context of reconstructing Jean-Claude Risset's music with MUSIC V. We begin by situating the field of ubimus archaeology as it overlaps with the area of software archaeology. We then explore the theory, where issues of sustainability, archival, reproduction, and recovery come to the fore. The next sections apply these ideas to a specific case, that of the reconstruction of computer music from original sources. We look at the work involved in restoring MUSIC V from its original Fortran code, and the attempt to bring it to a state where the music of Risset can be reconstructed in a modern computing environment. This involved extensive archival work to rescue and reassemble his original score files. The paper concludes with an overview of the current state of this project, some preliminary results and the next steps.

1. INTRODUCTION

Whether we look at the rate of change of computing power or at the way we conceptualise music making, over the span of six decades the design of computing tools has impacted how we create and how we experience music. The rapid changes of techniques and of the material support for planning, execution and sharing of technological resources sometimes obscures our vision of the state of the art of musical endeavours on the one hand, and of the extant knowledge inherited by current practises on the other. Take as an example the emerging field of ubiquitous music (ubimus) [1]. The emphasis of some ubimus approaches on the development and enthusiastic adoption of innovative design techniques could be misread as a dismissal of the previously acquired knowledge through a long legacy of music practises. This interpretation is wrong. To prove this point, Lazzarini and Keller [2] report the results of three "archaeological excavations" of the original versions of historically significant music-programming environments, MUSIC V, cmusic, and Csound. They label this endeavour *ubimus archaeology*.

Ubimus archaeology is conceptualised as a multi-stranded initiative that combines current technical know-how with applications that expand the frontiers of musical archaeology. Musical archaeology aims to increase our understanding of the past through the study of the material traces left by musical activity [3]. For music practises centred on the use of acoustic instruments, there is a fairly stable material base and a set of well-established methods to document and select the relevant information. As music-making starts to incorporate technological resources, it increasingly becomes dependent on the availability and maintenance of specific hardware and software. Consequently, music becomes as disposable as the resources enabling its existence. Some practises can be partially recovered through the documentation of their sonic products. But more often than not, the knowledge gained through the creative processes and through the community-shared musical experiences is lost. These aspects are key targets of ubimus archaeology.

In this paper we report work done to implement a functional replica of the MUSIC V acoustic compiler. This is a significant expansion of the work presented by Lazzarini and Keller [2], including the addition of tools to streamline the usage of the software and major adaptations to meet the requirements of current computer-music standards. Furthermore, we report the application of such work to the reconstruction of early works of computer music by Jean-Claude Risset. In line with ubimus archaeological objectives, we chose four targets that the artistic community considers worthwhile sonic and musical products of the past: *Little Boy*, *Mutations,* the *Introductory Catalogue of Computer Synthesized Sounds* and the *Computer Study on Trumpet Tones*, whose sources have been made available by the Fonds Risset of the PRISM laboratory. We include examples of the original files and furnish a description of the stages necessary to achieve successful replicas of creative processes based on technology previously thought to be extinct.

To frame our results, we situate the ubimus archaeology initiative within the context of ongoing efforts to increase the sustainability of both technological and musical practises. We also discuss emerging issues related to replicability and community-shared knowledge in an effort to expand the life cycle of creativity-support resources. Then we tackle the procedures of recovering MUSIC V from the ashes and point to the research avenues opened by its working replica. As an applied case, we describe the materials and procedures used in the partial reconstructions of the creative processes adopted by Risset in his projects from the sixties. We also include pointers to undocumented and original materials that may prove to be useful for future archaeological endeavours targeting Risset`s work. After a summary of results, we discuss the implications of this study for ubimus archaeology and information-technology design with an eye on potential future applications.`

2. ARCHAEOLOGICAL ENDEAVOURS AND RELATED WORKS

The widespread adoption of computational resources for music making and the increased presence of information technology in our daily life have opened both opportunities for innovative practices and an enormous can of worms of socio-cultural issues. Two aspects that have long-lasting consequences are the sustainability of the deployed infrastructure and the replicability of the procedures and products linked to the musical activity.

Replicability in music is doubly problematic. On the one hand, the standard methods of scientific inquiry have been expanded by the initiatives grouped under the rubric of practice-based research. This expansion changes the meaning of musical research and highlights the specific contributions of artists [4]. Artistic replicability may demand very stringent conditions that are not aligned with the expectation to obtain an identical product when applying the same procedures. Creativity-oriented support should foster diversity rather than mechanical replication. On the other hand, the dimensions of musical experience are not limited to the acoustic properties of sound. Yes, being able to freely and easily replicate a sonic product without introducing errors or degrading its quality is an important contribution of digital technology. But music-making activities involve a network of human and non-human resources with volatile symbolic associations that are difficult to understand just by analysing their sonic outcomes. Thus, replicating a musical experience not only entails recovering its material resources, it also involves engaging with the dynamic properties that emerge *during* the activity. As it will become clear when we discuss the methods employed in this project, these two layers of replicability involve complementary strategies.

Sustainability has emerged as a key aspect of technologically oriented musical endeavours [5, 6, 7]. Sustainable practices highlight the importance of a persistent material base for musical activities, including not only the tools needed to obtain sonic products but also the know-how inherited and produced throughout the technological design cycle. During the initial years of music-computing, the only places where it was possible to conceive and carry out artistic projects were the large research centres of universities and information-technology companies [8]. This restriction involved an infrastructure that demanded serious efforts of implementation. But on the positive side, over its first three decades of existence the infrastructure remained fairly stable. Today, the situation is completely different. We witness fast changes and widespread access to short-lived hardware, compounded with fast circulation of tools and know-how enabled by the internet. Thus, the tendency of software to become obsolete or unsupported has suffered a drastic increase.

How can we deal with the menace of disposable technology? Ubimus archaeology may open a window to the past that could furnish useful information on both the computational and the artistic strategies applied before, during and after the execution of a musical project. Some of these strategies may involve design choices that make sense at the specific historical context but over the years become conceptual culs-de-sac. Other strategies may survive as legacy approaches which linger on despite their drawbacks. And finally some of the early designs may prove their applicability in various contexts despite the sharp differences in social and aesthetic expectations between historical and current music practises.

3. MUSIC V

This section examines the recovery of a classic piece of software, the MUSIC V acoustic compiler, which was used by Risset to compose his works from the late 1960s onwards. It was written by Max Mathews, Joan Miller and others at Bell Labs using Fortran as the implementation language [9]. Although it was not the first of its kind written in a high-level language (as it was preceded by MUSIC IVBF from Princeton), it was widely shared and used in various places in the USA and Europe in the fifteen or twenty years following its creation. It is perhaps for this reason that we are actually able to recover it from sources and attempt to bring it to an operational level that allows us to reconstruct some of the music composed through its use.

3.1 System Structure and Operation

The structure and operation of MUSIC V follows more or less the design introduced by MUSIC IV. It takes in a score prepared by the user (the source code for the composition written using the MUSIC V language) and outputs a sound file. Originally, input was supplied in the form of punched cards and output was written to digital computer tape. There are three stages, or passes, involved in the process:

- Pass 1: parses the score, producing a numerical representation of it as output, optionally applying a Fortran PLF routine to generate or process data.
- Pass 2: takes the pass 1 output, applies action time sorting of all data statements, time scaling, conversion of data (optional Fortran CONVT routine supplied by the user), and optionally applies a supplied Fortran PLS routine.
- Pass 3: takes the sorted, time-scaled, converted numeric data and synthesises the sound.

From a modern perspective, we can think of these as three separate programs, taking different types of inputs and producing different types of outputs. While the original operation used punched cards for the text and numeric inputs/outputs, in today's operating systems, plain text files are employed and the programs can be run as terminal commands.

3.2 Restoration

The work to restore MUSIC V is based on three main sources:

1) The Fortran source code, as typed and reorganised by Bill Schottstaedt in 2008.
2) Max Mathew's MUSIC V manual and examples from his book [10].
3) Risset's *Catalogue of Computer Synthesized Sounds* [11].

Bill Schottstaedt's code was essential since it provided a means to re-build the software from a base that is very close to the original Fortran code. While we could potentially recreate MUSIC V from the other sources using a more current programming language, that would be a much more complex and error-prone project. However, it is also important to note that the source code has been modernised substantially (and it is therefore not exactly the original from 1970). In Schottstaedt's source code comments, it is possible to see that there was what was described as "major surgery" applied to the code in order to make the programs work again in a modern system with the latest Fortran compiler versions. His choice of leaving the original code commented out was very helpful as we could study how the software was originally conceived.

The provenance of the code is somewhat uncertain, but the comments indicate that it was

> "typed in from old XGP output[,] file last written 19Jun75 MUSIC5[M5,GM] (I believe GM = George McKee)[,] SAIL" [12].

Later on we see mentions of PDP in the comments, leaving us with a reasonable guess that this was the version kept at the Stanford Artificial Intelligence Laboratory, which had a computer of that line. The code was most likely kept as a deck of punched cards and someone in 1975 printed it in a Xerox Graphic Printer. We do not have any other direct indication of the earlier history of this code and so we can only assume it is reasonably close to the one used at Bell Labs.

It is likely that other printed sources may be available, but as of now this appears to be the only usable source in a machine-readable format. We have also seen various copies of the source files containing this code in Risset's hard drives kept by the Fonds Risset, but no other versions, although there were compiled Motorola 68000/20 binaries for the Apple Macintosh[1] amongst his electronic materials. Besides these, printed sheets from 1968/9 containing the source code were discovered (as reported later in this paper), but have not been examined in close detail yet.

Schottstaedt's version, while it could be compiled in gfortran at the time of its creation, was fairly incomplete. It ran some basic score examples from Mathews' book but was not capable of, for instance, rendering Risset's Catalogue. The FLT unit generator was also missing. In 2009, a version with some fixes and additions was produced and subsequently made available as part of the Audio Programming Book [13]. This had the additions of several GEN routines from Risset's Catalogue, as well as the general CONVT routine listed there. In addition, the IOS unit generator required for his endless glissando example (#513) was added as new code (with the assumption that it was an oscillator using a linear-interpolation table lookup). A shell script handling the copying of user score inputs to the score file read by the pass 1 program and copying the snd.raw output from pass 3 into a user-provided file name was also added to make running MUSIC V more straightforward. However, this version was also largely untested, and a bug in the code was preventing the CONVT routine from being called. Therefore, in order to run the scores from Risset's *Catalogue* some editing was needed to apply the necessary conversions.

A renewed effort in the last year has brought us somewhat closer to restoring this code to the point where the music of Risset may be reconstructed from his original scores. The following issues have been tackled:

- Further work was needed in resolving Fortran issues still left over, which caused errors and warnings. The code now is up-to-date with the latest version of the language.
- The bug preventing CONVT from running was fixed. This was in fact a simple typographical error where a variable name was typed in as a literal. However, any CONVT functionality related to frequency conversion was still broken because the sampling rate had been hardcoded in the sources (more on this below).
- The code could not run stereo-output scores. While the code for the STR unit generator was present, it contained a bug affecting the sample count. This was easily fixed. However, the number of output channels was also hardcoded to one in the sources.
- Supporting stereo required further work, or "major surgery" as described earlier. The output buffer needed to be increased in size to accommodate the data. The actual buffering mechanism needed to be debugged for this to be achieved. Following the logic of code written in 1970 is not exactly straightforward, but after many iterations a solution was found. However, the number of channels still needed to be hardcoded in order for it to work.
- Both the sampling rate and the stereo/mono switch are expected to be adjustable from the score. This is done via a mechanism that sets integers in all passes to indicate the required parameters. This mechanism was broken and it needed fixing. With this restored, a score containing STR automatically sets the output to stereo, and the SIA unit generator can be used to set the sampling rate in the score. An addition to pass 3 makes it write a text file documenting the

[1] M5Mac by Simone Bettini, written as part of his degree thesis, under the supervision of Giovanni de Poli at Padova. According to Betttini, this was a recreation, using newly written code, although based on the original program.

sampling rate and number of channels in the output file.

- The MUL unit generator was not producing any output and was brought back to operation.
- The pass 2 CON routine, which applies timescaling to the data statements, was fully broken in Schottstaedt's version. This was restored to the original code (which was commented out) with some adjustments to avoid numeric issues.
- The application of PLF routines in the first pass requires some adaptation due to the way Schottstaedt has reorganised the program and eliminated the original reading code (the READ1 Fortran routine). The PLF3 routine from example #500 in the *Catalogue* has been incorporated as an example of such adaptation work.

In addition to the restoration work, a number of enhancements to the code base have been implemented. A dependency-free sound file converter has been written in C to take the pass 3 output and produce a RIFF-Wave sound file. To facilitate operation, a driver program, also written in C, now takes the score input and produces a RIFF-Wave sound file by calling the three passes and the converter. A CMake project was added to simplify cross-platform building of the software. Finally, a code repository was created in github to share the development work as an open-source project [14].

4. RISSET'S SCORES

In this section we report on the findings in the Fonds Risset [Fonds Jean-Claude Risset, Laboratoire PRISM (UMR 7061 – France)], which enabled us to consider the reconstruction of Risset's music from original score codes. Risset's compositions and research work from the 60's and 70's are abundantly documented not only with sketches, drafts and written descriptions on compositional procedures but also with MUSIC IV and V code. Although pieces like *Inharmonique (*W21_001), *Mirages* (W23_001)*,* and *Songes* (W24_001) are all relatively well documented with preserved score code[2], we have opted to concentrate on the pieces and research from Risset's early period, *Computer Study for Trumpet Tones*, *Little Boy*, *Mutations*, and *Introductory Catalogue of Computer Synthesized Sounds*.

These works belong to Risset's first two visits to Bell Labs in 1964-65 and 1967-69. They share interests for certain problems, especially the questions of timbre and musical paradoxes. They belong to a period where, according to the available documents in Fonds, Risset was parallelly, on one side, learning and exploring the possibilities of digital synthesis and, on the other side, composing. This is suggested by numerous comments in score code that relate to the sound processing techniques as well as compositional issues (i.e., Fonds Risset, W20_004_1, p.4, 5 or R21_001).

Despite the fact that the *Study of Trumpet Tones* was done in 1964/65 in Music IV and the other three works in Music V, they all share similar computer instrument designs, compositional procedures and sound results. Additionally, we suspect that the source code might have been modified in the seventies when MUSIC V has been transferred to LMA in Marseille and Ircam, which could make our reconstruction of later pieces more problematic.

While the *Catalogue* has been published in its MUSIC V score code form, *Little Boy* and *Mutations* were never publicly available as score code, but only as rendered and mixed audio. Some researchers published parts of this code in their analyses [15, 16], but there was no such effort of a complete analysis for these early pieces as was done for *Inharmonique* [17]. More recently, Antonio de Sousa Dias adapted parts of *Inharmonique* and the *Catalogue* to Csound and Max [18], and Svidzinski and Tiffon recreated parts of the code of *Songes* using Faust [19]. However, to our knowledge, no previous reconstruction work has been attempted using MUSIC V.

Through our attempt to reconstruct the score code, we hope not only to shed some light to the genesis of classic works of early computer music but also to provide an insight on Risset's creative process of numerous forth and back movements from research to composition to develop the *Computer Study*, *Catalogue*, *Mutations* and *Little Boy.*

4.1 Fonds Jean-Claude Risset

Two years after Jean-Claude Risset's death in 2016, his entire estate was deposited in the Fonds Risset of the PRISM laboratory, part of the CNRS in Marseille, today under the direction of Dr. Vincent Tiffon. In the last two years we have collaborated on digitisation and cataloguing of an important part (including Risset's original MUSIC IV and V code prints, score manuscripts and sketches) of the material, which consists of well over 30,000 pages. This material in the form of JPEG files has been made available online to researchers upon request. Risset's notebooks, correspondence, concert materials and other documents of his compositional and research activity are (still) only accessible on site.

4.2 *Little Boy* Sources

The documents related to *Little Boy* are organised in numerous call numbers. Besides the manuscript, sketches and drafts of the orchestra version[3] [W10_05, W20_003_1], the manuscript of Naka [W10_007], a notebook with ideas and descriptions of sounds for *Little Boy* (and other pieces) [W20_003_1], press clipping for the theatre play *Little Boy* [Halet P. *Little Boy.* Directed by Guy Lauzin. Maison de la Culture de Nevers, 1974], correspondence with P. Halet [W20_003_3], there is a

[2] *Mirages* (1978) with its more than eight hundred pages of MUSIC V score code synthesised at IRCAM presents a valuable source for comparative research with the pieces made ten years earlier at the Bell Labs.

[3] *Musique pour "Little Boy" de Pierre Halet, épisodes orchestraux* [2222.2220.timp.3perc, soprano, e-guit., hp., pno./cel., string quintet, mixed choir] dated to 1968, 54 pages.

folder with printouts of the MUSIC V score code for *Little Boy* [W20_003_2]. Its 225 pages contain the score code on perforated continuous paper for line printer of the IBM 7094 computer, annotated by Risset with details on sampling rates, magnetic tape numbers, dates, code errors and/or possible solutions, instrument schemata, chords or notes to be played, ideas on sound to be produced, and possible technical solutions for certain passages; spectrograms of unidentified sounds annotated by Risset; and separated or clipped paper sheets with Risset's comments on the mix, instruments, code or other (including traditional notation examples, technical drawings of instruments and code examples).

4.3 *Mutations* Sources

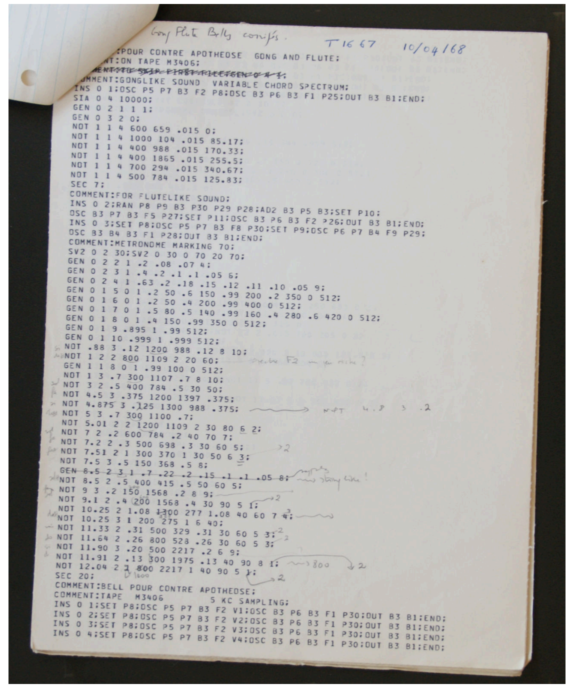
The material concerning *Mutations I* is situated in the folder with the call number W20_004, and its five containing folders. Two of them contain score code printed as for *Little Boy* on perforated continuous paper for line printer IBM 7094 [W20_004_1, W20_004_5], as well as separated and clipped paper sheets, annotated by Risset with details similar to *Little Boy*. In total they contain 341 pages.

All the documents of W20_004_1 were organised by Risset himself in the following subfolders: Brassy; LB type episodes; Mutations - *description des runs*, Mutations - *descriptions des mixages*; Nonlinear transfer Db Sine etc.; Drums - Gong harmony - Mutations; Parallel glissandi - Mutations; Fonctions sérielles; and Recent runs - Mutations. Besides these materials, W20_004 contains drafts and autographs of the program notes [W20_004_2], a photocopy of "Interview with JCR" [20], the transcription of Mutations in standard music notation [21] [W20_004_3], a photocopy of a part of Lévy's book related to Mutations [15] [W20_004_4].

We also took into account call numbers with *Mutations II* (1973), which contain further score code from *Mutations I*. In addition to the parts synthesised in Bell Labs, *Mutations II* was run in the Institut d'Electronique Fondamentale d'Orsay, and it shares the same score code used in *Mutations I*. In addition to the sketches, drafts and the autograph for ensemble (Fl., Cl., perc., pno.) [W20_005_2, W20_005_3], handwritten notes on the piece, sketches of program notes, the folder W20_005_1 contains the score code MUSIC V.

4.4 *Catalogue* Sources

Since it was used by Risset on repeated occasions, *Catalogue* source code is scattered in many different folders. We haven't identified drafts and sketches made specifically for the *Catalogue*. Some of the code was found together with *Little Boy* and *Mutations* material. Some other runs seem to be originating from Risset's study on pitch paradoxes [22]. Folders R21_001 to R21_016 contain the final version in manuscript and print.



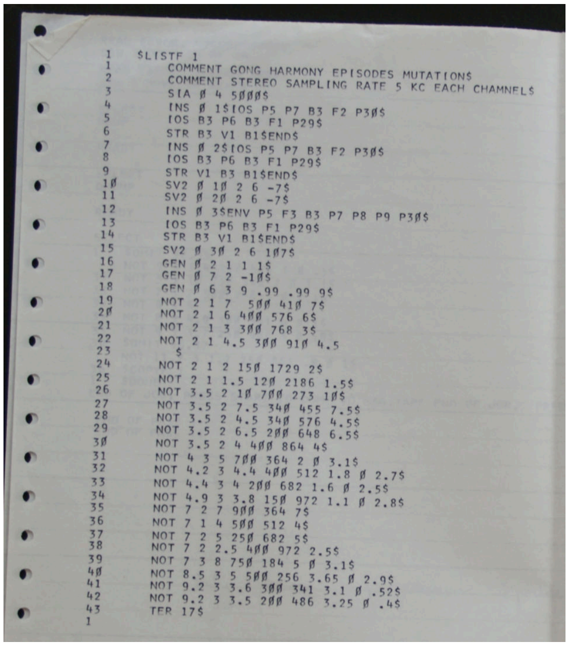
```
:POUR CONTRE APOTHEOSE  GONG AND FLUTE;
NT:ON TAPE M3406;
MMENT:GONGLIKE SOUND  VARIABLE CHORD SPECTRUM;
INS 0 1;OSC P5 P7 B3 F2 P8;OSC B3 P6 B3 F1 P25;OUT B3 B1;END;
SIA 0 4 10000;
GEN 0 2 1 1 1;
GEN 0 3 2 0;
NOT 1 1 4 600 659 .015 0;
NOT 1 1 4 1000 104 .015 85.17;
NOT 1 1 4 400 988 .015 170.33;
NOT 1 1 4 400 1865 .015 255.5;
NOT 1 1 4 700 294 .015 340.67;
NOT 1 1 4 500 784 .015 125.83;
SEC 7;
COMMENT:FOR FLUTELIKE SOUND;
INS 0 2;RAN P8 P9 B3 P30 P29 P28;AD2 B3 P5 B3;SET P10;
OSC B3 P7 B3 F5 P27;SET P11;OSC B3 P6 B3 F2 P26;OUT B3 B1;END;
INS 0 3;SET P8;OSC P5 P7 B3 F8 P30;SET P9;OSC P6 P7 B4 F9 P29;
OSC B3 B4 B3 F1 P28;OUT B3 B1;END;
COMMENT:METRONOME MARKING 70;
SV2 0 2 30;SV2 0 30 0 70 20 70;
GEN 0 2 2 1 .2 .08 .07 4;
GEN 0 2 3 1 .4 .2 .1 .1 .05 6;
GEN 0 2 4 1 .63 .2 .18 .15 .12 .11 .10 .05 9;
GEN 0 1 5 0 1 .2 50 .6 150 .99 200 .2 350 0 512;
GEN 0 1 6 0 1 .2 50 .4 200 .99 400 0 512;
GEN 0 1 7 0 1 .5 80 .5 140 .99 160 .4 280 .6 420 0 512;
GEN 0 1 8 0 1 .4 150 .99 350 0 512;
GEN 0 1 9 .895 1 .99 512;
GEN 0 1 10 .999 1 .999 512;
NOT .88 3 .12 1200 988 .12 8 10;
NOT 1 2 2 800 1109 2 20 60;
GEN 1 1 8 0 1 .99 100 0 512;
NOT 1 3 .7 300 1107 .7 8 10;
NOT 3 2 .5 400 784 .5 30 50;
NOT 4.5 3 .375 1200 1397 .375;
NOT 4.875 3 .125 1300 988 .375;
NOT 5 3 .7 300 1100 .7;
NOT 5.01 2 2 1200 1109 2 30 80 6 2;
NOT 7 2 .2 600 784 .2 40 70 7;
NOT 7.2 2 .3 500 698 .3 30 60 5;
NOT 7.51 2 1 300 370 1 30 50 6 3;
NOT 7.5 3 .5 150 368 .5 8;
GEN 8.5 2 3 1 .7 .22 .2 .15 .1 .1 .05 8;
NOT 8.5 2 .5 400 415 .5 50 60 5;
NOT 9 3 .2 150 1568 .2 8 9;
NOT 9.1 2 .4 200 1568 .4 30 90 5 1;
NOT 10.25 2 1.08 1300 277 1.08 40 60 7 4;
NOT 10.25 3 1 200 275 1 6 40;
NOT 11.33 2 .31 500 329 .31 30 60 5 3;
NOT 11.64 2 .26 800 528 .26 30 60 5 3;
NOT 11.90 3 .20 500 2217 .2 6 9;
NOT 11.91 2 .13 300 1975 .13 40 90 8 1;
NOT 12.04 2 1 800 2217 1 40 90 5 1;
SEC 20;
COMMENT:BELL POUR CONTRE APOTHEOSE;
COMMENT:TAPE  M3406             5 KC SAMPLING;
INS 0 1;SET P8;OSC P5 P7 B3 F2 V1;OSC B3 P6 B3 F1 P30;OUT B3 B1;END;
INS 0 2;SET P8;OSC P5 P7 B3 F2 V2;OSC B3 P6 B3 F1 P30;OUT B3 B1;END;
INS 0 3;SET P8;OSC P5 P7 B3 F2 V3;OSC B3 P6 B3 F1 P30;OUT B3 B1;END;
INS 0 4;SET P8;OSC P5 P7 B3 F2 V4;OSC B3 P6 B3 F1 P30;OUT B3 B1;END;
```

Figure 1. A page of the score code for *Little Boy*, W20_003_2, p.61.

Here we found a notebook with Risset's working notes (1967) [R21_001], a copy of *Music V: Quick Reference Manual* by F. R. Moore, 1967/68, a printout of Music V source code[4], annotated by Risset, 1968/69 [R21_002], score code, questionnaire and study design drafts for the *Pitch Study,* runs for glissandi for *Little Boy*; 1968/69, 284 pages [R21_003], annotated code for Shepard Glissandi [R21_007], a copy of Music IV manual [23][R21_008]

The folders R21_010 to 016 contain more specific material from the *Catalogue*: manuscripts and original printouts, two versions of *Catalogue* score code annotated by Risset, separate and clipped paper sheets with annotations on tape numbers, instrument schemata, accompanying description text manuscript (draft) of the *Catalogue*, letters to the publishers, distribution lists, reviews, James Beauchamp review article [24], Steven Held's translation of the *Catalogue* for MUSIC 11 (1990), a CD with text files from the *Catalogue* and Antonio de Sousa Dias' portings of some examples in Csound and Max [18], drafts of the texts for the Wergo CD [25], original *Catalogue* vinyl record 33+⅓ rpm [26]. Although it seems that much of this material is in its final form, there are several drafts of the code (especially in the folders R21_010 and 012) that might give us further insight into the genesis of the *Catalogue*.

[4] The discovery of this material will also contribute to further adjustments to our restoration of MUSIC V.



```
$LISTF 1
    COMMENT GONG HARMONY EPISODES MUTATIONS$
    COMMENT STEREO SAMPLING RATE 5 KC EACH CHAMNELS$
    SIA Ø 4 5ØØØ$
    INS Ø 1$IOS P5 P7 B3 F2 P3Ø$
    IOS B3 P6 B3 F1 P29$
    STR B3 V1 B1$END$
    INS Ø 2$IOS P5 P7 B3 F2 P3Ø$
    IOS B3 P6 B3 F1 P29$
    STR V1 B3 B1$END$
    SV2 Ø 1Ø 2 6 -7$
    SV2 Ø 2Ø 2 6 -7$
    INS Ø 3$ENV P5 F3 B3 P7 P8 P9 P3Ø$
    IOS B3 P6 B3 F1 P29$
    STR B3 V1 B1$END$
    SV2 Ø 3Ø 2 6 1Ø7$
    GEN Ø 2 1 1 1$
    GEN Ø 7 2 -1Ø$
    GEN Ø 6 3 9 .99 .99 9$
    NOT 2 1 7  5ØØ 41Ø 7$
    NOT 2 1 6 4ØØ 576 6$
    NOT 2 1 3 3ØØ 768 3$
    NOT 2 1 4.5 3ØØ 91Ø 4.5
      $
    NOT 2 1 2 15Ø 1729 2$
    NOT 2 1 1.5 12Ø 2186 1.5$
    NOT 3.5 2 1Ø 7ØØ 273 1Ø$
    NOT 3.5 2 7.5 34Ø 455 7.5$
    NOT 3.5 2 4.5 34Ø 576 4.5$
    NOT 3.5 2 6.5 2ØØ 648 6.5$
    NOT 3.5 2 4 4ØØ 864 4$
    NOT 4 3 5 7ØØ 364 2 Ø 3.1$
    NOT 4.2 3 4.4 4ØØ 512 1.8 Ø 2.7$
    NOT 4.4 3 4 2ØØ 682 1.6 Ø 2.5$
    NOT 4.9 3 3.8 15Ø 972 1.1 Ø 2.8$
    NOT 7 2 7 9ØØ 364 7$
    NOT 7 1 4 5ØØ 512 4$
    NOT 7 2 5 25Ø 682 5$
    NOT 7 2 2.5 4ØØ 972 2.5$
    NOT 7 3 8 75Ø 184 5 Ø 3.1$
    NOT 8.5 3 5 5ØØ 256 3.65 Ø 2.9$
    NOT 9.2 3 3.6 3ØØ 341 3.1 Ø .52$
    NOT 9.2 3 3.5 2ØØ 486 3.25 Ø .4$
    TER 17$
```

Figure 2. A page of the score code for *Mutations I*, W20_004_1, p.150.

4.5 *Computer Study of Trumpet Tones* Sources

Call numbers R20_ 001 to _016 (1867 pages) contain among others: typewritten *Computer Study of Trumpet Tones,* PISA tests of recorded trumpet sounds, score code for sound examples for the Trumpet Study, score code entitled Prelude, Study I-XV, Microtone Study I-III, Psycho, Purcell, Breize ma bro, etc., other unidentified score code, computer reports of executed runs, sketches and drafts of the study design, etc. We haven't located the audio examples for the *Computer Study*. Additionally the call number R21_017 includes printed and annotated spectrograms of trumpet tones for the study.

It is hard to distinguish Risset's composition from his research. Titles like *Prelude, Study I-XV, Microtone Study I-III,* or *Purcell, Breize ma bro*, are to be found often in the same folder indicating that Risset was experimenting with the synthesis parallely for his *Computer Study* of *Trumpet Tones* and his compositional activity. While *Purcell* and *Breize ma bro* clearly belong to the sound examples of the *Trumpet Study*, the *Microtone Study* represents an interesting discovery that is not easy to classify [27]. Although Risset later discarded all the computer pieces from this period [16], the preserved score code gives us the opportunity to analyse both his creative processes and research output.

4.6 Other Sources

Call numbers R24_001 to _003 and R25_001 to _016 contain more score codes from 1964-1969, but to date we have not done detailed research on this material. Additionally, numerous audio support (DAT tapes, CDs, audiotapes, magnetic tapes) are in the Fonds, but this material is not classified. The original tapes of *Little Boy* and *Mutations* are supposedly in INA, Paris [28].

4.7 Preliminary Results and Further Perspectives

With the thoroughly examined content of the Fonds Risset we have set the foundations for our research. Although it is plausible that some additional documents will be found in the future, we suppose that most of the surviving score code for the four works in question is located. Since no code was published as Urtext, at this point we do not know what code is the "autograph" and what is a sketch, study or draft. Once our reconstructions are done, we assume we will be a step closer to answering this question.

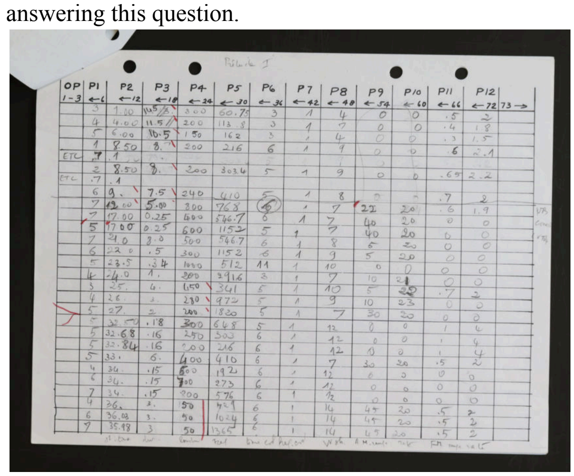


Figure 3. A card showing the content of the NOT section for *Prelude I*, R20_006, p.68.

We have retyped all the text containing the code and got fifty-one runs for *Little Boy* and ninety-four for *Mutations*. These were performed using our MUSIC V compiler, initially with mixed success. The failed runs have been used in debugging our source code restoration. We have also retyped much but not all of the score code for *Trumpet Study* and *Catalogue*. As part of our next steps, we will investigate and compare the content of the original magnetic tapes with our renditions of score code.

From this initial work, we may draw some interesting insights:

- Since we have the orchestra sections for some of the *Studies* from 1964/65 it should be possible to reconstruct and synthesise them in MUSIC V. This might enable us to get insights to the genesis of Risset's early composing style.
- *Study* examples, *Little Boy* and *Mutations I & II*, all use Pythagorean tuning extensively (Figures 1. - 4.). This has been concluded based on the observation of the score code, where NOT commands are given in Pythagorean tuning (A=432Hz). In the context of Risset's *microchirurgie sonore*[5] further perspectives open

[5] Sonic microsurgery: a term used by Risset to describe his handling of organised sound.

up: the relation of "large" major thirds to pure spectral thirds and to the inharmonic intervals used in bell-like sounds.

- Cross-referencing two versions of Mutations (I & II) might reveal interesting things on tuning. Our first findings suggest that he might have slightly modified the frequencies in Mutations II to match A=440, but kept the Pythagorean tuning (see Figure 4).
- A connection between *Microtone Studies* and *Little Boy* has been shown [27].

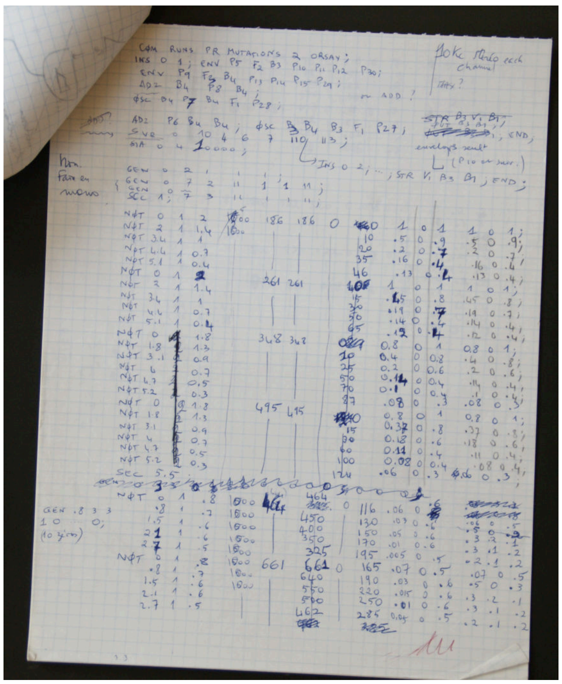


Figure 4. Risset's sketch for Mutations II, W20_005_1, p.39

5. CONCLUSIONS

This paper furnishes a description of methods and outcomes of an emergent field of study within ubiquitous music research: ubimus archaeology. We adopt the perspective outlined by Lazzarini and Keller [2] and tackle a two-pronged project. One branch deals with the computational issues involved in recovering the original version of the acoustic compiler MUSIC V to a multiplatform-deployable state that enables rendering musical works encoded during the 1960s. By making available the source code and a set of tools, the process of compiling MUSIC V code was streamlined. We hope this fosters future collaborations within the digital humanities. Another branch of the project entails recovering and analysing the earliest works done by Risset during his stay at Bell Labs. We chose *Little Boy*, *Mutations,* the *Introductory Catalogue of Computer Synthesized Sounds* and the *Computer Study on Trumpet Tones* as objects of study. Our analysis indicates a process of iterative explorations that includes both code-oriented work and annotations in English and French. Results obtained on one musical project often feed the development of other artworks. Thus, it is clear that a teleological method with explicit or fixed objectives was not adopted by Risset.

These results highlight new aspects of musicological endeavours and underline the diverse potential for application of ubimus frameworks. Ubimus projects have explored the expansion of technological sustainability through the adoption of repurposed hardware. Sometimes, this may imply inheriting the limitations and the biases of the hardware designs. As documented in Risset's annotations and in the multiple iterations of *Mutations* and *Little Boy*, the hardware constrains the compositional process, forcing the adoption of strategies to overcome some of the limitations. Complementarily, we can also infer that Risset's change of focus from the usage of alternative tunings to the explorations of new timbral possibilities and of perceptual phenomena was triggered by the creative possibilities provided by the MUSIC V environment. This raises a red flag on repurposing strategies. Stable technological infrastructures reduce electronic waste and are potentially good for the planet. But we may pay the price of reinforcing limited views on artistic activities and on music making.

Another issue illuminated by these results is replicability. The ubimus perspectives on replicability imply a delicate balance between scientific rigour and aesthetic diversity. By unearthing the original MUSIC V acoustic compiler we open the door to an exact replica of the code written in the sixties. Would this make sense in 2022? If it comes at the price of demanding the original hardware, then there are multiple arguments against it (see [5] for a detailed discussion of the caveats of this approach). While an exact replica may not be such a good idea, keeping the information in place and easily available makes a huge difference (as exemplified in Schottstaedt's version of the Fortran code). This procedure is aligned with Hunt and Thomas's [29] perspective on software archaeology. The source code is not enough. We need detailed comments, documentation and access to the history of design iterations. We also need to know the motivations for the implementation decisions. This approach is also applicable to the musical resources, as revealed by our analysis of Risset`s procedures.

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