Eurorack to VCV Rack: Modular Synthesis as Compositional Performance

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Eurorack is a hybrid, post-digital system for modular synthesisers produced by both experimental developers and established brands. With 'post-digital', we mean that the module designs and modular patches include both analogue and digital processes; each modular system has the potential to be a unique combination of oscillators, filters and modulators that draw on a heritage of vintage analog electronics as well as modern digital signal processing techniques. It offers a standard set of parameters for modular configuration, which is an attractive feature that aids its popularity, and which enables shared knowledge with a thriving scene of developers, music makers and enthusiasts. Designers develop modules, some of which are open source, which musicians and sound designers can assemble into bespoke creative systems. Within each modular patch, a specific combination of instruments and audio filter modules is interrelated; in other words, a network of embedded relations affects how each module operates. Starting from a relatively minimal setup, unexpected feedback loops with a generative module can produce an intricate sonic system. Interfacing with human creativity, the modular system produces musical sound through both its patch design and its serendipity; as modular performer Suzanne Ciani (2018) observes, composition is hereby constantly in process as a continuously developing performance. The attraction of working in this way was encapsulated, back in 1968, by minimalist composer Steve Reich:

> I am interested in perceptible processes. I want to be able to hear the process happening throughout the music. To facilitate closely detailed listening, a musical process should happen extremely gradually. (Reich, 2002:34)

Although initiated by the music maker, we argue that a generative patch seems to take on its own form of agency, enabling an explorative creative dynamic. Here we understand generative music as a configuration of modules that allows a certain amount of randomization and that is, in effect, "an open dynamical system" (Bown, 2011: 73). In this, we follow Waters (2021) who argues that music instruments are assemblages, dynamic processes within a performance

ecosystem in which “the non-standard instrument can be seen to be typical of human/instrument entanglements” (138). Such an ecosystem integrates the performer and instrument in a multiform environment. A modular generative patch has its own unique affordances and may therefore be understood as a performer within the ensemble; as a patch, the instrument becomes a performing partner with the musician in a creative relationship where boundaries between human and machine are symbiotic. Such an immersive musical relationship between human and machine produces a specific techno-aesthetic. Simondson (2012: 3), proposes that an embodied aesthetic is possible through *techne*, the craft and its related knowledge produced through making, suggesting in an unsent letter to Derrida back, in 1982, that,

> … contemplation is not techno-aesthetics’ primary category. It’s in usage, in action, that it becomes something orgasmic, a tactile means and motor of stimulation.
> Aesthetics is … also … the set of sensations …. of the artists themselves: it’s about a certain contact with matter that is being transformed through work.

Applying this concept to working with Eurorack hardware modules, a sonic techno-aesthetic develops within an active creative relationship with modular music technology. In this context, our research addresses interactive modular compositional performance, whereby engagement between human creativity and machine-generated serendipity leads to an improvisatory music performance and composition.

Investigating how we engage with the techno-aesthetic of the a generative modular practice, we take an auto-ethnographic approach. Our case study is of a patch within a hybrid setup consisting of Eurorack hardware modules and VCV Rack, its screen-based virtual open-source version. We thereby reflect on forms of creative practice in which the distinction between analogue and digital sonic processing are demonstratively blurred. We investigate generative musical processes as well as the distinction between physical and virtual musical interfaces. Our methodology consists of the preparation of a hybrid generative modular patch and noting the experience of flow in improvisation[1], supported by the descriptive practice of recording, and of reflecting on these dynamic processes. In this case, the attention is focused on the pleasure in making music with a generative network of machines that at times seems to have a mind of its own. This is because a generative process offers a form of musical improvisation, in which a musician creates material based on a set of rules. In doing so, our research addresses creative

[1] With the idea of a flow experience, we refer to Csikszentmihalyi’s (2002) notion of an autotelic condition, in which the creative process is about enjoyment in the improvisatory activity without prescribed external goals.

practices that are shaped by the intersection between the performer and analogue-digital hybrid modular systems. In the discussion that follows, we will first address the instrument, and next move the discussion to the case study to illustrate the interrelationship between musician and instrument, and finally expand the discussion to the wider environment, within which the creative practice with a generative modular patch can be understood.

Through a comparative exploration of creating music with Eurorack's physical modular system and VCV Rack as its on-screen manifestation the aim of our observations is to understand how the physical and virtual interfaces of a generative patch shape the process of musical interaction. In our observations, we are particularly interested in how the multi-touch and kinetic interaction with a modular system stimulates the flow of compositional improvisation, or *comprovisation*, as computer music composer Dudas (2010) names it. Hands-on interactivity puts an emphasis on listening, which is of particular importance in an era where the arguably reductive, yet visually seductive, interface of the screen-based DAW (digital audio workstation) dominates in electronic music-making. With the latter, we refer to DAWs that favor a linear timeline approach to the arrangement, which are currently ubiquitous in music production practices (Strachan, 2017). Whilst VCV Rack is a DAW, it operates according to the principles of interlinking and re/combination of Eurorack's modular system that similarly suggest a mycelium-like[2] underlying structure from which sonic structures spring forth and contract as the modular network of patch cords evolves. With such an instrument, the exploration of sonic textures and micro-tonalities is foregrounded over quantized timings and tunings.

The Eurorack standard was initially designed by Dieter Döpfer in 1996 (Doepfer, 1998), who defined the physical and electronic characteristics of this modular system (Groves et al., 2020). It provides an open, yet standardized, framework that encourages manufacturers, musicians, and sound designers to experiment with potential formats in sound creation. On a practical level, a standard format resolves issues in integrating equipment with different voltage to pitch standards, module sizes, and power requirements, thus providing a platform for designers to create modules that fit and function within a single environment. More significantly, the Eurorack standard facilitates the cross-fertilization of established analogue designs with digital counterparts. The ubiquity of self-contained DAW software in electronic music production can make the cost of investing in music hardware difficult to justify, instead enticing young musicians

[2] We take our metaphorical inspiration here from the *Mycelium* module synthesis conference held in Spring 2021 (Cohen, 2021).

and producers to start out on relatively affordable and even free computer-based alternatives (Strachan, 2017). The change from physical to virtual modes of music-making has had a profound effect on the creative process; and yet, it has arguably provided a catalyst for the resurgence of interest in modular music making.

The techno-aesthetics that emerge from the affordances of modular music-making emphasize sonic textures and intensities over linear structures. In this way, modular synthesis can enhance an affective relationship with electronica. In a brief historical discussion of the Moog synthesizer, Kristen Gallerneaux (2018: 21-22) describes the experience of working with modular hardware, as a "retreat from compressed sound and the closed system of purely automated and digital music-making", further stating that:

> "Using patch cords, wires, and keys to shape sound is at once frenetic, random, and meditative. There is a sort of ritualistic power in commanding the signal, and then determining how it lives and expands or decays into noise."

Moog synthesisers nevertheless offer an inbuilt keyboard, while our practice-led case study is based on a generative modular system, which purposely veers away from the use of a traditional-music interface. Within a generative patch, the artist is not in complete command, as the sonic outcomes are surrendered within the serendipity of a dynamic process between the human musician and the electronic instrument.

The first step in designing the modular patch is to research modules that can work together as a live performance system. For our case study, the initial prototypes were explored in VCV Rack as it is easier to try out different configurations of modules and connections in a virtual environment before investing in modular hardware and spending time on optimizing the physical layout of hardware modular patch. The main elements required for this patch are synthesis (sound generators) and (sound) sequencing modules; further utility modules are required to create a control schema, or concept, based on algorithmic processes. The concept considers how such a hybrid setup should work, both sonically and gesturally; and as Doornbush (2002: p.155) observes on composition practices in algorithmic patching, 'it seems that there is no set method for mapping data from the domain of the conceptual, gestural or structural to the musical domain.' In our case, the preference was to use hardware as the hands-on performance component, and VCV Rack as an algorithmic extension. The selection is based on a consideration of how modules will be patched together which is mainly gleaned from working with them – much like any instrument, this is mostly a tacit form of knowledge, derived through

techne, within the practice of making. Once a particular configuration of modules has been established, it provides a platform to explore the system by creating different connections between the modules. This phase is where the creative potential of a system is defined. It can take multiple rehearsals to establish various ways of patching the system to fully understand how each module can be interacted with. Engaging with the gestural concept of a generative system, a set of controls are combined to enable an improvised performance using both predictable and unpredictable sequences and sounds.

The generative modular patch developed for the case study (see Figure 1) is based on Mutable Instruments' sequencing module *Marbles* as the main algorithmic generator — a virtual version of which can be found in VCV Rack as Random Sampler. This module generates random CV[3] data based on an algorithm defined by Émilie Gillet and draws inspiration from Buchla's Source of Uncertainty module and linear feedback shift-registers as a way of generating CVs. The outputs of the modules are grouped into three types labelled T, X and Y:

- T 1, 2, 3 produce gate signals (for example: Note On/Off) depending on the position of the Bias control.
- Y produces a random CV, which is typically used as a modulation signal.
- X 1, 2, 3 produces random CV that can be looped into short sequences and typically used as pitch CV data.

There are three controls for the main compositional parameters of the generated CVs. The "Rate" parameter controls the timing of gate events on the T outputs as well as the random pitch CV of the X outputs. The "Spread" parameter controls the divergence of the X CV outputs, which in simple terms means it can control the melodic contour from small jumps to larger leaps (assuming this is how it is used). The "Deja Vu" parameter controls the probability of repetitions, from fully random to what is also referred to as a locking sequencer where random data repeats into a sequence. This is a high-level overview of what could be broadly defined as the compositional parameters that control the underlying arrangement of sounds in a generative patch.

With *Marbles* as the main generative component, the step sequencing module *Stages* is connected in a recursive feedback loop, providing CVs that modulate the clock rate parameter in Marbles. This results in a dynamic interaction between the two modules, where one

[3] CV: Control Voltage

sequencer (*Marbles*) generates pseudo-random sequences and the other (*Stages*) modulates the rhythmic structure. The outputs of Marbles are processed by the filtering module Branches, which introduces an algorithmic filtering technique based on Bernoulli gates[3]. This module controls the density of musical events (Rowe, 1992) and can be further modulated by CV signals from either *Marbles* or *Stages*.

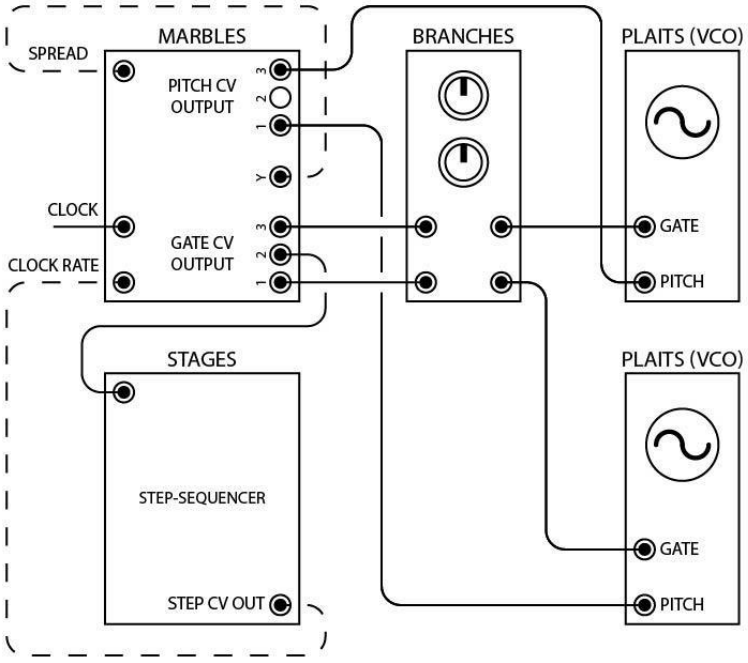

Figure 1 *(Inputs are on the left and outputs are on the right of each module)*

As in any modular patch, it requires at least one sound synthesis module, such as an oscillator, to produce a sound which is referred to as a voice; each voice can be a particular sound. In the context of a performance-oriented patch, a range of voices are selected and manipulated that can work across different registers. For this case study, the Plaits module, a macro-oscillator, has been selected to produce the voice. *Plaits* can synthesize a wide range of sounds such as conventional sawtooth and pulse-width modulated waveforms, percussive sounds, and more unusual granular textures and tones. As a self-contained voice module, it places some limitations on the sonic possibilities, but this simplicity makes it easier to use in a performance context. Oscillators can be combined to create further dynamic interactions at the point where the sounds are synthesized.

Our practice of patching embraces a symbiotic network of relations between the sequencing and synthesis elements. Similarly, modular musician Richard Devine observes that,

> "Within this architecture, you then discover these interesting interactions between different modules. It's been an incredibly intuitive tool for creating abstract textures and sonic spaces." (cited in Bjørn and Meyer, 2018: p.146)

The creative practice illustrates how humans are entangled in a music-making network in which the instrument is, ultimately, a process. Through the curation, consideration and selection of modules, integrated complexity is built from simplicity. An element of compositional performance becomes apparent as parameters trigger a range of changes across both the arrangement and the sounds themselves. In this sense, our understanding of a music instrument differs to the ecological approach of Waters (2007, 2021), in which players remain human, as we are concerned with the material process of an immersive sonic-bodily-architecture in which, we argue, the human and machine are both performers, both agents in the act of *musicking*[4]. The unique design of a modular ensemble contributes to the performative compositional process by interacting and responding. Such relationship reminds of Latour's Actor Network Theory (ANT), which Strachan (2017: 8) explains in relation to making music with electronic music technologies:

> "(E)ach network of creativity … is distinct and relational according to the make-up of a given network. … (T)echnologies are active in the production of experience for the human actor."

In the ecosystem of the generative patch, there is a creative dynamic between instrument control as performance and the response to machine-generated material. As such, the generative process enhances the fuzzy space in which the human participant is partly in control in a network of machines.

Working with a generative patch using *Marbles*, highlights the intersection between the human performer's creativity and the characteristic serendipity of the performing modular patch as instrument. Its brand name, Mutable Instruments, suggests the malleability in the affordances of its modules. Having previously developed DIY synthesizers, this was one of the companies that had been at the forefront of hybrid analogue and digital modular innovation between 2012 (Bjørn and Meyer, 2018) and 2022 (Synthead, 2022). Such a blend of technologies is intrinsic

[4] Small (1998: 9) describes "musicking" as: "to take part, in any capacity, in a musical performance, whether by performing, by listening, by rehearsing or practising, by providing material for performance (what is called composing), or by dancing."

to the way these devices are designed and manufactured, with each device offering unique sonic affordances that are subsequently manipulated in interaction with other modules and the performing musician-producer. Like many module designers, Mutable Instruments' Émilie Gillet places emphasis on the design of the module faceplate, reinforcing the importance of how the layout of the controls shape the mode of interaction and thus the process of music and sound creation:

> “One thing I didn't truly anticipate is that people can make music on systems without external MIDI controllers or sequencers. I come from this background which was really focused on having a MIDI sound generator, which you hook up to a sequencer or computer, in order to make it play music.” (*Why We Bleep*, 2019: podcast)

The way in which the modular sound is produced fundamentally reshapes the creative process. This is unlike a software interface, for which the mode of visual interaction is screen-based, and the interface is predominantly via a mouse and keyboard.

Modules that work with randomization can be traced to Don Buchla’s modular synthesizer principles, developed over half a century ago in collaboration with composer and musician Morton Subotnick, who was looking for “an electronic music easel” (Redbull, 2015: t 40), to sculpt “sound in a canvas of time and space” (t 1.22) and create a “visceral” electronic music for the future. In the words of music writer Harry Sword (2021: 180), Subotnick was “obsessed with the machine itself… describing the process as one of constant invention, bewitched by possibilities.” In his quest to develop an ecstatic aesthetic, Subotnick saw himself as a conductor while remaining in the role of composer, laying out his musical plans in advance, and working with Buchla to design modules with microtonal affordances required for his purpose. With generative synthesis, though, one is additionally enthralled by the unexpected, submerging oneself within the flow of sonic affordances while combining, connecting, rupturing, recombining, and overall tweaking electronic sound over a period of time. As electronic musician Alessandro Cortini puts it during an enthusiastic demonstration of his Buchla synthesizer: "I embrace that these machines... aren't completely controllable... it's a different chess game every time.” (*Sonic State*, 2015: t 6:24)

A trend in music software design is to recreate analogue devices through skeuomorphic software interfaces. Bourbon (2019) shows that, on the one hand, there is the practical aspect of creating a visual interface that mimics real-world controllers that have been established by hardware equivalents, down to a recognizable comfort-inducing wood paneling of a (sometimes

fictitious) vintage synthesizer. On the other hand, there is the (arguably contentious) issue of recreating the ‘inaccuracies’ of temperamental analogue circuitry in which oscillators drift in and out of tune, and amplifiers introduce subtle harmonic distortion. Overall, it appears there is a dominant preoccupation with reinforcing the notion that software is a true representation of physical hardware. This tendency can also be found in the creation of VCV rack, which the online electronic music instrument shop *Synthtopia* (2017) describes as being “designed to be used as a complete DAW for creating modular synthesizer compositions or as an extension of hardware modular systems.” However, there are issues with the assumption that virtual versions have exactly the same affordances - they do not. For example, VCV Rack can save and recall patches while hardware patches are more challenging to note and reproduce. The physical interface of a Eurorack module enables an interaction between performer and instrument, whereas the generalist interface combination of mouse and screen with VCV Rack presents a barrier to a more direct hands-on creative approach.

Certain companies have tried to overcome interface issues through the introduction of bespoke MIDI controllers, such as Ableton’s *Push* and Native Instruments’ *Maschine*. Whilst MIDI controllers can create a similar tactile experience to hardware, it is not quite the same. MIDI parameters can be customized to different mappings which means the performer has to remember the position of various controls; consequently, it offers a polymorphous interface that differs from the fixed layout of a hardware synth. Furthermore, the ageing 7-bit resolution doesn’t offer the granularity required for more expressive and subtle timbral changes whereas analogue circuitry operates with continuous control voltages. Eurorack may, in part, be understood as a response to the software-driven virtualization of music-making, and to the subsequent successes and failures of MIDI devices in bridging the barrier of simulation. Eurorack modules have come to fuse analogue and digital technologies into a new paradigm that is primarily experienced through a physical interface, which re-shapes the creative process of making electronic music and sounds.

VCV Rack provides a useful way to prototype ideas for modular patches that a musician may implement with hardware modules. The advantage of VCV Rack is that it also opens possibilities that are difficult and even impossible to achieve in hardware, such as the ability to save and recall whole modular systems, or the use of polyphonic modules and connections, simplifying a complex task in the hardware realm. After spending some time experimenting, and discovering modules that only exist in VCV Rack, it makes sense to explore the potential of

combining both software and hardware into a hybrid instrument. The main consideration is in deciding how to perform with the visually dominant screen-based VCV Rack, in contrast to Eurorack modules that we have observed enhance hands-on interaction. A bridge between hardware and software may be achieved with, for example, the *ES-9* sound card module by Expert Sleepers, as used in our set-up. This was designed to receive audio signals as well as control voltages. It is similar to a standard sound card, other than it provides connections that are compatible with Eurorack modules with switchable DC filters[5]. The latter are required to transmit low-frequency CV signals that would otherwise be filtered out on many sound cards. Using this approach enables the combination of both Eurorack and VCV Rack modules in a hybrid instrument consisting of both hardware and software. Part of the compositional practice is in the selection of physical modules as various haptic interfaces, and in the combination of the software elements on screen. This helps to learn the resultant instrument and to create a common performance interface that can be used for a range of different patches and compositions.

In the environments of Eurorack and VCV Rack, the dialogue between software and hardware is an ongoing process shaped by a complex web of commercial companies, smaller outfits, and enthusiasts. It is within this scene, or social ecosystem, that new modules are developed which can lead to entirely new approaches to the creative process. The open-source ethos leads to a community of modular designers and practitioners who exchange knowledge at music and showcase events (such as *Superbooth* in Berlin, Germany), as well as via web forums (such as *Modwiggler* at modwiggler.com). There are unintended uses of the modules, with unexpected outcomes, spin-offs. The design mutations, and an open-source ethos leads to new affordances in a fusion of old and new, whilst also stimulating dialogue between designers and end-users. For example, Émilie Gillet, the module designer of Mutable Instruments, states that:

> "I was surprised that the hardware and plug-in companies were promoting their products as if they contained magical ingredients. I wanted to dispel the anxiety about such a way of revealing the contents. We wanted the user to be able to customise the module to get around those restrictions." (*Clockface Modular*, 2017)

This open and fluid approach to design enables modular designers to respond to the creative needs of the Eurorack community. In the selection of modular parameters there is no analog

[5] DC means Direct Current, the opposite of Alternating Current (AC). Most digital soundcards tend to filter frequencies below 20Hz as they are not deemed necessary for conventional listening purposes. These would typically have a DC filter on the output.

versus digital, and in the context of their post-digital affordances, patching could even be understood as being analogous to coding. By providing the infrastructural affordances of a module, its designer can be perceived as an absent performer within the creative network of modular patch.

Reflecting on the creative practice of generating pseudo-random musical structures, different processes become interconnected into larger networks. Interacting with the modular system, the patch responds, creating further mutations. In this dynamic setting, parameters are explored and evaluated on their sonic qualities in the context of a performance. Serendipity plays a role throughout a modular performance until a desired musical sound emerges; when this is achieved, the main connections branch and solidify into a patch that forms the basis for a composition. As with any new instrument, it takes some practice to learn how to perform with the patch, and so it helps to record as much as possible to be able to review and iterate. To some extent the process can feel like jamming with a band, an experience that may be comparable to jazz improvisation as described in the ethnomusicological research of Elina Hytönen-Ng (2013), during which musicians' riff on each other's responses within the flow of music making. The best take is used as a whole piece, or the most interesting parts are edited together from several takes, while avoiding over-editing to maintain a sense of continuity. In effect, compositional performance becomes a recorded practice.

In summary, the experience of both the tactile and kinetic aspects in performing with hardware modules is of particular importance in working with Eurorack. Module designers, such as Mutable Instruments' Émilie Gillet, place much emphasis on how parameters shape the interaction during the design process, including the haptic considerations of the panel lay-out. During the performance, or music session, there is constant interplay between the affordances of the modules and their networked links on the one hand, and the active listening and flow of haptic responses by the performing artist on the other hand, that together produce an entangled form of musicking. There is a sense of intimacy in working with sound in this manner. As architect Juhani Pallasmaa (2012: 53) observes, "(s)ight isolates, whereas sound incorporates; vision is directional, whereas sound is omni-directional. The sense of sight implies exteriority, but sound approaches me …" Working with the haptic and sonic architecture of a hardware modular system, the division can blur between human and machine, between self and other, together as performers in a compositional network that articulates a dynamic creative relationship.

“Look at the network, and it starts to look at you,” Merlin Sheldrake (2020: 186) observes in the context of mycelial research, as he reflects on the use of metaphors by scientists. In asking the question of how we hear, see, perceive, and engage with the techno-aesthetic of making sound and music with Eurorack and VCV Rack, we were able to draw comparisons as well as indulge in metaphors that help to familiarize a musical communication with what seems, at times, like a close encounter of the third kind. In modular systems such as Eurorack, there is a return to Subotnick’s and Buchla’s 1960s quest to paint and sculpt electronic music in a way that is unique for such instrumentation. Like Reich in the opening statement from 1968, the modular musician longs for “perceptible processes,” for “closely detailed listening,” and for “a musical process (that) should happen extremely gradually.” (2002:34) While human subjectivity is increasingly intertwined and entangled via the internet, interconnected modular patches offer a sense of private yet social space. The patch is like a musical friend, interacting and responding, allowing the composing performer to test the affordances of the equipment as it offers up randomised variations as though suggestions from a co-creator. And the entanglement extends further, across the very digital communication networks that the hardware modular seems to offer an escape from, as friendships, module designs, and patch ideas are forged, fused, branched, broken, and abandoned, across a dispersed Eurorack social network that implicitly exists within its post-digital patches.

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