# Nanc-in-a-Can Canon Generator. SuperCollider code capable of generating and visualizing temporal canons critically and algorithmically

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## Abstract

In the present paper a SuperCollider library designed to produce temporal canons, like the ones proposed by Conlon Nancarrow, is explored in order to create new temporal conceptions within the field of live coding. We will define temporal canon as a composition strategy that allows a poly-temporal audition by expressing a single musical idea at different speeds simultaneously. Likewise, our intention is to socialise the work of Nancarrow, often captured by a reduced academic niche, so it may be integrated into a broader and more diverse context. In this paper a broad introduction to the library is provided that emphasises some of its salient aspects that overlap with specific interests of live coders. By de-canonising the ideas of Nancarrow and approaching them from a heterodox and unconventional perspective we attempt to unravel understandings of time and rhythm beyond the scope of the music of Conlon Nancarrow as well as the practices of Mexican and international live coding communities.

## 1. INTRODUCTION

> "Contrary to common belief, perhaps time does not keep everything from happening all at once, but is the nucleus that holds all the mixed realities together."
>
> Eleni Ikoniadou

The program and its use instructions may be downloaded from the platform´s website. In there you can find an installation tutorial (in Spanish) and some links to examples of the program´s use[1]. The version of the program we are referencing in this paper is **1.0.0-rc**.

## 1.1 WHY ALGORITHMS?

Keeping alive the legacy of Conlon Nancarrow has been problematic. The audio and video recordings of what could be heard in his studio, with his instruments and under the conditions proposed by the author are fundamental to disseminate and study his music[2]. However, it is worth inquiring about the possibilities of "bringing to life" Nancarrow's work by using the intellectual legacy of the composer as a starting point for new or different artistic practices rather than invoking his piano rolls and the unique conditions enabled by his studio, that is the only context in which an "authentic" audition of his music could be possible[3]. Similarly, other interesting questions will be addressed in relationship with the composer's work: how should we

[1] https://github.com/nanc-in-a-can/canon-generator/tree/1.0.0-rc

[2] Studies for Player Piano: The Original 1750 Arch Recordings. Conlon Nancarrow. Other Minds OM 1012/15-2. Studies for Player Piano, Vols 1-5. Conlon Nancarrow. Wergo WER 6907 2. It is also worth mentioning the videos documenting the player pianos in operation with the rolls created by Jürgen Hocker in the studio of the author.

[3] Nancarrow never thought that his music was going to be well/known outside a reduced group of close colleagues and family members. Hence we can think of his studio conditions, particularly his specially modified players piano, as the only authentic audition context for the rhythmic studies for player piano.

approach its analysis and significance? In what way is it possible to extend its practices since it has left us a series of ideas whose final consequences are still unknown? How could a performative practice be developed based on the work of Conlon Nancarrow?

To answer such inquiries first we must establish the conditions in which his work is framed nowadays from the perspective of the authors of the present paper. The media and technological devices to gain access to the music and ideas of Nancarrow (with the exception of the audiovisual documents widely disseminated on the internet and the case of Trimpin's digitization work based on the MIDI protocol (Murcott, 2012)) are now reduced to museum relic whose access has been enormously restricted in part by the acquisition of the rolls and mechanical instruments by the Sacher Foundation for its "conservation"(Brown, 2015). That is, the objects that make up the material legacy of Nancarrow now rest in the basement of a European tycoon that allows, once in a while, their exhibition and manipulation through agents who have the sufficient capital (financial and "cultural") to negotiate its loan. This causes a specific situation; those who have the "cultural capital" to access the legacy of Nancarrow are usually those whose narratives about the work of Nancarrow are conventional, often Eurocentric, orthodox and which partially distort and corrupt in the most fundamental sense what Nancarrow (a rather heterodox artist, nationalised Mexican and of socialist conviction) left behind. The distortion of Nancarrow's oeuvre has become an impediment for the access of younger generations. This is specially the case for people from artistic or cultural backgrounds far removed from the Western musical academic tradition.

It is important, thus, to rehabilitate the access to this vast musical world and to a legacy that remains open and needing of further research. Many of these issues have been addressed in the article "La irreverencia de Conlon Nancarrow", first of a three part article series named *No-Canon*, published in the web magazine *SulPonticello (2018)*. In this series the authors propose that the ideas of Nancarrow are what really constitutes his legacy beyond its fetishised material remains: studies for player piano, sheet music, instruments, etc. What Nancarrow's ideas are ultimately uncovering is a completely new space of possibilities for musical exploration, which implies a coexisting multiplicity of temporalities and a way to relate them (the convergence point, see 3.2). Nevertheless, this space has remained mostly unexplored due to the uniqueness, novelty and complexities of his proposal. This is specially so due to, in the one hand the early canonization of Nancarrow's oeuvre, and, in the other hand, the practical difficulties in realizing such exploration: the complexity of the calculations involved and the difficulties implied in its performance, either on public or while the music is being developed (not even MIDI and the "MIDI piano roll" can considered as appealing interfaces for such an endeavour).

Therefore it has become necessary to assemble a device through which the ideas of Nancarrow are revitalised, both through new/other practices and through other modes of understanding them. This reflection is the starting point of our project; it is absolutely fundamental to analyse, understand, signify and reappropriate the work of Conlon Nancarrow emphasizing the ideas behind it, away from the material legacy that is no longer available for Mexican artists and institutions.

We decided to use SuperCollider because temporal canons are highly susceptible to being expressed as algorithms. As it is proposed in the draft of the TopLap manifesto (TOPLAP, 2010), we believe that algorithms are thoughts; that is to say, they are a way of materializing abstract thinking as faithfully as few conceptual devices allow us. Therefore, we consider algorithms as an optimal framework to develop the concepts behind Nancarrow's work, his ideas and its meaning and yet unspoken possibilities.

## 1.2 CONCEPTS OF TIME IN LIVE CODING

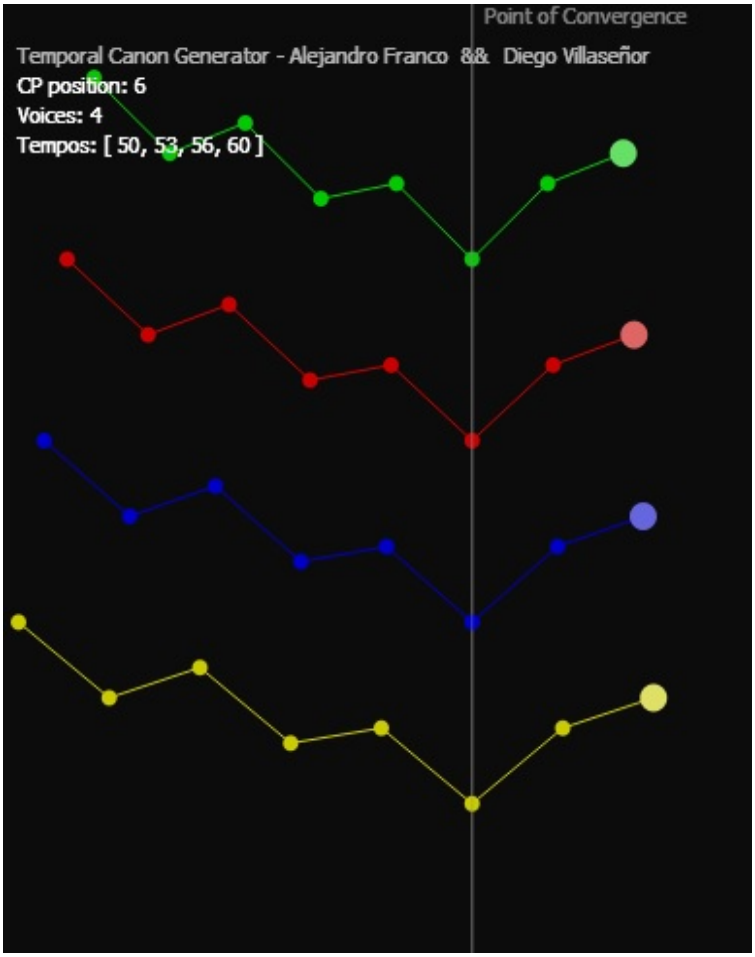
The device we have envisioned has a double critical edge since the many concepts of temporality that the practices around live coding favour are insufficient to conceptualise and incorporate multitemporal structures such as the ones here proposed. Some time-oriented implementations in live coding are SuperCollider's *ProxySpace* that allows users to declare *a posteriori* certain functions (Collins et al., 2003) enabling a more direct relationship between code manipulation and sonic outcome. SuperCollider's *Pattern library* allows players to create musical patterns on the fly with great accuracy and flexibility (Harkins, 2009), patterns are particularly powerful when combined with *ProxySpace*. *TidalCycles* (McLean, 2010) promotes the creation of cyclic temporal patterns with a functional language that provides a simpler and more expressive notational system. Other interesting conceptions of time are the temporal recursion devised by Sorensen

(Sorensen, 2010) for the program *Extemporum* or the idea of time-dependant variables embedded in *FoxDot* (Kirkbride, 2016).

These platforms tend to favour singular temporal grids over multiple ones, hence, they do not seem to be intrinsically poly-temporal. Often, poly-temporal components are emerging and contingent properties in live coding music. Rohrhuber´s reflections on algorithmic music and the philosophy of time (2018) point towards a very particular form of uncertainty enabled by computational algorithms that suggest a rich relationship between temporality, sound/music and computation. Rohrhuber depicted an uncertainty based in multiplicity, contingency and possibility that he identifies as a shared characteristic of music and programming. Nevertheless, there are few instances of temporal modalities in which simultaneity and multiplicity of tempos are explored. An exceptional precedent for the present project is the *Canonic Hill Loss* album and the platform produced by Nick Collins (2003) for SuperCollider 2 in which a program capable of producing mensural, acceleration (like the ones proposed by Nancarrow) and sinusoidal oscillation (Jaffe, 1985) temporal canons is provided. The work by Collins directly tackles the work of Nancarrow and proposes time maps as a representational tool with which research on tempo canons or generative music can be achieved.

## 2. WHAT IS A TEMPORAL CANON?

The temporal canon has its precedent in the proportional canon (sometimes known as mensural although both notions differ in a strict sense) devised in the historical period of the European musical tradition known as *Ars Nova* (14-15 century). A traditional proportional canon is defined when the information of a voice in a contrapuntal work is usually reproduced simultaneously in another voice with a different temporal proportion, usually at a 2: 1 or 1: 2 ratio and at a different pitch.




In the music of Nancarrow the temporal canon is more a strategic principle rather than a musical form that allows the audition of tempo differences usually much more complex than the simple proportions of its ancestors. We can find many integral temporal canons in the work of Nancarrow, for example Study 14[4] is a strict temporal canon that is part of the series of "canonical studies" with indexes 13 to 19.

If you have already downloaded *Nanc-in-a-can,* you copy these lines and compile them:

```
(
Can.defaultServerConfig;
s.boot;
s.waitForBoot({Can.registerDefaultSynthDefs;});
);
```

Then compile this so you can play your first Canon:

[4] To listen to a version produces as part of this project type: `ThePresetCan.study14Nancarrow.visualize(s);`
If you would like to listen the version produced by Arch Records and visualized by Stephen Malinowski follow the url (musanim, 2014): https://www.youtube.com/watch?v=1tvwX6Fguyg

```
(
Can.converge(\myNanc,
       melody: Can.melody(((1/4)!8),[62, 57, 59, 54, 55, 50, 55, 57]),
       cp:6,
       voices: Can.convoices([50, 53, 56, 60], [-24, -12, 0, 12])
).visualize(s)
);
```

As you can see in the previous example and in the Study 14 of Conlon Nancarrow it is relatively easy to understand what a temporal canon is. In this case we are listening to the same melodic configuration at different tempos (50, 53, 56, 60 bpm respectively) articulated by a formal component called *convergence point* (cp). The cp is fundamental for the temporal canons, it is the point where the temporal dimensions (the chronological temporality and the structural temporality) of the different voices of the canon are identical.

In Nanc-in-a-Can we have created a series of methods that assist the algorithmic composition of canons. In the previous example we can see a couple of them working. Like in the `melody`:

```
Can.melody(((1/4)!8),[62, 57, 59, 54, 55, 50, 55, 57])
```

`Can.melody` takes the arguments `[Duration]` and `[MIDINote]` both as floats that produce a series of events with a midi pitch value and a duration value. In this case: `[(dur: 0.25, note: 62), (dur: 57, note: 57)...]`.

Temporal canons are characterized as the spaces where many time lines remain simultaneously autonomous and in relationship with their cp. The canons allow for relationships between sound objects that have different temporalities that can be listened to simultaneously, this characteristic has been called temporal dissonance (Thomas, 1999). Temporal dissonance implies that tempo becomes harmonic and this means that multiple tempos can be organised in order to convey meaning. Hence, a temporal canon emerges from objects that can only exist in different temporal dimensions simultaneously suggesting something rather interesting: the understanding of the canonic we are proposing points toward a temporal ontology of music capable of producing a time-oriented musical praxis that stands in a different register than the sound-oriented music. In this way, Nancarrow is not understood solely as a modernist composer that explored the 'last frontier of music' as sometimes is suggested in musicological narratives, but as an artist that, among others, inaugurated a path that twentieth-first century artists are already exploring in depth.

Although this project, at this stage, only allows for the creation of audio and audiovisual compositions of a single canonical structure, it must be understood that the temporal canons are modular and can function as macro-structures (self-sufficient units of organization), as micro-structures that are articulated with other canonical structures or even, as virtual structures that enable poly-temporal segments of music but never fully actualised. What is possible in this version of the program is to modify the configurations of the canons in real time by enabling live coding sets that are a succession of time canons. To put it another way, it is possible to create an improvisational set where a melody remains identical but the number of voices, the ratio of tempo, transposition and position of the point of convergence differ reconfiguring drastically the sound material.

## 3. CONVERGENCE AND DIVERGENCE

Temporal canons can be categorized taking as main criterion the temporal stability for each voice. Hence, we could group them into three broader categories: *convergence*, *divergence* or *acceleration*. The first two types are implemented in the software here proposed however further research has to be conducted to develop the acceleration canons.

These classifications are not exhaustive and, of course, are eclipsed by the diverse and incommensurable dimensions of Nancarrow's work. We have taken such classifications as starting points to think about time and possible temporal relationships between different objects. In fact there are many formal and structural mechanisms that are not addressed here and that can be found throughout the composer's studies. Similarly, the SuperCollider computing capabilities and the possibilities that the program enables are many. As has been stated before, the work of Nancarrow is vast and there are still many ideas and premises to explore.

The most stable canons are those of convergence. A fundamental aspect of these canons is the different onset time for each voice. They usually present a single cp that is paramount for the piece´s structure. In some cases, the cp is, as Julie Nemire (2012) would say, the *raison d'etre* of said canon.

The canons of divergence-convergence (here abbreviated as divergence canons) present exchanges of tempi between their voices (also called tempo switches, see 4.3). These provoke tempo modulations between the voices. These modulations make them unstable compared to the convergence canons. These canons begin in a convergence that after the tempo switch reverses its tendency and eventually reaches a point of convergence.

The implementation of the divergence canon in *Nanc-in-a-Can* has been an important element of reflection and without a doubt it is an implementation that can be optimized for future editions. Based on the analysis of all of Nancarrow´s works published by Gann (1996) there are very few exceptional divergence canons that have more than two voices. The ability to create this type of canons with N number of voices is one of the most important explorations of Nancarrow's ideas that this software can offer and hopefully, the present platform will enable a creative uses of this feature.

## 4. TEMPORAL CANON COMPONENTS

### 4.1 VOICE

In the present context, a voice is the information that will be iterated in different temporal proportions and in different pitch transpositions. Voices are not simple monophonic melodies, in the case of the platform they can be blocks of chords, or heterophonic melodies, as can be fast arpeggios known as arpeggios "a la Nancarrow", ostinati, or any relationship that may arise from the organizational mechanisms mentioned here. The voices are, in a few words, self-contained musical works with their own structural integrity. They are autonomous to the canonical construction of the work. At the level of the voice is that the conventional musical context ends and the time-oriented music context imagined by Nancarrow begins.

### 4.2 CONVERGENCE POINT

The convergence points is, perhaps, the component of greater weight and relevance of the time canons. This is the precise moment where the different voices that make up a canon coincide. That is to say, it is the moment in which the chrono-metric time (hours:minutes:seconds) and the musical time (tempo:metre:rhythm:durations) of each voice are aligned with each other, they are identical in all the voices and this is the point where the echoic distance is zero (see 4.4). The function of these components changes depending on the type of canon. The points of convergence are indispensable for all types of temporal canons, although they are central to the canons of convergence (see 3). In the canons of divergence (See 3) they are found at the beginning and then they occur periodically by braiding the canon until it concludes at one of these points. In the canons of divergence its function changes slightly since it shares relevance with another component: the tempo switch.

In this program the point of convergence is identified by the 'key' `cp` of the object `Can.converge`. The integer number that the user assigns in this value is the index of the melody event, at which point of the melody the cp will occur. In the visualization of figure 1 the cp is identified by a grey line.

### 4.3 TEMPO SWITCH

The strategy that Nancarrow devised to make possible the canons of divergence was the tempo switch. When two or more voices start at a synchronous moment but have different tempos they begin to de-synchronize, if the voices exchange tempos during their trajectory they cause this divergence to revert, leading to another convergence. This exchange of voices may be produced any number of times, however, in the present program, the number of tempo exchanges necessary for a tempo canon to occur must be equal to the number of voices that the canon has. Nancarrow usually made divergence canons of two voices, however, it is possible to produce a canon with N number of voices and N number of temporary exchanges. Our melody developed so far can be expressed as a canon of divergence and we can observe the cp at the beginning and end of these while we can hear the effect that causes the exchange of tempos.

```
(
Can.diverge(\myNanc,
       melody: Can.melody(((1/4)!8),[62, 57, 59, 54, 55, 50, 55, 57]),
       voices: Can.divoices([-24, -12, 0, 12]),
       tempos: Can.divtempos([4,5,6,7], [25, 25, 25, 25], normalize: true),
       baseTempo: 15
).visualize(s)
);
```

### 4.4 THE VIRTUAL AND THEORETICAL DIMENSIONS OF CANONS

Beyond the components of the temporal canon it is important to point out two theoretical devices that allow analysing and determining the type of temporality that these produce: echoic distance and temporal dissonance[5]. At the moment, Nanc-in-a-Can does not generate measurements of these however it is one of the future key implementations of this software. The echoic distance and the temporal dissonance point towards that which allows us to imagine a kind of two-dimensional cartesian plane where both axis represent two different forms of time, similarly to the time maps elaborated by Jaffe, (1985). By determining the echoic distance and the temporal dissonance of a set of voices it is possible to implement many new features of interest theorised around the work of Nancarrow, for instance these theoretical components could be explored in order to create partial canonical structures that imply a convergence point but it remains in a virtual future not actualised by the program.

## 5. Nanc-in-a-Can LIVE CODING POSSIBILITIES

For a live coding setting it is useful to use additional arguments for each canonical structure: `id`, `instrument`, `player` and `repeat`. `id` is the first argument of every canon, it is passed to the function that generates the `player` (read next paragraph for details). `instrument` is an argument that passes an array of symbols for the `Synthdefs` that will be used by the `player`: (they should have been previously added, and should support a `freq` and `dur` arguments). For the default `player` each voice of the canon will take the instruments as ordered in the array of instruments: voice 1 will take instrument 1, voice 2 will take instrument 2, etc.

A very useful argument is the `player` argument. It provides an interface for the creation of custom players (whose interaction should occur via `play`, `stop`, `resume` and `pause` messages over the `Canon` class). This argument is optional: default player is a `Pdef` which makes use of the symbol provided by `id` argument. If a player should be provided, it must be a function that takes as arguments: `symbol`, `canon` (the canon data structure), `instruments` (an array of symbols) and `repeat` (a number, or inf), and should return an Object that responds to the following messages `play`, `stop`, `resume` and `pause`. The player argument allows for the easy integration of more complex functionality at runtime.

The following example generates a random melody with a random arrangement of transpositions and tempos per voices. Every time the canon structure is re-compiled it generates a new canon. Just by altering the number of voices, the tempos and transpositions it is possible to create vast variations of a given material that could define a live coding act.

[5] Echoic distance is the time interval between a structural point of a voice and its equivalent in any other. The closer two voices approach the cp, the smaller the echoic distance will be, the further away from the cp the broader the distance. Temporal dissonance is a concept where perceptive, cognitive, formal, metric and musical aspects must be considered in order to determine it. The proportions between tempos can be organized from consonant (simple relationships like 1:2, 2:4), to dissonant (60:61 or 2: $\sqrt{2}$). The further we move away from simple relationships like 1:2, 2:3, 3:4 and we approach the "higher partials" like 60:61 or use irrational numbers to create proportions like the greater the dissonance between voices. However, this is not the only factor to take into consideration, it is also necessary to take into account the echoic distance between voices to determine the degree of dissonance among other more complex aspects.

```
(
var densityOfVoices = [5, 10, 20, 30].choose;
var sizeOfMelody =    [5, 10, 20, 30].choose;
Can.converge(\myLiveCan,
       melody: Can.melody(
       Array.fill(sizeOfMelody, { [8,16,4,6,12].reciprocal.choose }),
       Array.fill(sizeOfMelody, { [60,67,68,72,75,55,56,53].choose })),
       cp: (sizeOfMelody/2).round,
       voices: Can.convoices(
       Array.fill(densityOfVoices, { rrand(75,  95) }),
       Array.fill(densityOfVoices, { rrand(-24, 12) }),
       Array.fill(densityOfVoices, { rrand(0.1, 1.0) })
       ),
       instruments: [\pianola],
       repeat: inf)
);

Pdef(\myLiveCan).play;
Pdef(\myLiveCan).stop;
```

The next example is similar to the last one but adapted for a divergence canon. The argument convergeOnLast is fundamental for producing live loops with this kind of canon, if set to `true`, it will use the last value of the melody to create the last convergence of the canonical form if `false` it will converge on the first attack of the next iteration of the loop.

```
(
var densityOfVoices = [4, 8, 12].choose;
var sizeOfMelody =    [20, 30, 40].choose;
Can.diverge(\myLiveCan,
       melody: Can.melody(
       Array.fill(sizeOfMelody, { [8,16,4,6,12].reciprocal.choose }),
       Array.fill(sizeOfMelody, { [60,67,68,72,75,55,56,53].choose })),
       voices: Can.divoices(
       Array.fill(densityOfVoices, { rrand(-24, 12)}),
       Array.fill(densityOfVoices, { rrand(0.1, 1.0)})
       ),
       tempos: Can.divtempos(
       Array.fill(densityOfVoices, {rrand(20,50)}),
       Array.fill(densityOfVoices, {rrand(2,8)}), normalize:true
       ),
       baseTempo: 30,
       instruments: [\pianola],
       repeat: inf,
       convergeOnLast: true)
);

Pdef(\myLiveCan).play;
Pdef(\myLiveCan).stop;
```

## 6. FOR THE FUTURE

There are many components of Nancarrow's temporal canons that have not yet been implemented. Likewise, all the possibilities that a program like SuperCollider allows have not been exploited. For the future it is particularly important to extend and optimize the divergence canon function since it is relatively limited and unstable for the time being. For example, it is not possible to create overlapping equal tempos in two or more voices as often happens in the work of Nancarrow, that is, that the transitions of tempo are not synchronous between voices. The interaction between tempo switches and tempo variations in general must

be made more complex. The great debt of this software is the ability to create acceleration canons which requires slightly more sophisticated tools that will be explored in the future. The possibility of live-coding time canons that this program foresees is fascinating, however we must create APIs and notational systems with greater flexibility and clarity, and to better quantize these processes in order to have better control of the operation of our canons in contexts where other instruments and other modes of understanding rhythm can interact with these. The visualisation must work with the "live coding" aspects of the canonical structures and should show relevant data of the piece, measurements of echoic distance and we must design a way to express and visualise the temporal dissonance that helps shed light on the characteristics of the canon. Finally we will develop more auxiliary functions that help to create complex proportional tempos, a function based on harmonic rhythm capable of transforming transposition values to temporal proportions and vice versa, and a dynamic transposition function that allows to create different pitch patterns in each voice.

## 7. CONCLUSION

This program aims to provide the user with a robust, explicit and clear api that allows for an easy understanding and manipulation of the parameters of different temporal canons. With a minimum knowledge of SCLang it is possible to design melodies and express them as canons of convergence or divergence. On the one hand this offers compositional or pedagogical tools for musicians and teachers, on the other, the novel ability to create sets of live coding with tempo canons (a new addition to the enormous arsenal of resources that have been created for these practices).

This code can be manipulated by anyone and any suggestion of how to optimize it or of new functions or modalities of use will be welcomed through the github repository we have created for the software. Likewise, all outstanding issues are being addressed in this platform. This text and codes are an invitation to establish a dialogue and collaboration to enrich the universe of the time-oriented music inaugurated by Nancarrow beyond the canonical narratives often over-represented in academic and intellectual literature.

This project does not intend to be an exhaustive, definitive and absolute statement of the meaning of Conlon Nancarrow's oeuvre. Although it has been prepared from a critical point of view, it does not pretend to distort previous musicological or technological research, much less inhibit future research on the subject. However, it arises in response to a generalized understanding that tends to produce a hegemonic and homogeneous narrative of what this music is or should be. Thus, this software is an attempt to promote a plurality of narratives, understandings and knowledge regarding the art of Conlon Nancarrow.

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