# Automatonism: towards dynamic macro-structure in generative music for modular synthesisers.

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# Abstract

In patching the modular synthesiser we discover its ability to become an *automaton* and for patches to generate music by themselves. This practice-based PhD explores modular synthesis through composition, software design and performance. The research identifies the challenge of controlling macro-structure dynamically in self-playing generative music made with modular synths. Traditionally the way to control musical structure with these systems involved editing pre-recorded material or engaging physically with its parameters. This research is devoted to simplifying the process of automating micro- and macro-evolution of patches. In my artistic practice I am mainly concerned with treating the modular as a self-playing machine and my objective is to become an observer and enjoy its performance of my ideas. A modular synth platform has been developed in *Pure Data* called *Automatonism.* The software has unique macro-structural tools not found on any other platform. They allow for compositions that address the problem of generative loops in existing music for modular synthesisers. A portfolio consisting of five works will be discussed and used to answer the research questions. There are three self-playing compositions that address the question of dynamic macro-structure in three different ways. The two other pieces are live performances: one for guitar and *Automatonism* and one for live patching in *Automatonism.* They will highlight the other possibilities for exploring form and structure with modular systems. In this process I have been led by underlying ideas such as connecting familiar objects in unfamiliar ways, escaping linear left-to-right timeline and mapping out musical opportunities in novel ways well beyond my compositional aesthetics.

The research will likely impact the field of composition with modular synthesis, software design in Pure Data and live coding practice.



**Keywords:** modular synth, generative music, pure data, live coding, sonic ecosystem

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# (1) Introduction

## 1.1 The Modular Resurgence

The modular synthesiser presents itself to us with a multitude of sonic possibilities. It allows us to connect familiar objects in unfamiliar ways to achieve new musical spaces. In his book, *Electronic Music: Systems, Techniques and Controls,* Allen Strange (1983: 3) states that the lack of pre-defined structure forms a collection of possibilities rather than an imposed working method. It has the ability to influence itself and create an ecosystem of voltages to become a self-playing *automaton.* This phenomenon is put into words perfectly by musician Richard Devine:

> It's like you captured this little electrical ghost, this little electrical spirit...Floating between these different modules...It's kind of like making music with nature. (Devine, 2014: podcast online)

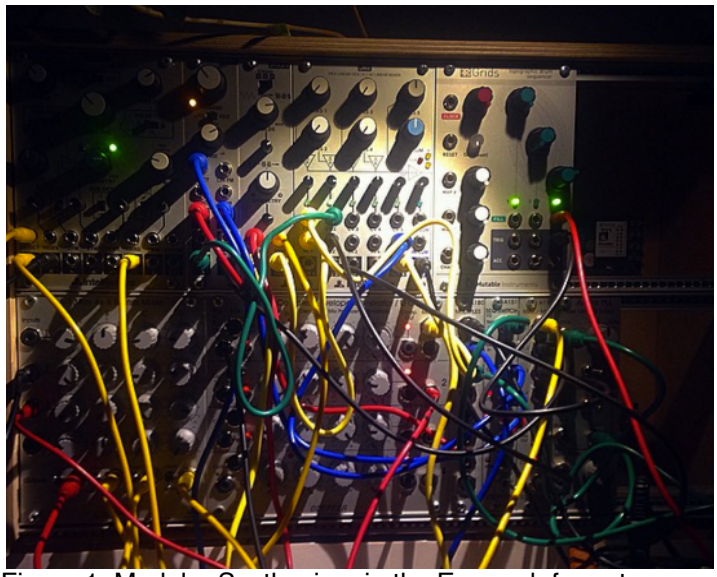

Figure 1: Modular Synthesiser in the Eurorack format.

Dalgleish (2016) explains how the modular synth became popular in the 1960s, disappeared from the mainstream in the 1980s until having a resurgence within the last ten years. The modular instruments developed independently by Robert Moog and Don Buchla in the 1960s were open ended tools for experimentation. But the immediacy of pre-patched functions later gained popularity and knobs and faders

forced the freedom of cables and jacks aside. The advent of digital FM-synthesis and Yamaha's DX7 instrument became the starting point of a digitalisation of electronic music and made analogue synthesisers rare collectors' items (Rossmy & Wiethoff, 2019: 2). The modular synth started to slowly gain traction again in the late 1990s with the Doepfer company's A-100 modular system which became what is called the Eurorack standard. (Bjorn & Meyer, 2018: 352) The current renaissance can be measured by the number of manufacturers making modules in the popular Eurorack format. There were only 10 different manufacturers in 2010 (bouzoukijoe1, 2012: online) and in July 2019 there are 368 manufacturers listed on the main online synthesiser planning resource (ModularGrid, 2016: online).

This explained chain of events has made its mark on the existing literature and repertoire for modular synthesisers. Published sources are outdated while contemporary music is not well documented outside of online community forums (Muffwiggler, 2016: website) and video streaming services. The most detailed published material on modular synthesisers is the already mentioned book by Allen Strange (1983). It is not a book about composition with modular synthesisers but can "instruct one about how to make sure things happen when they are supposed to" (Strange, 1983: 3). It provides useful information, but the discussed equipment is outdated. The closest we get to a modern equivalent to Strange's book is arguably musician Richard Devine's Vimeo channel (Devine, 2019: website). There he shares recordings of patches with notes on how they were made. Both sources provide an insight to modular synthesis techniques rather than being composition handbooks. We can conclude that there is a current resurgence of interest in modular synthesis, but there is not much scholarly material on how to compose with contemporary systems.

## 1.2 The Good, the Bad and *Automatonism*

In my personal experience from working with modular synthesisers, I have found two major advantages to the format:

**Advantage 1: Experimentation and invention of new signal flow**

Not being confined to routings or decisions made by manufacturers or commercial entities is aesthetically liberating. My feelings on this are supported by Rossmy & Wiethoff (2019) who have conducted empirical research in a questionnaire with 35 Eurorack manufacturers. Their research indicates a consensus about the modular synth's ability to create a "bidirectional creative feedback loop" and an emotional connection between user and instrument. The participants read a statement and answered whether they agreed on a scale from 1-7 where 7 stands for 'very much agree'. See Figure 2 & 3 for examples:

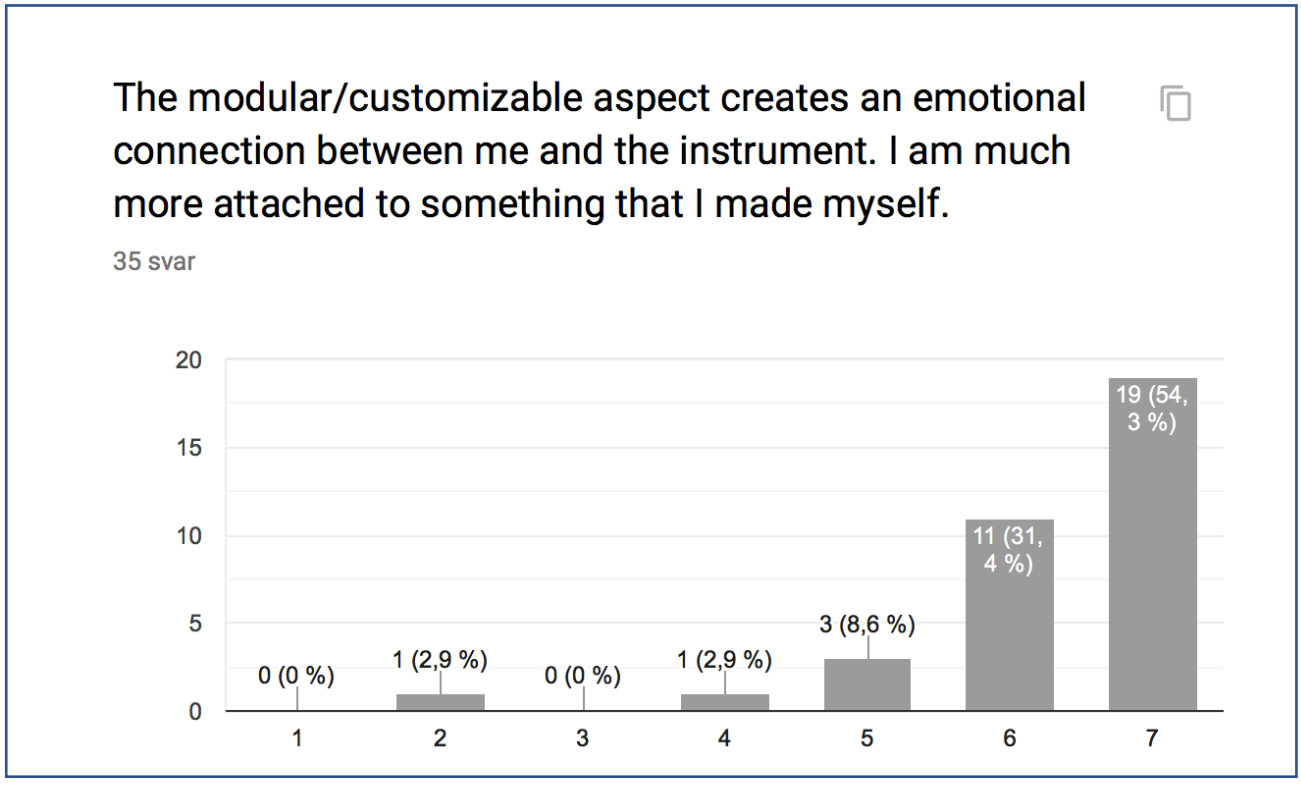


Figure 2: Screenshot from Rossmy & Wiethoff's (2019) interview results

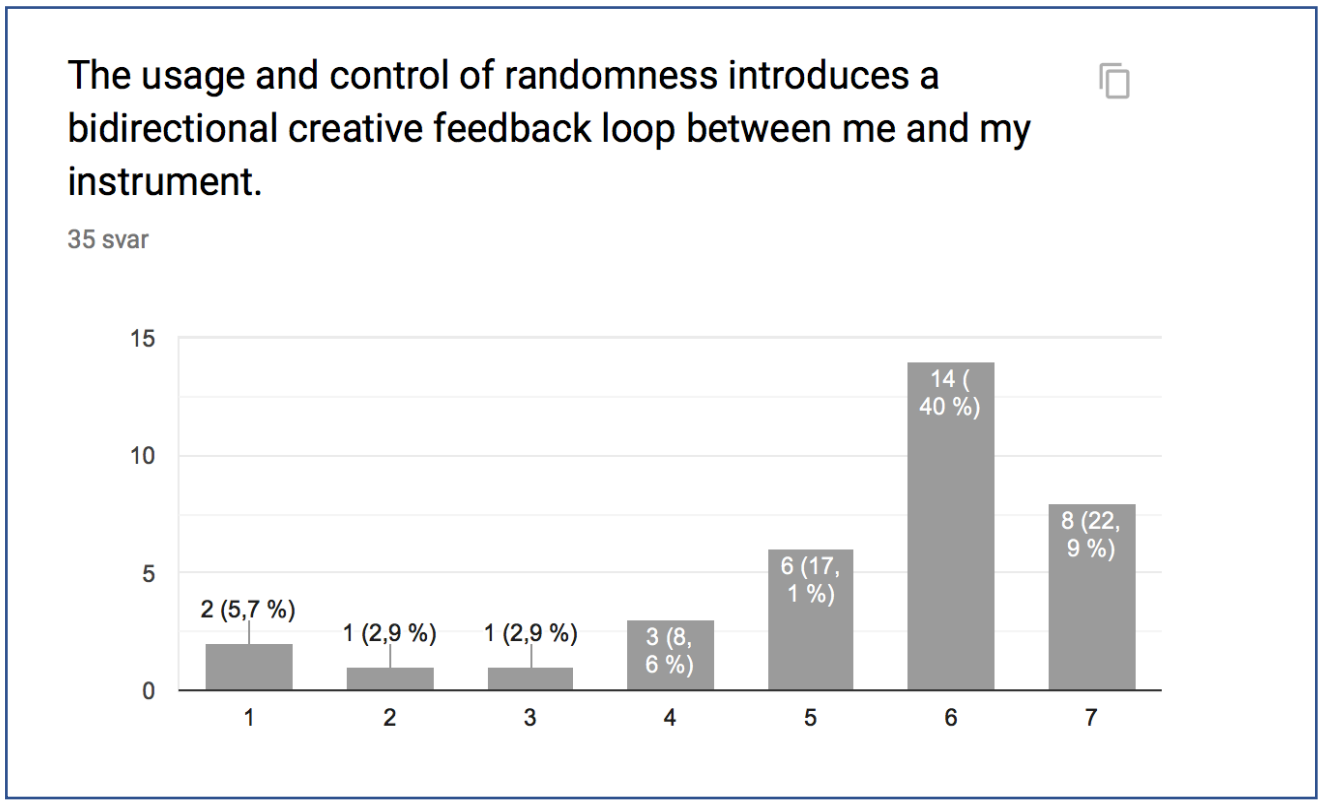


Figure 3: Screenshot from Rossmy & Wiethoff's (2019) interview results

**Advantage 2: Voltage control leading to generative ecosystems**

Voltage control means we don't have to manually turn a dial back and forth. We can automate that motion with an electrical control voltage from the system itself. This leads to working with the modular in a way that resembles a partnership with a living organism. By combining invention of new signal flow with voltage control we can create self-playing machines or in more poetic words, sonic ecosystems. Looking at interviews with artists in the field I have found that I am not alone in experiencing the modular as a living thing:

> It was almost like it had its own personality, it was like a living organism that would sort of do its own thing. These circuits would come to life. - Richard Devine (Devine, 2012b: video online)

> ...it's like getting to know a person. The modules are alive with the different things they can do and you have to get intimate. - Suzanne Ciani (Doran, 2012: online)

However, there are also things that make the hardware modular synth a limited

compositional tool. It is very hard to recreate patches and get the exact previous results, there is no preset saving system and most importantly, modular synths can be expensive. When I started out with a small modular setup I was constantly frustrated of not having enough modules as my ideas for patches grew larger and more complex. Four years ago, in an effort to address these problems, I started the development of a virtual modular synthesiser in the open source programming language *Pure Data*, developed by Miller Puckette (Puckette, 2007). The platform is called *Automatonism* (Automatonism, 2017: website) [See Figure 4] and is a large modular system featuring 97 different modules.

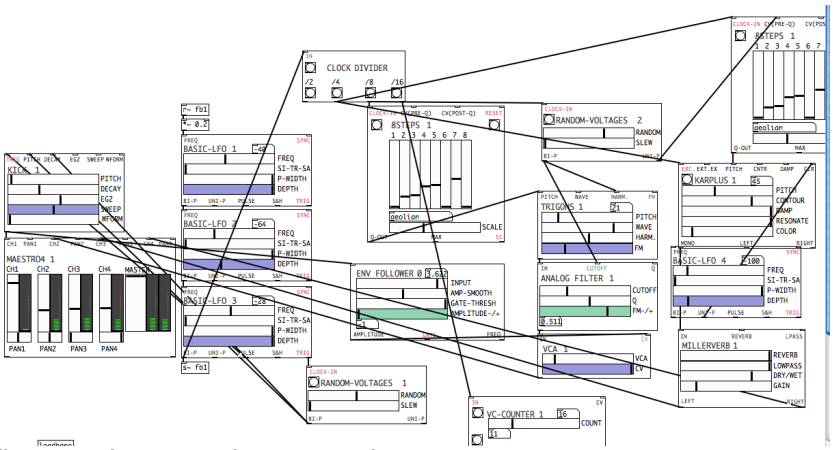

Figure 4: *Automatonism* screenshot

## 1.3 The Generative Loop: Identifying a Problem and Paths Towards a Solution

In order to understand the unique compositional possibilities of *Automatonism*, we need to start from an analysis of self-playing patches that I conducted at the beginning of this research, identifying a musical problem within the field. The analysis was made by comparing two pieces of generative modular music: a classical piece from the late 1960s and a contemporary piece from 2015. The two pieces were *Entropical Paradise* (Leedy,1969: video online) for a Buchla modular system and *CR Hex Mutant Patch* (Devine, 2015a: video online) for a Eurorack system. I recreated the pieces in the *Automatonism* software (Eriksson, 2016a, 2016b: audio stream) using Leedy's signal flow chart (Strange, 1983: 244-247) and Devine's video description on Vimeo. The

replicas proved that the software could faithfully reproduce modular repertoire while giving insight to generative patching techniques. Recreating these patches in *Automatonism* led to one other major discovery: even though they sound completely different from each other – they are both static on the compositional macro-structure in that the patches never move away from their initial self-playing mechanism [See Figure 5]. While there are plenty of variation on the micro-level, there is no evolution that drastically changes the pieces over time.

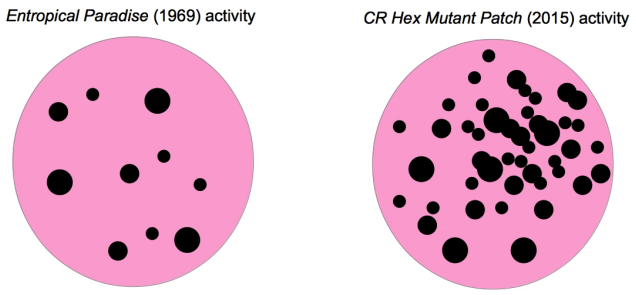


Figure 5: Activity analysis of two generative patches where the pink circle represents silence and the black dots are musical events. The circles are snapshots of how I perceive the entirety of the pieces.

Both pieces form something that I propose to call a generative loop. It consists of musical material that is being constantly generated but does not evolve towards new sonic landscapes. Very much like a waterfall, where there is constant change on the micro-level, but when stepping back and watching it from afar, it looks static. This is because of the very nature of a modular generative patch: once it is set up to do something, it is very hard to get it to do something else. My development of *Automatonism* was led by finding solutions to this problem. I aimed at finding a way to enhance the possibilities for a self-playing patch to evolve dynamically over time, thus transferring simple compositional structural techniques to generative patching. I wanted to be able to compose self-playing generative modular synth music with contrasting sections, thus giving pieces dynamic form.

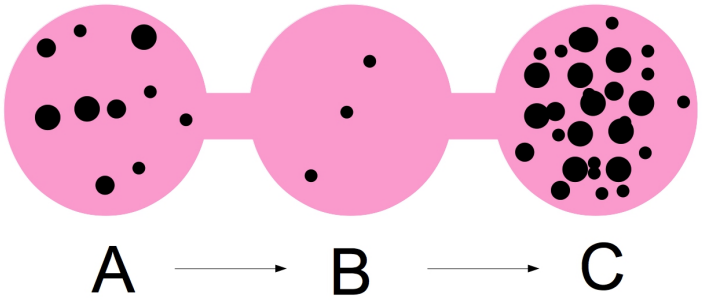


Figure 6: Dynamic macro-structure suggestion where a self-playing modular patch could move between material A, B and C. The figure suggests a piece where material A is similar to *Entropical Paradise,* material C is similar to *CR Hex Mutant Patch* and material B is something much stiller with more silence and less activity.

A new question then arises: how to get out of the generative loop? Looking for answers to the question this research has chosen two paths:

1. Development of a dynamic preset management system
2. Mapping the void by nudging the space

**Development of a Dynamic Preset Management System:**

The analogue modular synthesiser has several issues in performance and composition: it is hard to tune, it cannot save states, and it is hard to achieve the same results twice when dealing with a complex patch architecture. A modular synthesiser can have hundreds of parameters accessible for human interaction in the shape of knobs, buttons and so on, but a user can only physically turn two dials at the same time. I acknowledge that these shortcomings are precisely what makes modular attractive for some artists. In my own artistic pursuit, however, it has become a problem and the digital domain opens up potential satisfactory solutions. Taking inspiration from a design by Don Buchla (Model 225e, 2016: online: 5), I have developed a preset management system in *Automatonism* that allows the user to read all modules' parameter settings and positions. This data can be stored and recalled, either manually or automatically from the patch itself. The difference from standard software state-

saving behaviour is that it is possible to both store and recall data dynamically using musical parameters from the self-playing patch itself. This technique allows transitions between widely contrasting musical material while still using the same patch architecture and signal flow.

**Mapping the Void by Nudging the Space:**

In using the previous mentioned technique of preset management we encounter a new creative hurdle. When a patch contains hundreds of parameters, it becomes next to impossible to map interesting combinations in an efficient manner. As explained by Dahlstedt (2007: 77-96), mapping parameter values one at a time is time consuming, and plenty of sonically interesting material would be missed because of the vast parameter space it inhabits. A modular synth patch has seemingly infinite number of combinations in terms of parameter combinations. I believe the word 'void' can be used to depict this concept. This leads to the conclusion that users would benefit from an automated function that helps the mapping of new parameter spaces. If composition were the process of creating possibilities in this void, where anything seems endlessly possible; music itself would be the manifestation of what possibilities were acted upon and came into play. According to Boden (1998: 3) there are three types of creativity: combinational, exploratory and transformational. Using the modular synthesiser, we are already concerned with the first and the second type. The modular lends itself to connect familiar objects in unfamiliar ways to achieve new results; an act of combinational creativity. Exploratory creativity is what happens when we are mapping out the void, exploring the instrument, turning knobs and pushing buttons. Whether we call it void, complete emptiness or *tabula rasa,* the role of the composer becomes the same: populating the void by exploration. In doing these activities we bring to the table an "inherited style of thinking and musical skill that allows us to explore the particular space" (Boden, 1998: 6). I suggest that modular synthesis can transform ideas and spaces to discover new sounds and a new music unrelated to human style of thinking. Combining the ideas of Dahlstedt, Boden and Don Buchla, I propose a technique for mapping the void in complex modular patches to enable dramatic transformations of the musical space. A technique in *Automatonism* has been invented that can assign new random values to every parameter in a patch. This is realized by a module called

[PARAM-NUDGE] that is explained in more detail in Chapter 4.4. The random values can be fine-tuned and passed on to three different parameter groupings in any combination. This allows for minute changes to a patch or a complete recreation. It becomes a powerful tool because the same number of modules and their signal flow can be kept intact, whilst opening up to endless variations. This technique nudges parameters in search for new territory and can even do so dynamically by the patch itself. In combination with the earlier discussed preset management, these techniques aim to solve the problem of how to gain structural control over generative modular patches, letting us escape the generative loop!

A rising interest in modular synths has been established and a problem with structural control over self-playing patches has been identified. This created the need for a new software platform in order to create compositions that address the issue. *Automatonism* will be discussed in further detail later in the thesis.

## (2) Research Questions, Aims and Objectives

This research aims to extend the compositional possibilities of generative music made with modular synths by developing a software that allows for self-playing patches with greater structural control. I am using my practice in composition, instrument design and performance to get there. The five works of the portfolio answer the following research question:

How can a new compositional practice for modular synths be discovered through the development of a software platform to expand the conditions for self-playing systems?

Over the course of this PhD a secondary question has emerged out of the research process:

What are the implications of composing without a linear timeline in the form of a Digital Audio Workstation (DAW) or a music score?

The objective is to show that pieces for self-playing modular synths are possible where the composer has detailed control over the larger structure. The question will be answered by oscillating between composition, instrument design and performance.

# (3) Software- and Portfolio Context

This chapter does two things: it identifies other software modular systems that are similar to *Automatonism,* while explaining their differences, and puts the portfolio in its proper context.

## *3. 1 Automatonism* Context

I have developed a modular system in *Pure Data* called *Automatonism* as part of a methodology to answer the research question. Its functions are described in Chapter 4. This section will put the software in context and describe its differences to similar existing systems. First of all, I argue that systems that are known as patchers, like *Max/MSP, Reaktor* and *Pure Data,* are not comparable to *Automatonism.* The fact that they are all modular does not in itself make them the same. *Automatonism* is actually more comparable to a physical modular system like Eurorack, Buchla or Serge Modular. It is not a programming system where you construct functions yourself. It is a modular system where the blocks have more specific functions. I will highlight three similar software systems and identify important differences:

### Nord Modular

The Nord Modular was a hardware synthesiser by Swedish company *Clavia* produced between 1998 and 2004. It is mentioned here because it was the first modular synth of its kind. It featured a modular software patch editor to make patches on the computer and then run on the DSP of the synth. In my opinion this was the first modular software that resembled more a physical modular compared to *Reaktor* or *Max/MSP.* It featured more low-level building blocks than *Automatonism,* but no macro-structural tools as explained in Chapter 4. There is an interesting morph group feature in the patch editor that lets the user assign various parameters with individual ranges to a MIDI knob (Nord Modular, 2019: 40). I consider this more of a great performance friendly feature in contrast to the macro-structural morphs between stored presets in *Automatonism.*

In short – the Nord Modular is more aimed at instrument sound design and performance where *Automatonism* is more aimed at creating self-playing dynamic systems.

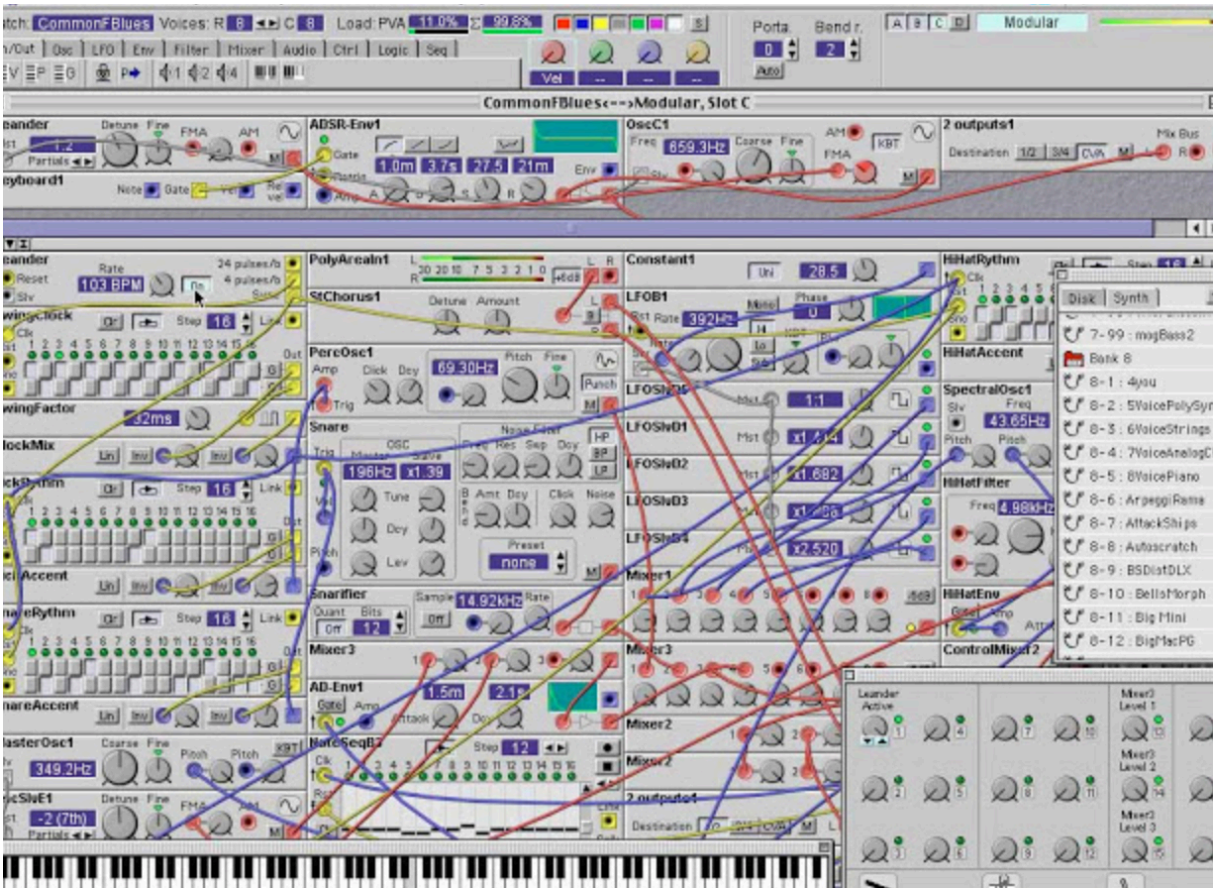


Figure 7: Screenshot of the Nord Modular patch editor

## Reaktor Blocks

*Reaktor Blocks* is a modular synth software from *Native Instruments.* It is examined here because Native Instruments is a major player on the market and their products have a large user base. On the *Native Instruments* website for *Reaktor Blocks* we find this description: “start creating insane synths and sounds” (Reaktor Blocks, 2019: website). This make me believe it is intended for sound design and DAW integration rather than as a standalone generative compositional tool. The software follows the physical modular format of laying out modules in horizontal rows. In my experience this limits the patching creativity compared to a layout where modules can be dragged around freely and placed anywhere. There are no possibilities for self-playing dynamic macro-structure in *Reaktor Blocks* even though one could argue that DAW integration

makes many things possible. However, I argue that its linear timeline and many possibilities are distractions that when removed, lets us discover ways to create more complex self-playing patches with the modular by itself.

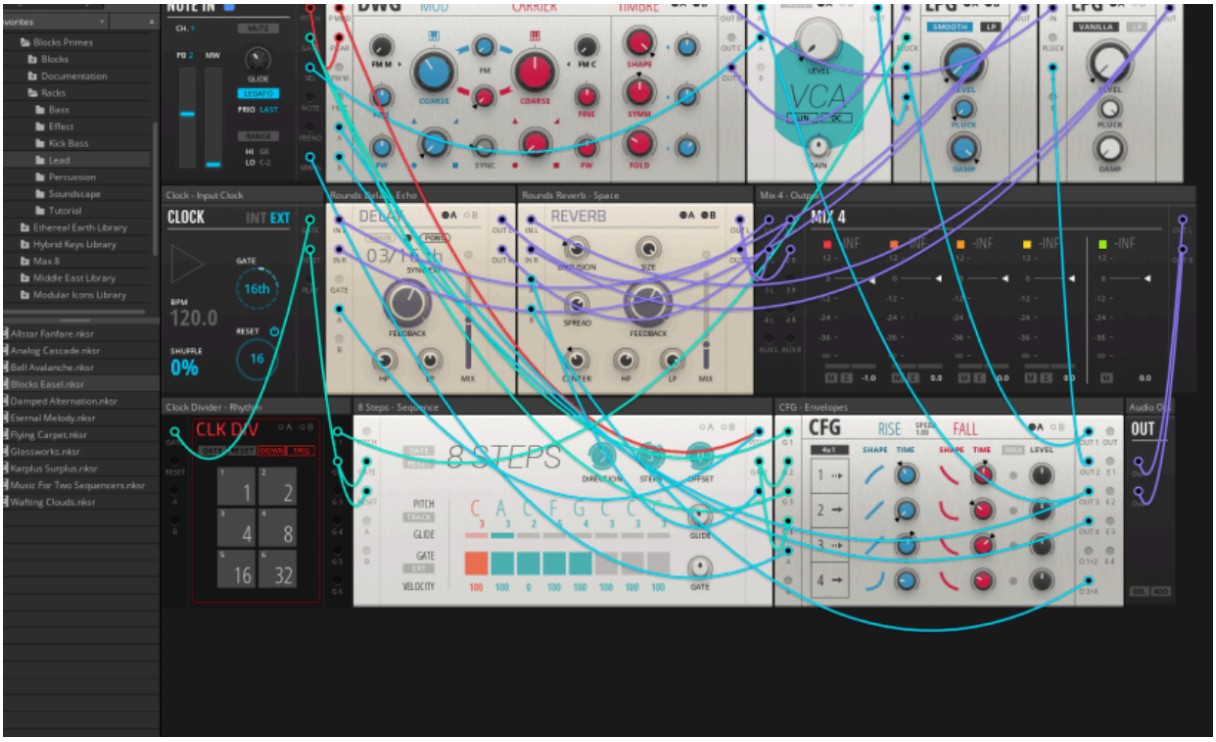


Figure 8: Reaktor Blocks screenshot

### VCV Rack

*VCV Rack* is an open-source software modular (VCV Rack, 2019). It is featured here because it is open source just like *Automatonism* but it came out after *Automatonism* in the middle of this research. *VCV Rack* seems like a great software substitute for a physical *Eurorack* system and actually features many replicas of existing modules. Once again though, the GUI constrains modules to rows and there are no specific modules to deal with self-playing macro-structures. An important point needs to be made here. Very high quality self-playing music can be created on any modular system. It is the medium's major strength. Arguably there are ways to create a generative piece that moves between contrasting material on any of the afore-mentioned modular systems. As long as there are enough modules, a user could create, for example, three generative sub-patches within one patch and use some kind of switching mechanism inside the patch to change between them. However, the

macro-structural tools of *Automatonism* present a new perspective on dealing with structure in modular systems. By using the preset-manager there are many more possibilities with less modules and same signal flow. It allows mapping of new parameter settings by nudging, generating new material from morphing and managing time and structure with time-management modules in a very precise way. These techniques combined enable self-playing compositions not possible on other systems. The specifics of this will be described in Chapter 4 and 5. In my experience from working with many modular mediums - *Automatonism* has been the only one I felt good enough about the music without having to intervene or edit it in post-production. Even though *Automatonism* is a software modular and we have looked at three other similar products I argue that it is more similar to the Buchla 200e hardware system (Model 225e, 2016) where up to thirty presets of parameter settings can be stored.

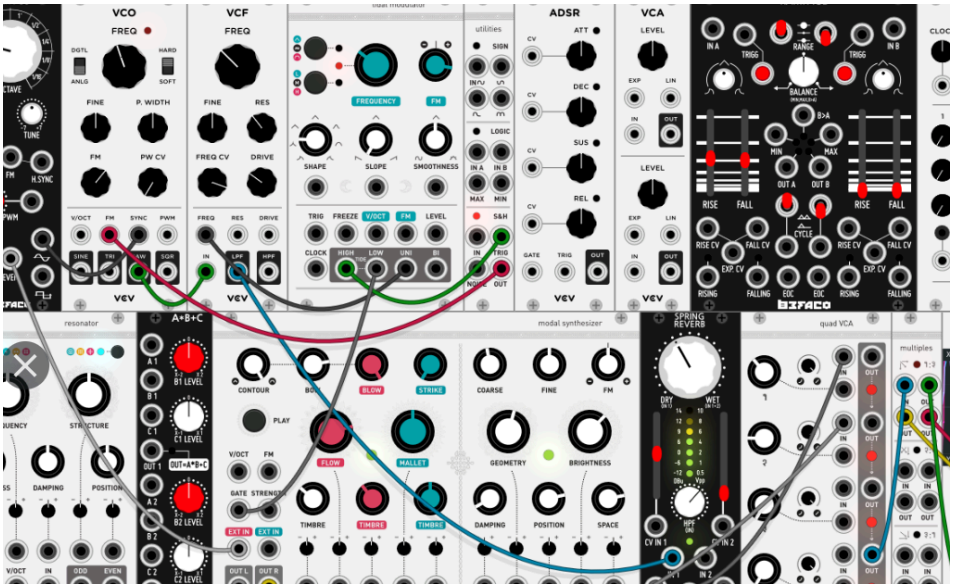


Figure 9: *VCV Rack* screenshot

The Buchla also allows dynamical changes to active presets with triggers from the patch itself. This was the inspiration for the *Automatonism* [PRESET-MANAGER] module. My design then added morphing capability for three selectable parameter groups and a parameter nudging module to help map out interesting settings. In a software version there is the added benefit of visual feedback when settings change. This is not possible on a hardware system unless the rotary knobs have mechanical motors which the *Buchla 200e* does not have.

Figure 10: Buchla 225e preset manager module

We have looked at three similar software systems to *Automatonism* and highlighted differences as well as pointing towards more similarity to a *Buchla* hardware system. Lastly, I would like to state the argument for *Pure Data.* One of the major advantages of *Automatonism* is that it is simply a patch in *Pure Data.* This means it has backward and future compatibility secured and can run on any platform. We can see *Automatonism* already being used running on a Raspberry Pi-based *Eurorack* module in a community project called the Terminal Tedium (2017).

## 3.2 Portfolio Context

A rationale for aesthetic decisions, rhythm and harmony paired with personal musical background will be the object of Chapter 5 – Preface to The Portfolio. This section will position the portfolio in the context of algorithmic- and generative music and music for modular synths. Palle Dahlstedt (2001: 121) argues that formal methods like algorithms and generative processes are not the work of a lazy composer. In fact, he claims that it takes more time than conventional compositional methods. From my experience with working on this portfolio I agree with Dahlstedt that there is a benefit to allowing the compositional process to take time. With this type of music and method the composition started at the same time as the software design process began. The

tool is part of the final object. I believe the key to compositional success lies in what Dahlstedt describes as the expansion of the creative circle (Dahlstedt, 2001: 122). In short it means that it is difficult to put the musical expansion Mozart experienced after each piano concerto he wrote into an algorithm or automatic process. Dahlstedt uses formal methods to step out of the creative circle to discover new material and surrender to the algorithm. I do not think my music is ever surrendering to the process. It forms modular networks – algorithms – but they are not in charge. They behave like a well-trained dog without a leash under verbal control. I believe the process is the most important thing as long as the process does what I like sonically. There is an interesting battle between process and results in my music. This duality almost becomes a trait and I do not feel the need to state clearly which is most important to me. I build patches that form musical ecosystems that perform processes. They are inseparable from the object itself. Ironically, the tools I have built differs the most from other similar tools in that they give me access to more conventional composition techniques in a generative ecosystem (macro-structural tools described in Chapter 4). They help me control the process to achieve the results I want. The music of this portfolio is not primarily related to algorithmic music, generative music or computer music. It is self-playing music for modular synthesisers and we can look at artists like Richard Devine, Keith Fullerton Whitman and Suzanne Ciani to position it properly. They are all composing and performing with modular synthesisers. When I analyse their patches I keep coming back to the same conclusions: their attention to micro-detail and patch construction skills are exquisite. To solve the problem of the generative loop and create overall structure they all use the same technique – human intervention with the patch. Richard Devine can be seen pushing buttons on the sequencer module to create pattern variations in this video of his piece for Eurorack: *MakeNoise Tempi-Samurai Beats* (Devine, 2016: video online). Keith Fullerton Whitman (2015: video online) can be seen interacting with his patch throughout a performance from 2012 of his piece *Redactions* for Eurorack. It seems to me that he is using the same method discussed by Devine in a video interview at 2:51 where he describes a system consisting of eight patches that he switches manually through (Devine, 2015b: video online). Finally, Suzanne Ciani (2017: video online) performs with a Buchla 200e and two Ipads in London 2017 by engaging with the controls to create compositional structure. I argue that there are

benefits of allowing the modular patch to be a completely self-playing system. Obviously without human intervention the music can be used in installations and procedural audio situations but that is not its main benefit. Without human intervention the modular moves philosophically from instrument to machine and this is an important distinction. I am not concerned with the aspect of electronic music where you make an object and perform by playing with its parameters. I want to build a musical Frankenstein and observe it in the wild. I think this method expands the artform of patching modular synthesisers – the more you ask of it the more you have to ask of your craft. This also changes the way the music is perceived. When a human alters parameters, we can immediately give it emotional connotations like we do with any instrumentalist. I prefer the mysticism of the machine's own actions. I think it creates an interesting relationship between random and composed material. This duality will be explored in Chapter 5.3. Let's also clarify that I am referring to the recorded music of this portfolio, where the patches are completely self-playing throughout. I argue that the art form of patching a modular synth in this way is more authentic to its strengths compared to recording bits of material and editing them in post-production on a computer. In that sense I am a modular purist. However, for the performance pieces of the portfolio I wanted to find another way from what is seen in the performances by Devine, Fullerton Whitman and Ciani by combining modular synthesis with elements of live coding. These processes are discussed in Chapter 6.4 and 6.5.

# (4) Automatonism

This chapter will explain the main design choices of the *Automatonism* software and highlight what makes it different from similar available systems. A musical problem regarding compositional structure has previously been identified and the process of finding a solution to this problem has been the main driver for the software design choices. An explanation of what *Automatonism* is will be followed by the description of several of its modules and finally by the dissection of four distinctive modules from the Macro-structural tools section: Preset-manager, Param-nudge, Time-manager and Random-time-manager.

## 4.1 What is *Automatonism?*

*Automatonism* is a modular synth software. While it acts like a stand-alone application, it is actually just a patch made and run in *Pure Data*, which is a visual programming language invented in the 1990s by Miller Puckette. *Pure Data* is very similar to Max/MSP because Puckette was also the creator of the original Max language at IRCAM. *Automatonism* is a modular system with 97 different modules. All fundamental building blocks commonly found in any modular system are present like oscillators, filters, sequencers, modulation sources, sound processors and amplifiers. The present research is not about specific oscillator or filter designs and it is beyond the scope of this commentary to dissect every module in that manner. I will instead focus on the most important design choices and what sets *Automatonism* apart from other systems.

## 4.2 The Argument for *Pure Data*

*Pure Data* was chosen as a platform for *Automatonism* for several reasons. *Pure Data* is an open source software that has been around since the 1990s and it has a large developer base. This means that running *Automatonism* within *Pure Data* insures both backward and future compatibility. *Automatonism* can be run on a 10-year old desktop and most likely on any machine of tomorrow without changing its code. The

development of micro-computers like the Raspberry Pi (Raspberry Pi, n.d: website) has made *Pure Data* more relevant than before. It can now run on a wide range of different platforms and can be used for installations or DIY technology projects. Recent products like *The Owl*, *The Organelle* or the *BELA* (2020) project are all based on the idea of the user making *Pure Data* patches and uploading them to the hardware. *Automatonism* can be used wherever *Pure Data* can be used.[1] This is one of the strenghths of this research and will make it valid into the future.

## 4.3 Signal Flow, Color Code and Patch Example

At launch *Automatonism* starts with a blank canvas and the module list [See Figure 11].


Figure 11: Screenshot of new project in *Automatonism.*

The user can click on a module's name and it will appear on the canvas. This makes *Automatonism* behave like a software outside of *Pure Data.* This removes the need for programming knowledge or previous experience of similar visual programming languages and makes it easier to expand the user base for the software.

[1] In the case of the *BELA, Automatonism* does not work because *BELA* is not running *Pure Data* patches, it converts them to C code.

*Pure Data* deals with two different types of data messaging: control rate and audio signal rate. In *Automatonism* everything is converted into signal rate. This design choice was made to make the user experience more similar to patching a Eurorack modular where any output can be patches to any input in the system. I believe this is an important aspect of the modular experience and enables a creative freedom and immediate desire for experimentation. Figure 12 shows the basics of how a patch is constructed in *Automatonism*:

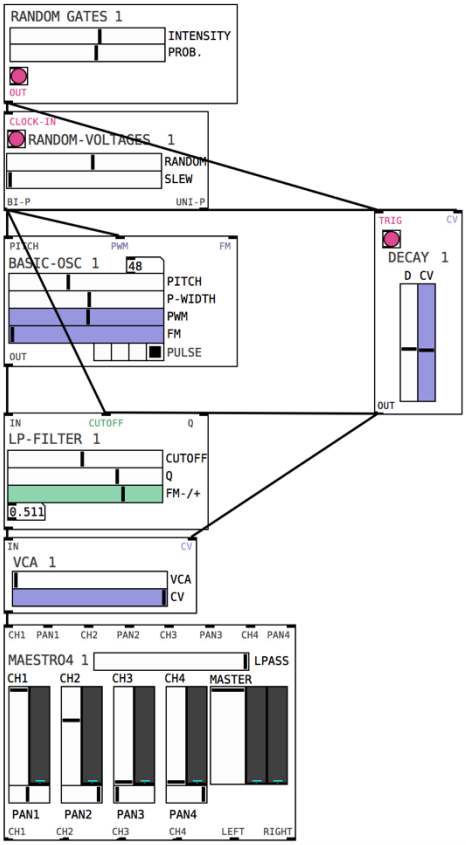


Figure 12: Patch example from *Automatonism*

The above patch consists of a pulse-wave oscillator being fed random control voltages clocked by a random rhythm generator. Technically it is not correct to use the expression ‘control voltages’ in this scenario because *Automatonism* is purely digital. However, I will continue to use that terminology because it best describes that function and is commonly understood. The architecture of the patch is simple subtractive synthesis with a lowpass filter being modulated by the amplitude envelope. Three colours have been used to understand the signal flow better: purple, green and pink. They all indicate a specific function. Purple means that the

slider is an attenuator for incoming control voltage. Green means the slider is a bi-polar attenueverter[2] for incoming control voltages. Finally, anything in pink indicates a trigger/gate signal. The names of inlets and outlets use the same colour coding system for further clarity.

## 4.4 Macro-structural Tools

There are four modules in *Automatonism* under the subheading Macro-structural Tools: Preset Manager, Param Nudge, Time Manager and Random Time Manager. Those are specifically designed to help structure larger patches and we will look at each one more closely in the following section:

**Preset Manager:**

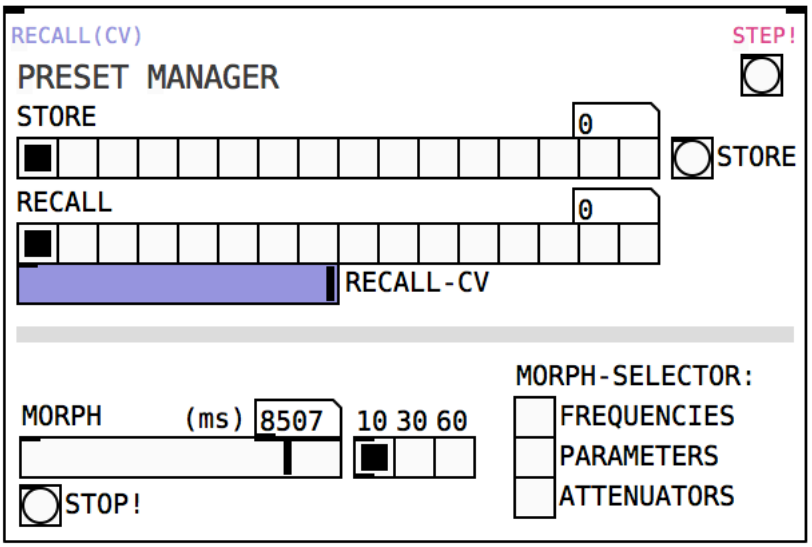


Figure 13: The Preset Manager module

The Preset Manager can store 16 versions of global patch parameters and address these dynamically. The user can step through each preset 1-16 by manually clicking the slots on the module or by sending a trigger/gate signal to the STEP! inlet on the module. A control voltage can also be sent to the RECALL(CV) inlet and change the active preset more unpredictably. There is an option to jump immediately to the new

[2] A type of attenuator that can also invert the polarity of the voltage passing through

set of saved parameters or morphing can be used. Morphing introduces a linear transition between 1 – 60 seconds to reach the targeted preset. All *Automatonism* controls have been divided into three groups: frequencies, parameters and attenuators. The morphing process affect any combination of these.

**Param-nudge:**

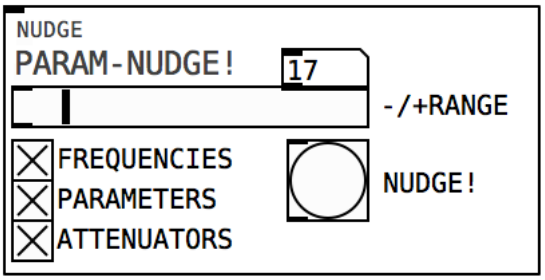


Figure 14: The Param-Nudge module

The Param-nudge module is a tool to map interesting patch parameter settings. For example, in a patch ecosystem consisting of 50 modules there will hundreds of sliders and controls. It becomes very difficult to manually discover all possible parameter combinations such an architecture withholds. With the Param-nudge a new random value can be assigned immediately to every parameter in a patch. The degree of randomness is controlled by setting a range between 0-127. For example, with range set to 127 the patch will sound completely different. With values on the lower end of the range the patch will sound quite similar, like a recognisable variation of the original patch. Again, it is possible to select which of the three parameter groups (frequencies, parameters or attenuators) that is to be affected by the nudge.

**Time-manager:**

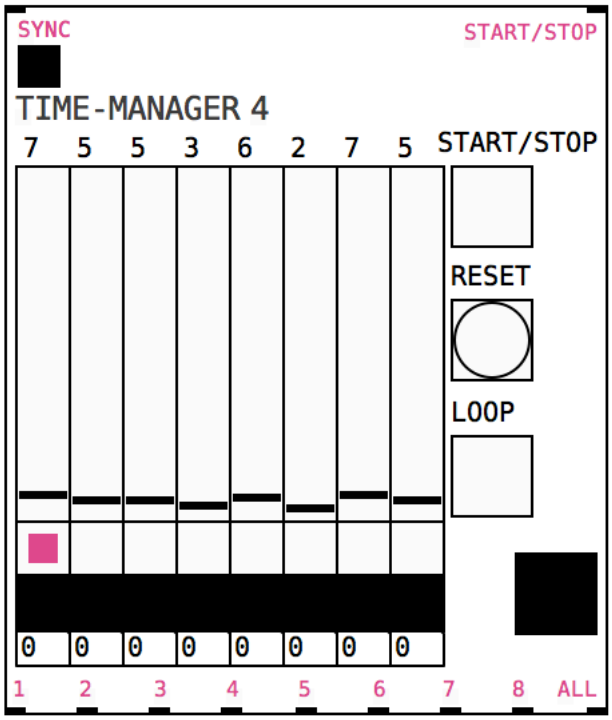


Figure 15: The Time Manager module

The Time Manager allows us to time with precision key events in the patches. The module is basically an eight-step trigger sequencer that works on a larger time scale. The time is set in seconds for each step and the module will output a trigger signal after the set time. Each step has a range between 1- 120 seconds. This module is essential to enable larger patches to progress structurally. An important feature is the SYNC inlet. When a relevant trigger source is sent from the patch the Time Manager will first count to whatever value the slider is set to, then wait for the next trigger to happen at the SYNC inlet and simultaneously output a trigger at the corresponding output. This enables musical changes to happen in sync with the patch.

**Random Time Manager:**

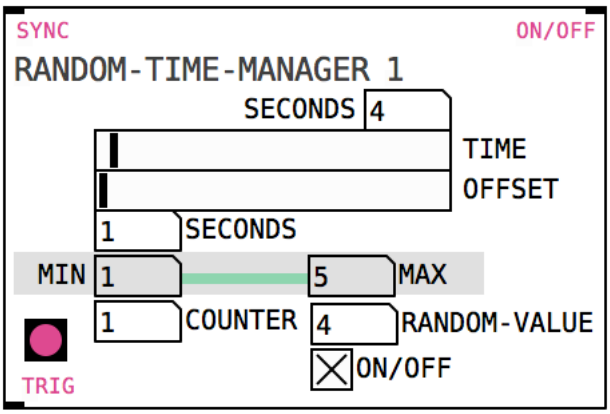


Figure 16: The Random Time Manager module

The Random Time Manager works similarly to the Time Manager but does not give precise sequencing of global events. Instead desired minimum and maximum values are set in seconds, and the module will output a trigger signal at a random value between the set limits. This allows more unpredictable structural variation in the architecture of the patch. The module also uses a SYNC input to make the outputted triggers sync musically in time with the patch.

## 4.5 User Feedback

During my process of developing this software I did take into consideration to allow for user feedback to inform my research. Over the last couple of years, I have been receiving almost weekly e-mails from *Automatonism* users either troubleshooting or coming with suggestions. It could be argued that this was a good opportunity to collect their feedback to try and better the software. However, I chose not to act on that possibility. I noticed that users primarily were not interested in using the modular in the same way I was aiming for. I realised that my research was not about discovering the perfect modular synth software, it was about enabling more complex

structures for self-playing patches. The development was led by trying to solve a problem I had encountered in my own music, and as long as it became a useful tool for me to make my perceived music I was satisfied. I identify myself as a composer and a musician foremost, not a software developer. Collecting user feedback to inform the software development would also have shifted that self-image and I think that would have been detrimental to my creative process and the musical results. This is not to say that I ignored communication with users, and when possible, I would of course rectify bugs or malfunctions that were mentioned to me. However, I would not start programming new modules that were asked for or making other functions to adhere the users. I felt that would take too much time from my focused effort and philosophically transform me into more of a programmer/software developer instead of a composer and musician. Since *Automatonism* is open source software and built inside *Pure Data* it is my hope that users themselves in the future will create their own communities that can adjust the software to their needs. At the time of writing, there has been a very well documented user created sampler module and hopefully there will be more initiatives like that in the future (Megalon, 2020).

# (5) Preface to the Portfolio

This chapter will describe the context of my music with some personal background and explanations of aesthetic choices. First of all, I would like to remind the reader that the music in this portfolio is not to be considered general electronic music nor computer music, but self-playing music for modular synthesisers. It may resemble other types of electronic music, but its contribution to knowledge lies in a novel approach to generative music for modular synthesisers. The *Automatonism* system was created to enable the work in this portfolio. Its macro-structural tools present a non-linear straight forward way to work with more complex self-playing structures. Pieces 1-3 contributes by moving towards more dynamic macro-structures without physically intervening with patches after they are built. These pieces run themselves and use the macro-structural tools in *Automatonism* to allow me to become an observing composer instead of a performer while the music is generated in real-time. Pieces 4-5 explore what happens when a performative aspect is applied to the same concepts. In these pieces the foundational rules are the opposite from the first three pieces. These two pieces force me to perform or no music will happen. In piece 4 I intervene by performing the act of patching and in piece 5 I intervene by playing the guitar. Each piece in the portfolio will be discussed on a philosophical, technical and musical level, followed by a description of the methods used to achieve dynamic macro-structure.

The music in this portfolio is in the tradition of Braindance or IDM (Intelligent Dance Music). I studied contemporary classical composition during my bachelor's but after graduating I have mainly been occupied with electronic music in this genre. Before I started studying composition academically I played the electric guitar and was playing hardcore metal and punk. Later I discovered fusion jazz via Frank Zappa. In Braindance I found the DIY-attitude from punk and hardcore music again. There existed the idea of re-invention and transformation of objects that fascinated me. I interpret this as a direct heritage from one of the Roland Corporation's famous machines: the TB-303. Made in the 1980s, it was a bass synthesiser meant to replace a real bass player. It sounded nothing like a bass and was a bargain on the second-hand market a decade later from its arrival. Techno musicians picked it up and the acid

bass line sound was discovered (Vitos, 2014). Here an object meant to do one thing had more affordances than the creator had thought of. I fell in love with the sound of the acid bass line, and the philosophy of how it came about: taking an object and giving it new meaning. My music in this portfolio obviously exists in the same realm as tracks like *feed1* by Autechre (2016, audio stream) and *Plonked Spectral* by Richard Devine (2012a, audio stream). But there are also other important sources of inspiration from other genres of music. In this way I am trying to follow the tradition of Acid House – to take familiar things and make them unfamiliar. These sources of inspiration will be mentioned later, when I describe the rationale for my aesthetic choices in regard of rhythm, harmony and randomness.

## 5.1 Rhythm: Departure from Fixed Tempo and Master Clock

The critique of the over-saturation of fixed tempi in electronic music has become increasingly important to me over the course of this PhD. There's a tendency to put emphasis on the BPM (Beats Per Minute) in electronic music. In the DAW (Digital Audio Workstation), the BPM needs to be chosen and set, and when buying or streaming tracks online they are often labeled with a BPM. I think this is a simpleminded approach towards tempo. It may be valid sometimes but leaves many possibilities unexplored. It seems to me that Karlheinz Stockhausen in conversation with David Felder (1977:85-86) tried to explain that macro-time concerns form, and micro-time concerns figures and motifs, but, depending on the perspective, everything is rhythm. When a rhythm occurs 18 times per second it becomes a pitched sound (Strange, 1982:9), so in that sense music is contracted or expanded rhythm in time. This same sentiment echoes in an interview with modular artist Keith Fullerton Whitman as the essence and beauty of electronic music:

> I think one of the most powerful ideas in electronic music is the way that you can actually work in a completely atemporal way. You can just, you can expand and contract time as much as you want. (Podcast 064: Keith Fullerton Whitman, 2015: podcast online: 7:00)

This notion spoke to me as an artist and I saw the potential to let this inspire my modular synth patching. My patches consciously make an effort to move away from the idea of a master tempo. I am using several clock sources of different speeds. I am

modulating their frequencies and often use feedback loops to generate irregular clock information. These collections of clock sources now become what triggers events in the music. I can also clearly track this aesthetic of rhythmical complexity to music I loved as a teenager, in songs like *Black Page* by Frank Zappa (1996) and the rhythmically complex progressive metal in *Concatenation* by Meshuggah (1998). The sounds I create for drums and percussion can be traced to modern hip-hop from Atlanta: trap music. Its signature is a deep and pitched kick drum that doubles as bass and is paired with rapid-fire hi-hats of varying subdivisions. (Hall, 2019: 44-45) The song *Circle Of Bosses (feat. Quavo)* with Young Thug is a clear example of those musical ingredients and I have expanded on that sound in this portfolio. I think trap music withholds potential to become more experimental than perhaps what commercialism allows it to be. It is obvious that my music exists in the context of Braindance and IDM, but if you listen to drum-programming by Richard Devine (2012: audio stream) or Autechre (2018b: audio stream) it is clearly in a fixed tempo and evokes drum n' bass in the tradition of *Drukqs* by Aphex Twin (2001). Stockhausen once gave his thoughts on Aphex Twin's music and concluded that there were too many "post-African repetitions". He encouraged Aphex Twin to start experiment with changing tempi and changing rhythms (Stockhausen et al, 2004). In a sense my music is in the sonic tradition of Aphex Twin but trying to respond to the wishes of Stockhausen in terms of liberating rhythms and minimising repetition. To conclude, my rhythm programming in this portfolio is in debt to the pioneers of Braindance while blending Frank Zappa's and Meshuggah's complexity with the sounds of contemporary hip-hop from Atlanta.

## 5.2 Harmony: Diatonic Pitches, Noise and Modality

> There are so many people who are dashing away from diatonic music in order to give the appearance of being modern – which I think is a waste of time - Frank Zappa (Clement, 2009)

The pieces in this portfolio are harmonically diatonic. Sometimes the infusion of harmonically unrelated sounds – the result of timbral modulation and extreme sound design - might give the illusion otherwise. This is intentional. I have always been

fascinated by what happens when blending simple melodies and chords with other sounds – a C major chord is not the same as a C major chord with white noise added. I believe the emotional response to something familiar can be changed by mixing it with something unfamiliar. This idea mirrors the very modular activity that is at the heart of this music – connecting familiar objects in unfamiliar ways.

The use of diatonic harmony is all over Braindance and IDM. I believe this helps to put focus on the rhythms and timbres. However, before I started studying classical music and before I even knew how to write or read music I discovered the music of Frank Zappa. I owe my first lessons in harmony to him. It was his album *The Yellow Shark* with Ensemble Modern (Zappa, 1993d) that gave me the courage to go to university and study to be a composer. In Zappa's music I fell in love with his particular use of the Lydian mode. According to Brett Clement's (2009: 103) Zappa defines modal harmony a chord that is held for at least four bars. The harmony is the result of three functions: pedal (bass), chord and melody (Clement, 2009: 119). When there is a new chord and change of the bass note the diatonic scale changes with it. This is a very non-functional approach in contrast to classical music or jazz where the modulation often moves to the new center seamlessly with ii-V-I progressions, secondary dominants or diminished chords. The non-functional hard-switching harmonic approach is evident in for example the song *Uncle Meat* (Zappa, 1993a) which starts in G Lydian, suddenly switches to Bb Ionian at 0:25 and jumps back to G Lydian at 0:39. When later on I found the exact same approach in a song by Autechre, I was excited! The song *ilanders* (Autechre, 2010c) starts in Eb Aeolian and suddenly transposes to C Aeolian at 1:52. This was the same move Zappa had done but going down a minor third instead of going up a minor third. I was aesthetically drawn to the sound of both transpositions. I stumbled upon somewhat of an explanation to this - an esoteric explanation yet an explanation - by jazz pianist Barry Harris (2014: 5:10, video online): "The minor third is the most important thing of all". He claims that the four notes of a diminished seventh chord, which are at a distance of a minor third from each other, are like family and related key centres (Harris, 2014: 5:25, video online). I believe he uses the word 'family' to highlight that just one diminished seventh chord can be four different dominant seven chords with a flat ninth when adding bass notes derived from another diminished seventh chord. For example, Ddim7 can be G7b9, Bb7b9, Db7b9

and E7b9. That way a dominant chord from the music's current key centre can function as dominant chord for the key up or down a minor third. I had found the same harmonic ideas from three very different musicians and I too use them in this portfolio. However, my patches stay longer in the same key centre than perhaps Zappa or for certain Barry Harris would allow. I use it to avoid patches that sound too much like generative loops, thus showing compositional presence to the listener. My sequencer modules in *Automatonism* all have extensive scales and modalities pre-programmed in the interface that can be easily changed with trigger impulses. Hence the harmonic ideas of Zappa have influenced the very design of *Automatonism.*

In my music I think of the harmony as the overall combination of timbres and sounds. I aim to blend harmonically related sounds with harmonically unrelated sounds. Harmony in this portfolio was meant to be, as James Tenney (1983: 3) suggests, aesthetically neutral, and not tell the composer what to do or not to do. I see this method being connected to a long heritage starting with John Cage and David Tudor's *Variations IV* (1965: audio stream) and the birth of the idea that music can be a combination of any sounds without harmonic relationship. I argue that this notion is acoustically interpreted in the *Sonatas and Interludes for Prepared Piano* by Cage (2001: audio stream) where the mix of harmony (pitched keys unaffected by preparations) and sound design (prepared keys) becomes the signature of the music. The fusion of traditional harmony and sound design in *Sonatas and Interludes for Prepared Piano* has inspired the harmonic approach of my music. This tradition was continued by Brian Eno with his ambient music (1982: audio stream) and his creative approach to making art out of *muzak*. My music does not incorporate FM radios, prepared pianos or field recordings. However, it takes advantage of the possibilities for a modular system to create new sounds that can be layered with more traditional musical gestures: again, combining unfamiliarity with familiarity towards something new.

## 5.3 Random: Taming Chance to Create a Digital Orchestra Without Habits

I have been asked many times (and surely many of those who engage with generative music have too) what is the point of my music if the computer is doing everything by itself. There seems to be a burning desire to know who the composer is – the computer or me. At first the question feels almost insulting, but then one wonders how to try and answer it in all seriousness. If the person asking the question were to borrow my laptop and use the exact same tools they would realise that it is impossible to make it do the same thing. There is a strong compositional and architectural element in the process. The patch becomes an object that exists in the world and somebody had to create it. But there is more to it than that. Dahlstedt (2001: 122) feels alienated from his work when creating musical algorithms. I feel the opposite way – I feel more connected to the system the longer I have spent building it and trying to make it do the right thing. I want to explain what my role is and what the patch does by itself. It is actually not that different from writing for an orchestra where the written score provides instructions to the players on what to play. There lies a selection process and traditionally the idea is that the composer selects what to play. However, in my generative compositions for modular synthesiser it is equally important to convey clearly what *not* to play. In my view this is the essence of randomness: don't do this, don't do that but within these parameters do whatever you please. The analogy with the classical orchestra is not perfectly fitting, but looking in another direction towards jazz it becomes more clear. When a jazz group approaches a standard tune, they know two things: the chords and the melody. The composer no longer controls exactly what the musicians play. My patches can be looked at in the same way: they have set architectures and a lot of rules about what is not allowed. I am led by my aesthetics to fine-tune the rules until I am satisfied with the computer's performance. This method gives freedom both to the jazz musicians and to my patches. I want the patch to surprise me. I want to hear sounds or gestures I could not have thought of myself. But I do not want to hear unpleasant surprises. Rogalsky (2010, 134) mentions Cage's well-known dislike for jazz because it is too easy to fall back on habits when improvising. Random processes in generative music are a great tool to avoid those habits and clichés. To further back

up this argument we can look at user made music with *Automatonism* by HAND (2019), In the Arms of Somnus (2017) and Fahmi Mursyid (2019) - which is clearly different from my music. HAND makes ambient music, In the Arms of Somnus evokes fixed beat techno and Fahmi Mursyid makes experimental acid/chiptune music.

My role as a composer of self-playing music made with *Automatonism* is to build and create a musical object or an ecosystem that performs in accordance to my aesthetics, but still has the freedom to supply happy accidents. Once again, the selection process is key. I have to use randomness in order to be surprised – but I have to tame randomness in order not to be disappointed. Let us briefly go back to Cage. Rogalsky (2010, 133) describes how *4'33"* is the opportunity to populate a passage of time with anything rather than simply being a piece of silence. I interpret this as the ultimate act of chance or randomness. *4'33"* becomes an absolute random piece. It is so random that during those 4 minutes and 33 seconds anything can happen. It becomes the *tabula rasa* of randomness and from there we have to populate the board to start taming the process. This is what I consider the essence of writing music for self-playing modular synthesisers. It is the heart of modular music. A blogpost on Horizontalpitch (2016) tries to identify if modular synth music has a sound, an identity or both. Conversations with people in the modular community helped answer the question. There are a few recurrent qualities mentioned in those conversation about the modular sound and those are: audio rate modulation, feedback, the ability to modulate or apply any stepped random voltages on nearly all parameters. I have used these techniques in the portfolio extensively to try and clearly distinguish myself with a modular sound. Often in the portfolio audio rate modulation is being applied to global parameters. I have used stepped random voltages in sync with complex clocks that affect many different parameters simultaneously. These techniques are not very easy to achieve quickly in other environments and became of aesthetic importance to me because I believe they audibly position the portfolio in its right context: modular synthesiser music.

# (6) The Portfolio

The portfolio consists of the following pieces:

1. That Classic Poetry (20'31")
2. This Garden is Growing Wilder (15'32")
3. Thinking Like the Seeds (10'00")
4. Purple, Green and Pink – live patching video (18'59")
5. Singing Like the Lydians – electric guitar + *Automatonism* live video (5'59")

This chapter will describe each piece in detail, how they achieve dynamic macro-structure and how they address the research question from different perspectives. Patches 1-3 were automatically recorded in *Automatonism* by starting the [AUDIO-RECORDER] module at launch. This produces a WAV file in the folder called 'recorded_wavs' within the project's parent folder. Recordings 1-3 have not been mixed or mastered or put through any kind of post-production process. Patches 4-5 were recorded via a second computer at the venue and the audio has been slightly limited and compressed in post-production.

## 6.1 *That Classic Poetry (20'31")*

*That Classic Poetry* is the longest piece in the portfolio. To perform a dynamic macro-structure in the patch I use the hard-switching technique to move between material and modal content. The title alludes to how language can be used to describe simple ideas with complicated words or the other way around; complex ideas with simple words. Whether the idea or the words are complex or simple often lands with the subject to decide. The form of *That Classic Poetry* tries to illustrate this in musical form. The structure starts with rhythmically complex material and slowly moves non-linearly towards utmost rhythmical simplicity. I wanted to create a clear structural idea that would reach the listeners. This is achieved in the patch by using a multitude of non-fixed clocks and slowly moving towards a single fixed clock. The transformation is performed by fine-tuned settings on the Time-manager modules. The initial patch ecosystem starts with seven musical elements or gestures. The patch uses the Time-

manager module to turn these elements on and off. When the Time-manager triggers, probability logic is used, giving a fifty percent chance of the musical element being turned on or off. This technique gives musical motion and variation to the instrumentation of the patch.

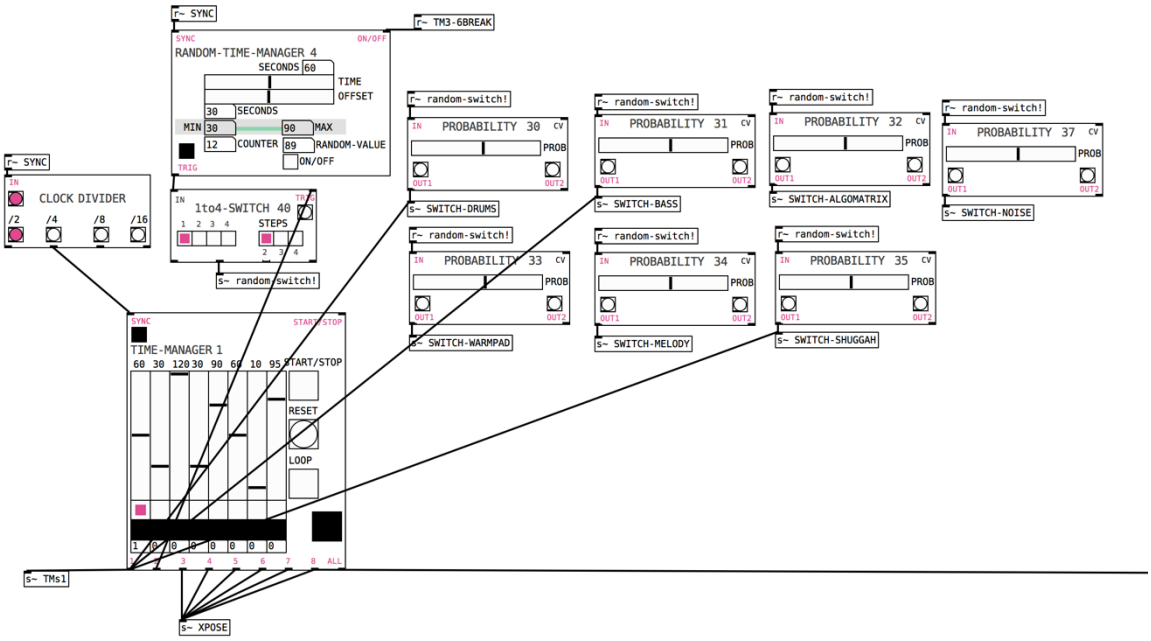


Figure 17: Screenshot from *That Classic Poetry* showing the fundamental ecosystem of the patch.

We can study this by looking closely at Figure 17. [RANDOM-TIME-MANAGER 4] outputs a trigger randomly between 30 and 90 seconds. Those triggers cannot pass through until 90 seconds have elapsed because initially [1to4-SWITCH 40) is closed. When [TIME-MANAGER 1] triggers its second outlet, a total of 90 seconds has passed and it opens the [1TO4-SWITCH 40] and passes the [s~ random-switch!] message on to the various probability modules. The first 60 seconds of the piece are uninterrupted and the first outlet of [TIME-MANAGER 1] outputs a trigger that perform switches so that we can hear the drums, the bass and the distorted synth (called SHUGGAH in the patch). Outlet 3, 4, 5, 6, 7 and 8 on [TIME-MANAGER 1] are being used to transpose between C Aeolian and A Aeolian in various places of the patch. This technique is discussed in chapter 5.

I have been concerned in this research to avoid the previously discussed *generative loop.* There is a big difference in composing using *Automatonism* this way compared to programming electronic music in a DAW. On the traditional linear timeline from left to right in a DAW the user has instant access to any point of the project by clicking and moving the playhead. There is no such visual representation of the music in a modular composition. Apart from the blinking lights on some of the modules, the patch is visually static and since the music is being generated in real time there is no way to skip ahead or move back in time. At first glance, this might seem like a compositional hurdle. But I argue the opposite and this apparent issue has made my compositions more structurally consistent. It forces me to become as much a listener as a composer. Over and over again I have to sit back and listen to the patch play by itself. When I hear something that I don't like, I have to stop, change something in the patch, re-run it and listen again from the beginning. I have to use my ears and aesthetics to decide when it is time to move on in the music. In the case of *That Classic Poetry*, I have tried to set up a self-playing ecosystem with as much variation as possible and when the music started to feel like a *generative loop,* I made the patch intervene. In the composition, that point occurs at 6:30, at a key moment in the structure of the piece. Here follows a hermeneutic analysis of *That Classic Poetry*:

**PART 1: Introduction (0:00 – 0:58)**

A synth pad blended with white noise holds chords around a minor tonality for the first minute of the piece. Seemingly simple, in a self-playing modular system this kind of musical introduction can be difficult to move on from. Without manual intervention, by turning knobs and controls, it is hard to have control over the exact time the patch should do something else. In this piece this is solved by having the Time-manager count to 58 seconds and then switch on the percussive elements.

**PART 2: The Beat Starts (0:58 – 6:30)**

Seven musical elements are turned on or off using the Time-manager and probability logic. This forms the foundational ecosystem of the patch.

**PART 3: Intentional silence (6:30 – 6-38)**

These sudden eight seconds of silence are an intentional marker for the listener that the music is not just going on without a sense of direction. The person who created the patch can make it stop if necessary. This pause becomes a dramatic event and sets up the patch's next move.

**PART 4: Tempo and activity are suddenly intensified (6:38 – 8:13)**

At the start of this section tempo and activity are much intensified. This clear departure from the earlier sound-world is supposed to be another sonic clue to the listener to believe that the composer's intentions are still in charge of the music. The patch settings change using stored parameters in the [PRESET-MANAGER] module which is being triggered by the [TIME-MANAGER]. This section is where the patch is at its most complex rhythmical state.

**PART 5: A first effort to simplify clock information (8:13 – 10:13)**

Clocks are slightly simplified to imply an almost steady beat even if there are still plenty of irregular gestures. This piece has traces of regular techno at this point. The distorted synth stabs evoke the guitars of Meshuggah and the FM-marimba gestures resemble Frank Zappa. The swelling synth pad and the kick drum places the music in the world of Autechre or Richard Devine.

**PART 6: The climax of the piece (10:13 – 12:13)**

This is what I consider to the be the climax of the piece. The perception of tempo is simplified again as a heavily side-chained rave synth enters. The clocks are still being modulated and changing pace, but musical events are being triggered more and more simultaneously from this point on.

**PART 7: Sudden moment of clarity (12:13 – 14:13)**

Things come to a stop and percussion and synths now solely occur at the same time from the same clock source.

**PART 8: Activity infusion (14:13 – 16:13)**

More activity again. This event is infused into the structure to avoid a linear gradual decline of clock activity that would be too predictable.

**PART 9: The ending (16:13 – 20:31)**

The clock becomes slower and slower. It becomes so slow that longer silences are now in between triggers. I wanted the ending to be the opposite of a predictable fade and make the listener wonder whether the silences meant that the piece has ended.

The piece uses four [TIME-MANAGER] modules, a multitude of switches, two [RANDOM-TIME-MANAGER] modules and the [PRESET-MANAGER] to achieve dynamic macro-structure. The focal point is accomplishing change of events by hard-switching material on or off or changing parameter settings on the [PRESET-MANAGER]. Figure 18 shows the basic clock network being used in the piece:

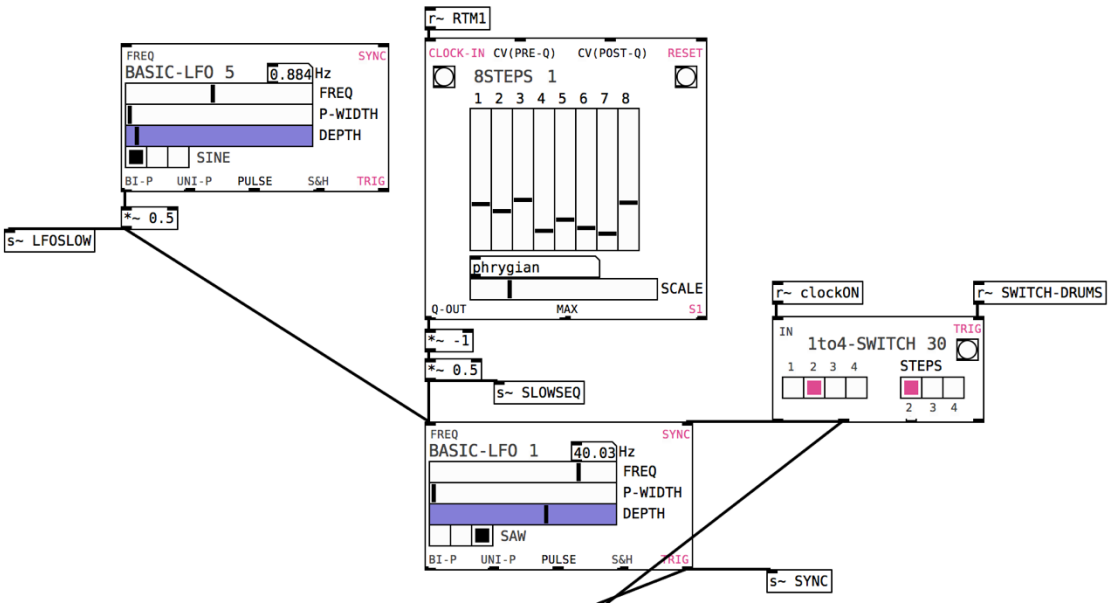


Figure 18: The basic clock network of *That Classic Poetry*

[BASIC-LFO 1] outputs trigger impulses at the TRIG output that are used and manipulated all over the patch for clock impulses. It is being modulated by a slow sine wave from [BASIC-LFO 5] and by the [8STEPS 1] sequencer. The sequencer is being clocked by [RANDOM-TIME-MANAGER 1] which outputs randomly between 20-30

seconds. Later in the piece the [PRESET-MANAGER] also change the frequency of [BASIC-LFO 1]

## 6.2 *This Garden is Growing Wilder (15:31)*

This piece has the most variation from each time the patch performs it. Just like in the previous patch, seven elements are randomly being switched on or off. But in this piece the parameters of the seven musical elements are being slowly morphed while being switched randomly by a [RANDOM-TIME-MANAGER]. As a result, depending on what randomly turns on and where the parameter is currently at under its long morph it can sound quite different each time you run the patch. This is what I wanted but it means more listening and attention to parameter details in order to be aesthetically happy with all things that will randomly happen. To achieve dynamic macro-structure this patch uses a combination of parameter nudging, preset-management and slow morphing. These continuous morphs, which are two minutes long, adds a new macro-structural element not present in *That Classic Poetry.*

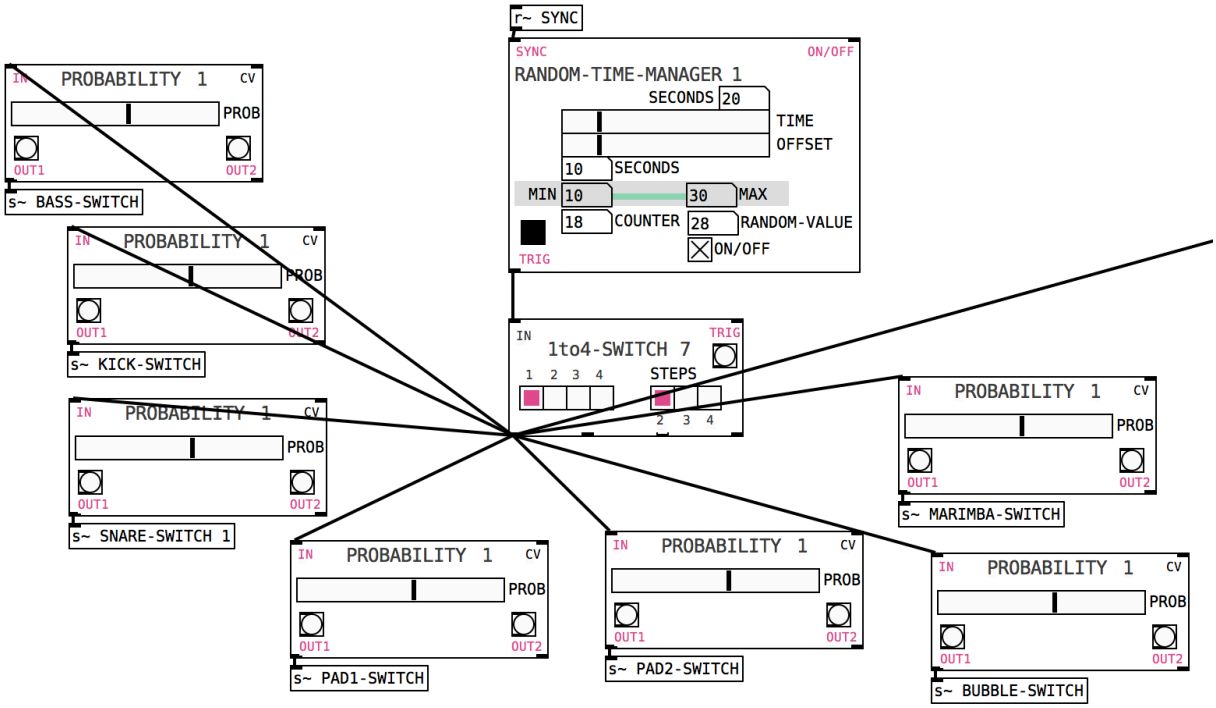


Figure 19: Random switch ecosystem for seven musical elements of the patch¨

Figure 19 once again show a random probability network to switch elements on or off. After a random duration between 10 and 30 seconds there is a 50% chance of a switch being triggered.

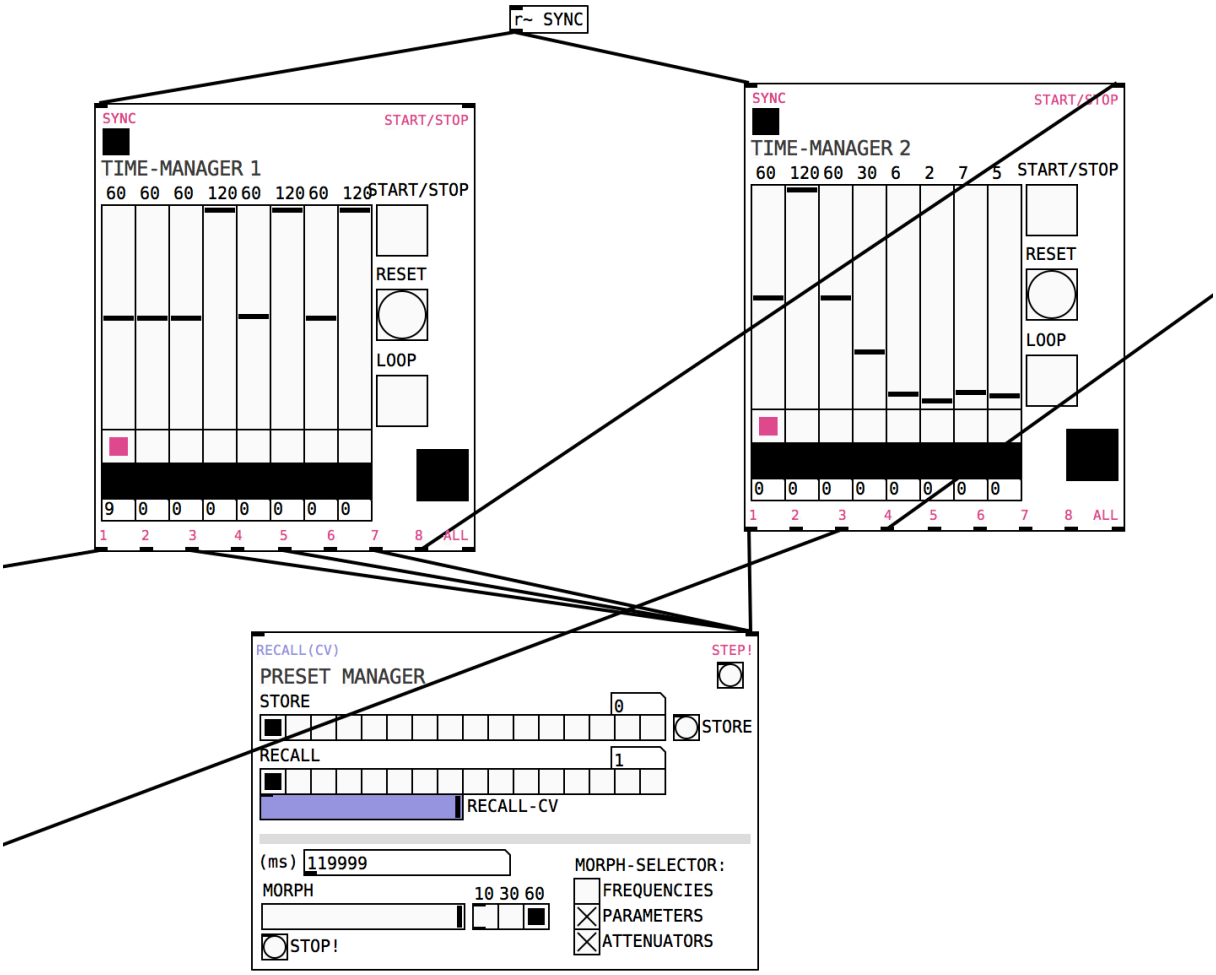


Figure 20: Macro-structure system with [TIME-MANAGER] and [PRESET-MANAGER]

In Figure 20 we see the macro-structure being controlled by [TIME-MANAGER] and [PRESET-MANAGER]. I have also chosen to exclude all frequency parameters from the morphs to avoid sounding like one large glissando. We can do a hermeneutic analysis of the piece's structure:

Part A: 3 minute presentation of patch ecosystem

Part B: 2 minute morph to new parameter settings - then stay there for 1 minute

Part C: 2 minute morph to new parameter settings - then stay there for 1 minute

Part D: 2 minute morph to new parameter settings – then stay there for 1 minute

Part E: 2 minute morph back to initial parameter settings – then stay there until the end

One could put forth the criticism of such a rigid system and point out that it looks predictable. I would not agree. In written text it might look that way, but it is my opinion it is not perceived like that in the music. It is changing in the grey zone between parameter setting A and parameter setting B thus creating a sense of constant movement. I feel that the consistent use of similar durations in this piece helps give coherence to a music that otherwise could be perceived as lacking direction because of the amount of morphing going on.

The long silence at 07:30 is not scheduled like in the previous piece. It is simply a result of the seven elements randomly happening to be turned off simultaneously. When picking recorded versions of the piece I appreciated the breathing and pausing this created. I made many recordings of this patch before I was totally happy with it. I am interested in that working method. I want to feel like I experienced something unique and was lucky to hear a perfect performance of the patch and record it. This is the beauty of this kind of music and I argue it fills the same function as the risk of mistakes in live music – it is what makes it interesting. This reiterates the ideas expressed in Chapter 3.2 *Portfolio Context* in that process is the most important in this kind of music but only if process gives you the correct results. If not, change the process!

I used the [PARAM-NUDGE] to map out settings for the [PRESET-MANAGER]. In this piece the morphing of parameters had a large impact on the sound design of the piece. At 06:20 there is a sound that sounds – for lack of better words - like a screaming bird. This was not a sound I patched up initially, but it came to life as a result of morphing between parameters. This is a very powerful concept because when you have material A and morph towards material B over 2 minutes, the actual morph can become material C where new sounds are discovered. This process is repeated throughout *This Garden is Growing Wilder.*

## 6.3 *Thinking Like the Seeds (10:00)*

This piece was born from the idea of building a patch with rhythmic activity without relying on percussive sounds. *Thinking Like the Seeds* uses timbral modulation to create a sense of rhythm and movement. The piece takes advantage of both hard-switching and morphing with the [PRESET-MANAGER] to achieve dynamic macro-structure. It utilises morphing in a different way from what we saw in the previous piece. *This Garden is Growing Wilder* uses morphing to transform sounds over time where in this piece the morphing is used to control amplitude and fade elements in and out. Thinking like a seed means wildly yearning for freedom of growth. I wanted the music to sound as if it were trying to grow stronger and to be set free. The structure of *This Garden is Growing Wilder* can be divided into three parts:

**BEGINNING (00:00 – 04:45):**

00:00 – 01:00 Introduction with sparse synthetic sounds with plenty of reverb.

01:00 – 04:45 The introduction is over when the bassline enters with a multitude of timbral modulations of rhythmic intensity. A soft pad fades in slowly controlled by the [PRESET-MANAGER] and is later followed by a looped sample of hi-hats run through granular effects.

**MIDDLE (04:45 – 08:56):**

At 04:45 the patch stops itself and is interrupted by an altered version of the Introduction before a sparse beat enters. Even though percussion is present the bassline at 06:05 remains the rhythmical motor of the patch. Pitches change at a moderate to slow pace but timbral modulations occur constantly to produce rhythmic patterns. The slow fade that starts from 08:00 with the coming back of the granular hi-hats is the start of the ending of the middle section, and prepares us for the final part.

**END (08:56 – 10:00):**

The ending starts with a direct transposition of the modality that goes down a minor third as mentioned in Chapter 5. Finally, it circles back to the initial musical gesture from the beginning before it ends.

## Clocks and Macro-structure

The patch operates with three different clock elements and makes use of [TIME-MANAGERS] to structure events.

### Clock Mechanism 1:

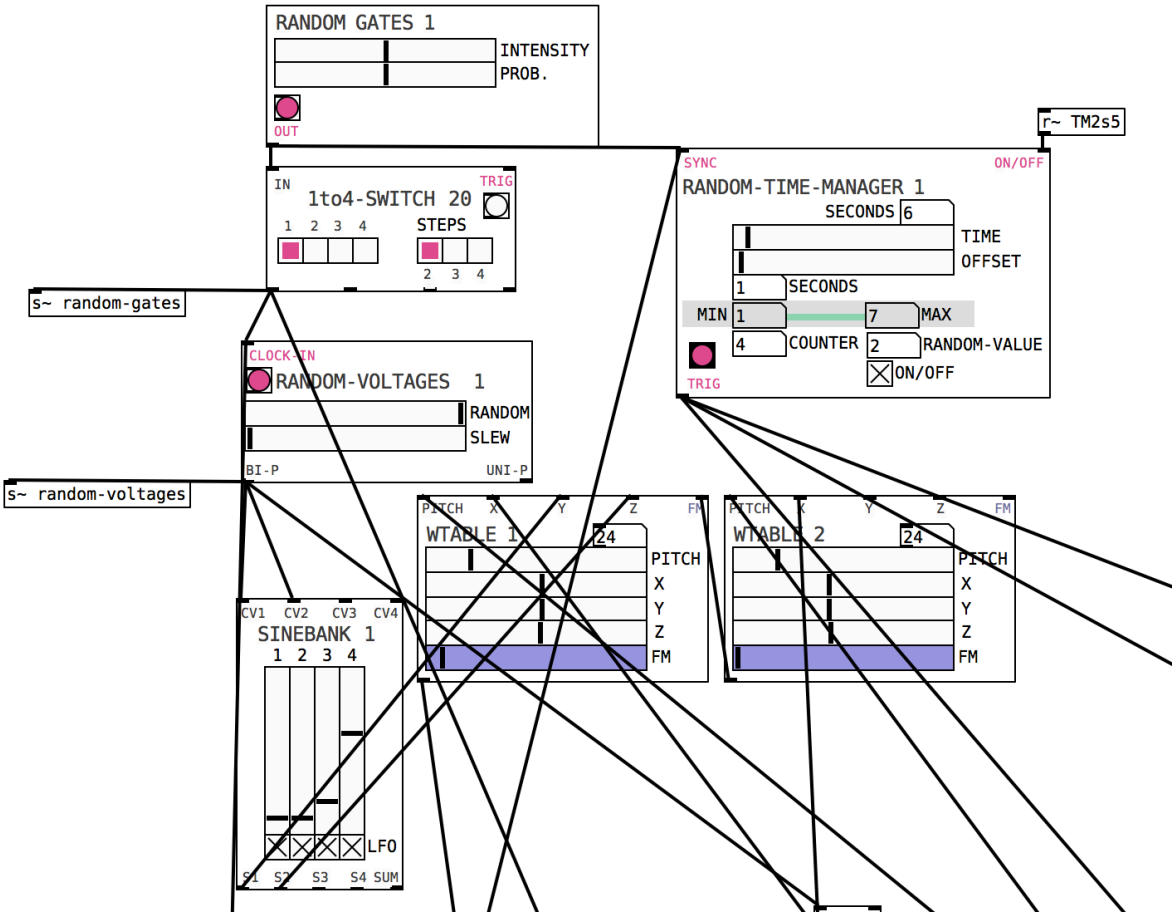


Figure 21: Clock mechanism 1 from the patch built around the [RANDOM-GATES] module.

Figure 21 helps to understand Clock 1. [RANDOM-GATES 1] is the “master-clock” in the patch. It clocks a [RANDOM-VOLTAGES 1] that modulates several things: amplitude of [WTABLE 1], X parameter of [WTABLE 1], the frequency of two low-frequency sinewaves from [SINEBANK 1] which in turn modulate the Y and Z parameter of [WTABLE]. Another [WTABLE] is being used to modulate the frequency of [WTABLE 1] to add to the metallic and erratic nature of the bass sound. [RANDOM-TIME-MANAGER 1] is synced by the random-gates clock and clocks mega-

sequencers that supply pitch to the [WTABLE] randomly between 1 to 7 seconds, but this is not activated until [TIME-MANAGER 2] outputs 5.

**Clock Mechanism 2:**

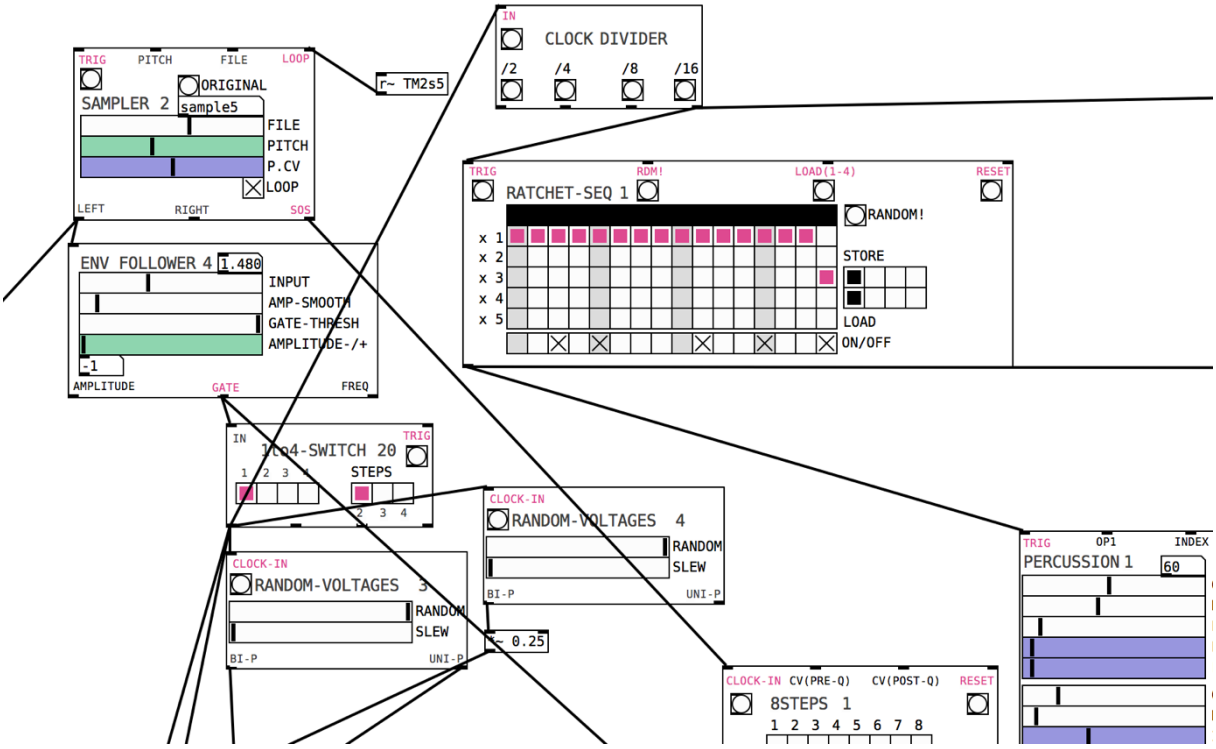


Figure 22: Clock mechanism for the drums and percussion in *Thinking Like the Seeds.*

The drums come from an independent separate clock source. In Figure 22 we can see that a looped sample in [SAMPLER 2] is put through a [ENV-FOLLOWER] that creates gate signals that passes through dividers and a [RATCHET-SEQ 1] to become the source for percussive events. The bass uses these clocks for rhythmic modulations but uses the first clock for changing pitches. This method of using unsynchronised clocks helps to convey a wild and free sound.

## Clock Mechanism 3:

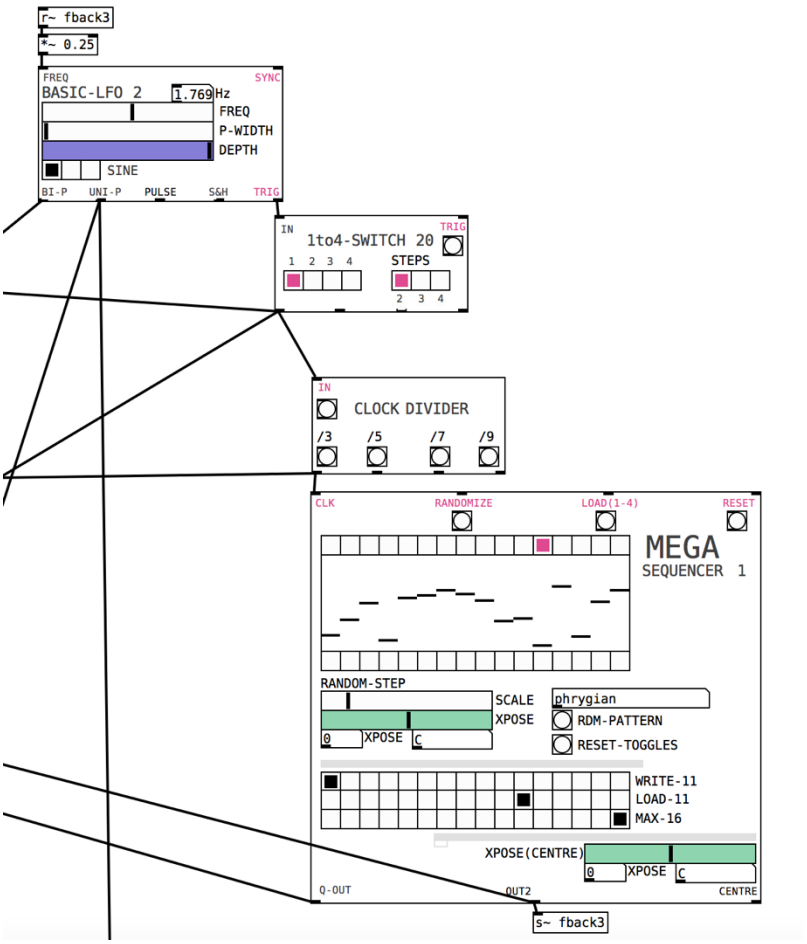


Figure 23: Screenshot of LFO-based clock with feedback modulation

The clock in Figure 23 is used only for the sound of synthetic bells and also functions independently from the other two clock sources. An LFO clocks a sequencer which modulates the frequency of the LFO and forms a feedback loop, which is a good way to infuse unexpected patterns to otherwise fixed impulses.

### *Thinking Like the Seeds* Macro-structure

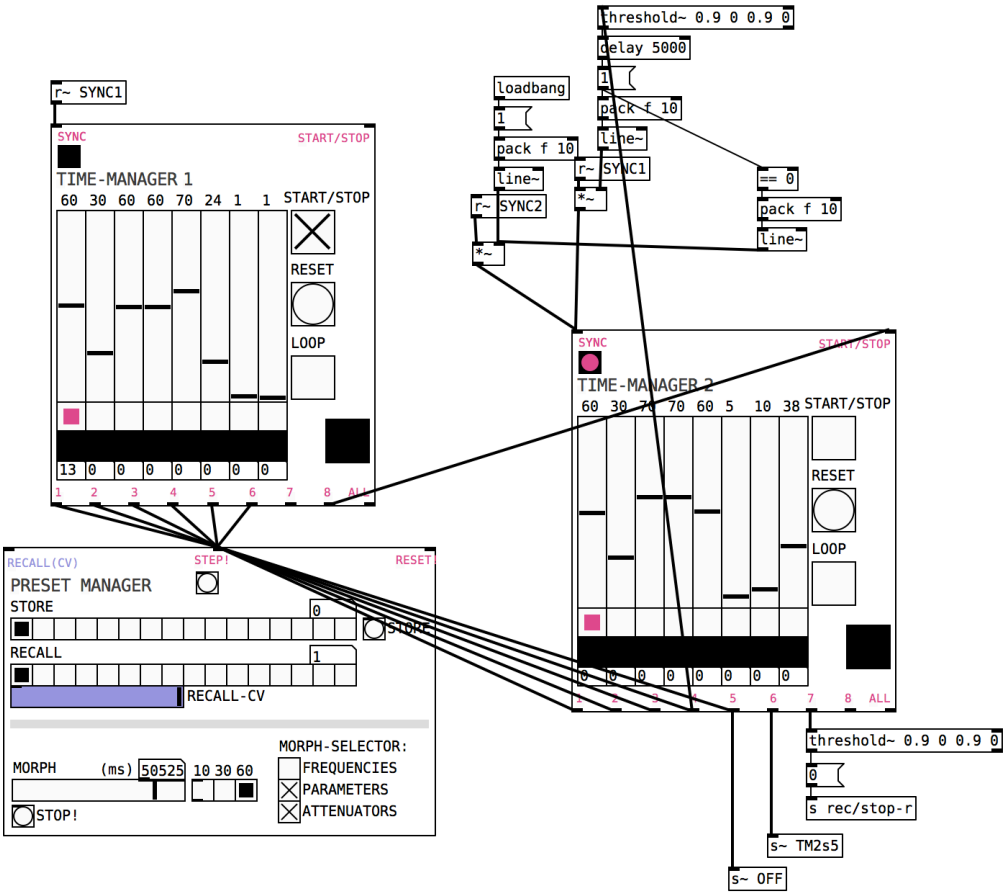


Figure 24: Screenshot of modules dealing with the macro-structure in the piece

In Figure 24 we can see that two [TIME-MANAGER] modules are used to tell the [PRESET-MANAGER] when to step forward to the next stored setting. The [PARAM-NUDGE] module was used in the compositional process to discover new parameter settings from the same modules and their signal flow in order to store them in the [PRESET-MANAGER]. The patch takes advantage of both morphing and hard-switching. I use switching modules to turn elements on or off and since they are binary – they cannot morph. Hence the change is direct whenever the Preset-manager steps forward. When I want the slow morph or fade I use a VCA which has sliders that will be affected by the morph time set to 50525 milliseconds (50.525 seconds). This combination of modules and presets is a good way to combine immediate change with slower morphs. Additionally, the MORPH-SELECTOR is used to exclude all parameters concerned with frequencies from the morphing mechanism.

Finally, I would like to acknowledge the existence of custom Pure Data code or objects within the patch. Pure Data and *Automatonism* does not feel separate to me. They co-exist and some things are easier and take up less space in the patch in plain Pure Data code. One could make the argument that the patch would look more conceptually consistent if only *Automatonism* objects were used. I disagree, since this way of working has been part of my iterative design approach. Whenever I noticed that I kept adding the same Pure Data code in patches I knew that it was time to encapsulate it into a new module.

This piece is important to the portfolio because it uses both preset morphing and preset switching to achieve dynamic macro-structure. It also presents a method to build rhythmical intensity with independent clocks and modulation instead of using drum programming.

## 6.4 *Purple, Green and Pink (18:59)*

This piece is a video of a live performance with *Automatonism.* It explores another way to achieve dynamic macro-structure for self-playing modular systems where human intervention is highlighted. It is important to explore this method of working in contrast to the three self-playing compositions in the portfolio. The piece exists by the idea that the actual construction of patches is the art form itself. While this might be true for the whole portfolio this piece follows that philosophical idea and tries to make it into a performance practice. Hence the proposition is that in a live environment that very patch construction is what should be put on display. This is a clearly different approach compared to presenting an algorithm where the performance becomes pre-planned improvisations and altering of musical parameters. This piece is about performing the act of patching. This live work in *Automatonism* is in the tradition of live coding, which first emerged in 2003 (Collins et al, 2003) and made the creation of musical algorithms into a performance practice. A decade later, Magnusson suggests that the practice of live coding reaches further back than computer science and points out resemblances with pre-romantic ideas of composing through performance (Magnusson, 2014: 14). This piece shifts the perspective from structured improvisation to precise and accurate live interpretations, as shown in the patch instructions for *Purple, Green and Pink* in the 'VIDEO' folder on the accompanying USB disk. In the same way a pianist puts on display their playing, I want to put on display the construction of ecosystems. I believe this translates the idea of the instrumentalist into the realm of digital musical instruments.

*Purple, Green and Pink* starts from a blank canvas and from there I perform the act of patching while projecting it on a big screen. This creates a direct visual representation of the musical progression. The piece consists of three patches all represented by a coloured canvas background. A clock that is counting down from 5 minutes is shown at the top of the screen. The piece is pre-programmed to randomly switch between the three patches between 30 and 90 seconds from the start. Part of my performance becomes to respond to what patch is active and remember where I last left it in the building phase. This system creates a good musical narrative which starts with silence and builds towards complexity over time and this transformation is visually

communicated on the projection too. The timers create suspense and presents the audience with the question: what will happen when we reach zero? When each patch reaches zero they self-terminate and when all patches have self-terminated comes the unexpected coda of the piece. After fifteen minutes of music where everything on the screen has been depending on the performer's actions there comes a new section of the piece that is pre-programmed to build a patch by itself automatically. I can now stop patching and just watch the computer patch by itself. This is meant to pose an open-ended question to the audience whether my presence as the performer was essential. This final patch self-destructs, quits *Pure Data* automatically and brings the performance to an end. Borrowing the title of a recent article in *Organised Sound,* I position this performance practice at "the intersection of 'live' and 'real-time'" (Hagan, 2016). Traditionally generative computer music was considered a 'real-time' process rather than a 'live' event. But in "getting our hands dirty", as suggested by John Richards, the building of tools and the performed music are intertwined and together constitutes the piece of art itself (Richards, 2008). Extending upon that idea, I propose a model where the actual building itself, the creation of the patch, is not only intertwined but forms the performance act. This model is similar to the practice of live coding. Emerging in 2003, live coding aims to "keep a sense of challenge and improvisation about electronic music-making" while arguing that "music is more compelling with elements of risk" (Collins et al, 2003: 322). Live coding is simply the creation of musical algorithms into a performance practice. It blurs the concepts of composer, performer and audience (Magnusson, 2014: 14). In my experience the risk with live coding lies in a potential disconnection between the algorithms and the audience. Projected code makes little or no sense if you are not a programmer yourself. This raises the question whether the music itself or the idea of the piece is more important. This performance proposes a model that gives equal importance to both the music and the idea. Starting from a blank canvas, I perform the act of pre-composed patching while projecting it on a big screen. This creates a direct visual representation of the musical progression. Live patching is not code, but bricks forming a masonry of sound. My proposed performance practice argues that a patch in *Automatonism* is more visually relatable to an audience than lines of code, putting on display the human creation of evolving sonic ecosystems being performed by a self-playing machine. Highlighting the construction of the patch as an art form.

## 6.5 *Singing Like the Lydians (5:59)*

This piece is also a live performance using *Automatonism.* It is different from *Purple, Green and Pink* because it provides another perspective by using the electric guitar as input. Here it is not the creation of the patch which is highlighted, it is the guitar instrumentalist and how he/she affects the patch. It is a more classically performative work. However, it is not a contemporary classical piece of music where the instrument is played and the electronics alter the sound. It is more in the context of artists such as Christian Fennesz. Looking at a live performance by Fennesz (2017: video online) with electric guitar and laptop from 2012 in Belgium, I identify a key difference between his approach and *Singing Like the Lydians*. He switches back and forth between playing the guitar and changing things on his laptop. *Singing Like the Lydians* has completely different conditions for existence. If I do not play the guitar – the patch is silent. The guitar sound is primarily used as a controller where amplitude and pitch information are processed and affect the patch's parameters. Some parts of the guitar can be heard in the audio and some parts are constructed by re-synthesising the guitar from its harmonic partials with the [AUDIO-FREEZE] module. I chose the electric guitar simply because I play it myself. By including this piece, the portfolio covers three aspects of how to use *Automatonism:* self-playing patches with dynamic macro-structure, building patches as a performance model and performing live instruments in tandem with patches. The piece has a simple harmonic and melodic outline, as seen in the lead sheet for *Singing Like the Lydians* on the accompanying USB disk (Chapter 10). The harmony is based around Lydian motifs in three different keys or modal centres: F Lydian, C Lydian and A Lydian. The most important quality of the patch mechanics is that there is no musical motion unless the guitar plays something. All motifs and gestures are depending on amplitude and pitch information from the guitar. This gives the power of music or no music to the performer. I believe this is an important aspect of live performance – the performer's ability to make sound or not. The piece also uses a foot pedal to control the patch in addition to the electric guitar. Each time the pedal is pressed the bass notes change by stepping through presets of the [MEGA-SEQUENCER] to follow the harmonic structure and settings on the [PRESET-MANAGER] are being addressed too. By doing this the piece makes use of

*Automatonism's* already mentioned advantages. I acknowledge that there are already plenty of ways to integrate instruments with live electronics but this piece highlights how an instrument can be used in tandem with the macro-structrural tools of *Automatonism* to expand its use. The patch is self-playing and take cares of itself throughout the piece, which allows me to never stop being the guitar player. Because of this the performance feels more like an instrumental piece instead of an instrumental plus electronics kind of work. To conclude - the piece does three things with the guitar: it manipulates its sound, creates synthesised sounds with information from the guitar and the structure is controlled by the guitar and a foot pedal. In future research and compositions, I see this kind of fusion between live playing and self-playing modular systems to be a promising path towards new music. The piece functions well as a response to the other four works because it musically argues that there is a way to combine self-playing modular music with live instruments and that the proposition might be a better solution than looking at new digital interfaces for electronic music.

# (7) Conclusion and Implications of Research

> Everyone's in a rush to sound the same. At the same time you've got this audience who have got access to fucking everything that was ever made, so the audience is actually extremely sophisticated. It's a weird paradox. You hear a lot of stuff with the same kind of synth lead and the same sucky compression and the same kick drums, the same long chords. It's incredibly conservative. Then you've got this audience who know about Xenakis and Stockhausen and they're fucking 16-year-olds. I see that as a great opportunity to make things that are genuinely a bit weird – Autechre (Sherburne, 2018: interview online)

The above quote by Autechre poignantly identifies a paradox for modern electronic composers to consider. My research and the music of this portfolio is my effort to not shortchange the listener or my own craft. *Automatonism* has grown iteratively into a complex modular ecosystem. It was developed as a way to escape generative loops and increase dynamic control over self-playing structures, but the software has other advantages in terms of accessibility, future-compatibility, community development, cross-platform support and educational possibilities. The modules are open ended enough that many different styles of music are possible. This is reflected in user posts on Instagram and YouTube. In July 2019 there were 256 posts under the hashtag #automatonism on Instagram, 109 tracks tagged on Soundcloud and on YouTube many compositions and user made tutorial videos are available. This presence on social media indicates that people are using the software and sharing their ideas. *Automatonism* has received good publicity and was mentioned in articles in Fact Magazine (Wilson, 2017), Create Digital Music (2017), Tape Op Magazine (Baccigaluppi, 2017) Vlogger Andrew Huang (2019: video online) has 1.7 million followers on Youtube and in his video '10 best FREE music tools in 2019' *Automatonism* is featured at 4:38. Richard Devine himself has posted a composition made with *Automatonism* on his Instagram page (Devine, 2017: website).

*Automatonism* has great potential for educationol use. It has been used by myself to teach a course at Royal Birmingham Conservatoire in composition with modular synthesis in 2018 and 2019. In addition, I have conducted workshops on how to use

*Automatonism* in Greece, Denmark and Norway. Outside of my own efforts the software has been the subject of a workshop in London hosted by CV FREQS (2017: website) and a week-long class in Mexico (Introduction to Pure Data with Automatonism, 2019: website).

The music of this portfolio has stressed the importance of expanding the possibilities for self-playing modular systems to create dynamic structure. The five pieces in tandem with the software have shown how to broaden the prospects for self-playing modular synthesisers. The techniques used can be adapted by other composers and also in the future can incorporate instrumentalists in conjunction with generative systems. By showcasing the act of patching in live performance the research has proposed a model for performing with modular synthesisers that is not reliant on improvising with parameters by fusing live coding with traditional instrumentalism.

The self-playing compositions in this portfolio follow a macro-structural arc that is similar every time you run the patch. However, separate takes can also sound very different from one another because of the random variations built into the patches. This poses an interesting question: is the presentation of the piece actually the *Automatonism* patch and its possibilities, or is it one chosen recorded version? It was tempting to adhere to the idea of a piece being the patch itself and accept all its possible variations. Initially I liked the idea of the music being different every time it reached any audience. However, my thoughts on this slowly shifted during the compositional process. I ended up working a long time on each patch trying to make it behave the way I wanted while retaining elements of chance and surprise. I realised that, no matter how much I went into the details of every patch, some takes would sound much better than others. The pieces in this portfolio organically came into existence by listening and observing them in order to re-evaluate and re-iterate towards the goal of having a clear structure with lots of variations on the micro-level. It became obvious to me that I had to choose a version that I felt illustrated this the best. I did not want to leave it up to chance to prove my points. Hence, I opted for submitting the portfolio as recorded definitive pieces of music, while also providing the patches for further insight into the mechanics of the works. I think this humanised

the music since the element of choice was there throughout the composition process, thus it seemed only fitting that it would end with a final choice between recorded takes. I think this method is valid because providing a definitive recorded version of a tune does not mean other versions do not exist on a philosophical level. For example, there can be many recordings of a jazz standard or a bluegrass tune. They are all unique but are derived from the same source. Similarly, in the case of this portfolio, the patches are the original material and the final recordings are my versions. By using this approach, I also achieve closure and the feeling of being finished. The same method is reflected upon by Autechre in an interview with the Quietus (Frame, 2013: interview online) where they mention tracks being derived from the same 'song machine'. They present the idea of genealogy where the recorded tracks are the children of their parent algorithms. I believe choosing a final recording from a 'song machine', or in my case *Automatonism* patches, has twofold benefits: it is a more practical way to reach potential listeners in a medium they are accustomed to, but more importantly, it brings forth the element of human choice to the algorithmic music and thus makes it more personal. It is also helpful for me personally to achieve a sense of closure. I believe it is easier to move forward when I can thoroughly evaluate my previous work and creative decisions. I have also found support from Squarepusher on the subject. He says that he dreams about a perfect piece of music that unites everything he does:

> "I want to make that piece. It's one of the strongest things that exerts creative pressure on me. Just to try and make that piece that makes my world make sense." - Squarepusher (2013: video online)

If I continue to elaborate on those thoughts I realise that selection process and creative decisions are what makes composition interesting to me. I like building things. I like the feeling of finishing things. Sure, one could argue that building the patch and the 'song machine' itself is one form of closure too. But in my experience, that simply felt like coming up with a design for a house and never actually building it. Leaving the piece open and different every time would mean to me that I could not put it in my bank of experience towards the ultimate piece of music that Squarepusher talks about.

When I recorded a big number of takes and listened to them I realised that a long recording of a patch will never be perfect everywhere. Something might happen after three minutes that I'm not too pleased with, but as a counter to that something miraculously unexpected happens after ten minutes. This then becomes the last important job in my compositional process - filtering out and choosing what to highlight. I made seventeen recordings of the piece *This Garden is Growing Wilder* and none of them were perfect. I had to choose the perfect compromise. I like this idea of music not being perfect, it reminds me of live performance where I believe excellence resides in the combination of mistakes and good execution. The mistakes are what keeps the audience interested and often used as an argument for why live coding is a good performing practice for electronic music (Collins et al, 2003). In a piece like *Singing Like the Lydians* this happens organically. The addition of live electric guitar to the so called 'song machine' or parent algorithm fuses the two practices where neither one is perfect. Mistakes are made on the electric guitar and the patch does sometimes do things I did not really intend for it to do. There is a constant compromise in live performance and this compromise is equally present in the recorded versions I chose for the other pieces. To conclude - this research has identified a problem with music composed for modular synthesisers and has named it the *generative loop.* I argue the need for modular systems to be self-playing in order to push the art of patching forward and move towards music with dynamic macro-structures. I have used a method of iterative software design and practice-based research in the form of composition to address the identified gap. A portfolio consisting of five works (three recorded patches and two video performances) has been submitted together with this commentary to describe the procedures of the methodology. The portfolio covers three aspects of how to use *Automatonism* – self-playing patches with dynamic macro-structure, building patches as a performance model, performing live instruments in tandem with patches. It can be clearly concluded that the music of the portfolio answers the research question of macro-structure in the way that they use the software design to move successfully out of the generative loop. As a result of this compositional method further benefits came from not using the DAW's traditional linear visual feedback. A deeper connection with and knowledge of the material have been discovered by the necessity for repeated listening in order to get the patches to take the correct musical decisions.

Implications in fields like education, open-source, DIY-culture, live-coding, modular synthesis and generative music have been identified.

My research journey started with a fascination for modular synthesisers. I had fallen in love with the freedom of creating patches that seemed to come alive and surprise me musically. When trying to use modular synthesisers for entire compositions without involving other production techniques I could not control the patches enough to create the kind of musical structures I desired. That lead me to design *Automatonism* to be able to make the kind of music I wanted to make. It was a music with the wild and free nature of the modular combined with structural control. For me personally, this research has been extremely valuable. I can now make music that I could not make before. The relationship between me the composer and *Automatonism* has grown over these years and I feel we are just starting to know each other better. By the end of this journey I started to feel a slight programming fatigue and as a consequence I was drawn to acoustic music in my spare time. I started playing a lot of jazz and bluegrass music because I was missing the immediacy of playing an instrument and a simple tune. It is alluded to in the portfolio that I see myself moving towards a fusion of playing instruments in combination with *Automatonism* in the future. I feel I have mastered a style of complex generative patching that can be very effective in combination with the immediacy of instrumental performance. This research has come to an end but really is just the beginning of my work as a composer. Lastly, to sum up this research, let's look at a couple of quotes from Suzanne Ciani about her modular setup:

> The way to play this is to play it. It is a relationship. It's deep. Its organic. It has a brain. – Suzanne Ciani (2019: video online)

Ciani and myself differ in what we think of as playing a modular synthesiser. To her it means interacting with it. To me playing a modular synth is the act of building the patch – not playing its parameters. But our differences aside I will let her have the last word, because after all my efforts trying to decode what a modular patch is or can be, I think she still explains it the best:

> After you know what each one [module] does, then you figure out how you want them to talk to each other – and that's the patch. – Suzanne Ciani (2019: video online)

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# (10) Portfolio of Works

There is an accompanying USB flash drive with this thesis. It contains audio files for *That Classic Poetry, Thinking Like the Seeds* and *This Garden is Growing Wilder.* There are video files for *Purple, Green and Pink* and *Singing Like the Lydians* and PDF files for the lead sheet and patch instructions. In addition, there are the *Automatonism* patches of the pieces and a version of *Automatonism* 3.0. For installation help please refer to http://automatonism.com. Lastly there is an appendix folder with audio files of two albums of music made with *Automatonsim* by myself during the first year of this PhD for context and proof of evolution. USB Flash Drive Folders:

1-AUDIO

- That Classic Poetry.wav
- Thinking Like the Seeds.wav
- This Garden is Growing Wilder.wav

2-VIDEO

- Purple Green and Pink.mov
- Purple Green and Pink patch instructions.pdf
- Singing Like the Lydians.mov
- Singing Like the Lydians.pdf

3-PATCHES

- Singing Like the Lydians – Patch/ main.pd
- That Classic Poetry – Patch/ main.pd
- Thinking Like the Seeds – Patch/ main.pd
- This Garden is Growing Wilder – Patch/ main.pd

4-SOFTWARE

- AUTOMATONISM_3.0/ main.pd

5-APPENDIX

- Automatonism Album #1
- Automatonism Album #2