PROGRAMMING A MUSIC PERFORMANCE INSTRUMENT FOR A WANDERING MIND AND CLUMSY HANDS

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ABSTRACT

The Chaos Conductor is a live performance instrument for concrete sounds, designed around human fuzziness. Most humans have average dexterity and a cognitive need for novelty that limit their ability to perform conventional musical instruments. The Chaos Conductor addresses both through second-order parameter control. Stochastic triggering, MIDI virtualisation and a three-stage workflow (design, practice, performance) replace the precision-and-repetition model of classical instrument practice with accessible bounded exploration. This paper presents the design rationale, the control architecture, and reflections from solo and group performance. It argues that shifting the performer's agency to shaping conditions for sonic emergence can broaden the accessibility of performance interfaces.

Keywords: digital musical instrument, second-order control, stochastic triggering, live improvisation, performer-centred design

1. INTRODUCTION

1.1 The dual constraint

I learnt during my encounter with the classical guitar that, just like most humans, I wasn't built for conventional musical performance. It demands millimetre and millisecond accuracy achieved through thousands of repetitions of the same piece of music. I am fuzzy: I have average dexterity and the discipline of rehearsal is beyond the capacity of my wandering mind. The instrument and the approach didn't suit me.

Improvisation offers a different approach to skill development. Cornelius Cardew reframes the performer's preparation as training, an open exploration of an instrument's sonic possibilities that preserves creative freedom [1]. But training still requires the human to conform to a fixed instrument. With the Chaos Conductor, I also redesigned the instrument to accommodate my fuzziness.

1.2 The conducting paradigm

Seeing Rob Mazurek conduct the Exploding Star Orchestra was the phenomenological trigger that started the journey. Shaped by the Chicago tradition of "open improvisation", Mazurek conducts free improvising musicians through structured pieces. The conductor doesn't enforce a score; rather they shape the novel music that emerges from collective improvisation. The Chaos Conductor applies this philosophy to concrete sounds, the material of electroacoustic music, and releases them from their usual fixed media into live improvisation.

1.3 A machine-mediated human instrument

From the same Chicago school of improvisation, G. E. Lewis created *Voyager* [2], an autonomous computerised agent that established a dialogue with human musicians. It is deliberately a peer, not designed as an instrument. The Chaos Conductor makes a different commitment: offering an interface that the musician plays and that shapes their behaviour in return.

But machine mediation introduces a structural separation between the performer and the sound events. And Cardew's position on improvisation wouldn't tolerate such a boundary: "We are our sounds" [1]. The protective layer against fuzziness must be permeable enough that risk, choice and bodily engagement survive the mediation. Pressing "Play" is not a performance. As an artist in Rosenberg's sense [3], the performer must act. The tension between action and automation is at the centre of the design of the Conductor.

2. MAKING INSTRUMENTS FOR FUZZY HUMANS

2.1 Conditions for competency

Cardew's training [1] still assumes the performer can sustain the concentration that skill acquisition demands. Ericsson identifies three phases in this process: a cognitive phase where the beginner grasps the task's requirements, an associative phase where errors decrease and performance smooths out, and an autonomous phase where execution becomes automatic [4]. Most people reach the autonomous phase at an acceptable level and plateau there. Those who continue improving do so through deliberate practice: effortful, concentrated work on tasks beyond current ability. Deliberate practice is not inherently enjoyable. It demands sustained attention that most humans find aversive.

Kahneman and Klein arrive at a compatible conclusion from a different direction: genuine intuitive expertise develops only in environments of sufficiently high validity,

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where stable relationships exist between cues and outcomes, and where the practitioner has adequate opportunity to learn those regularities through repetition with feedback [5]. Without both conditions, experience produces confidence without skill.

Instruments differ in how much they ask the body to conform. The classical instrument meets these conditions through total conformity. Cue-outcome relationships are stable because the instrument's fixed physical structure encodes knowledge. The practice regime is supervised repetition, and the human conforms to the instrument. Magnusson observes that digital instruments reverse this relationship [6]: they encode the designer's musical vision in software, designed from conceptual understanding. This is often framed as a limitation, since the designer freezes a musical culture into code, creating what Magnusson calls "expressive closure". Even so, gestural instruments such as the T-Stick [7] keep the bodily apprenticeship while offering the ability to invent new idioms: the ultimate prepared instrument. The Chaos Conductor flips the terms. A standard MIDI controller the body already knows opens onto an effectively unbounded sonic space. Designing digitally this way leverages the performer's fuzziness, building the instrument around it.

2.2 The mediation problem

When the interface is separated from the sound source, the mapping between them becomes a design variable in its own right. Hunt and Wanderley argue that this mapping deserves the same attention as the input device or the synthesis engine [8]. They propose a multilayered architecture where abstract parameters, representing musical actions, mediate between raw controller data and the synthesis engine, allowing the designer to change the physical interface or the sound engine without disrupting the performer's learned gestures. The Chaos Conductor adopts this principle explicitly (see Section 3.3).

Separation accommodates fuzziness, but it introduces its own constraint: the more the machine mediates between performer and sound, the less the performer acts. A fully mediated instrument allows imprecise humans to make music, but at the cost of the bodily engagement that makes performance a performance. At the extreme, it removes the human entirely.

Lawrence Morris's Conduction practice demonstrates that this tension is navigable [9]. Morris developed a codified vocabulary of signs and gestures to conduct freely improvising ensembles in real time. The conductor shapes form, timing and dynamics; the musicians supply all sonic content. Morris described this as controlling change, not content.

The Chaos Conductor asks whether the same logic applies when the ensemble is replaced by stochastic machines and the conductor is the sole performer.

2.3 Fuzziness and accessible design

Fuzziness as a design condition has precedent in Gaver's argument that ambiguity is a design resource [10]. Where Gaver addresses ambiguity in information, fuzziness names the human source. This sits on a continuum with Treviranus's inclusive design framework, where disability is a mismatched interaction between a person and their environment [11]. Recent accessible digital musical instrument research applies similar reasoning to instrument design: constraints are design parameters, not deficiencies to overcome [12]. Fuzziness extends this logic beyond specific impairments. Average dexterity and a wandering mind produce the same kind of friction when an instrument is designed around a different human.

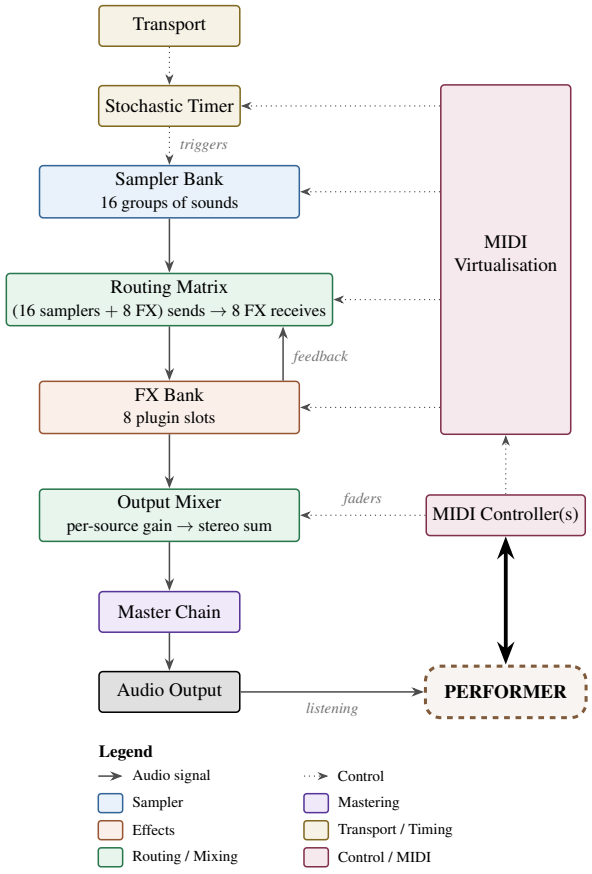


Figure 1. System architecture and signal flow of the Chaos Conductor. The performer only interacts with MIDI controllers.

3. DESIGN RATIONALE AND ARCHITECTURE

The Chaos Conductor is a Max/MSP instrument controlled exclusively through MIDI (see Figure 1). Its signal chain runs from a bank of samplers through a routing matrix that selectively sends the signal to a set of effects. The performer controls stochastic timers that trigger sample playback (with parameters such as density and period of events), and a subset of effect parameters selected during design (see Section 4). As the piece progresses, they dynamically remap the physical controllers through a MIDI virtualisation interface (see Section 3.3). The performer shapes how sounds behave; the machine decides when sonic events actually happen.

3.1 From first-order to second-order control

The performer's fuzziness motivated the design of the Chaos Conductor. First-order control, where a performer's action directly produces a sonic event, requires extremely accurate hands and a mind that can focus during the large number of repetitions needed to reach that accuracy. Most humans are not built to meet these challenges.

Von Foerster's second-order cybernetics offers a way forward [13]: where first-order control acts on a system, second-order control acts on the conditions under which the system operates. Controlling a statistical parameter instead of triggering individual events provides inherent smoothing of the outcome.

Event density is one such parameter. A Poisson event counter alternates a randomly drawn number of slow and fast events. The knob controls a Bernoulli gate that lets through a given fraction of the events produced, taking the sampler from silence to maximum density. Turning it reshapes a rhythm the performer can neither control nor get *wrong*. The closest the interface comes to "playing a note" is to push the density to maximum. But the sound still arrives according to the stochastic timer rules. By design, the machine is the mediator between the human and the loudspeaker.

Second-order control smooths the demands on dexterity. The wandering mind is addressed through the workflow described in Section 4.

Output amplitude resists second-order control most sharply. Gain is perceptually immediate and needs to be acted upon rapidly, especially when sound events are not pre-agreed upon. The gain curve I arrived at has low sensitivity where volume changes are most noticeable, imitating professional console fader laws. The convergence with professional practice suggests the constraint (human gain perception) invites this solution regardless of the design path.

3.2 The motif trade-off

Each sampler operates as an independent stochastic system. There is no cross-correlation between sound events: each fires in its own void. This independence reveals the design trade-off. Music is a temporal art, and one of its central tenets is memory. Repeating motifs anchor the listener, create the sense of return, give a piece its structure. With the Chaos Conductor, the only repetition is the recurrence of samples at more or less regular intervals.

This choice is purely pragmatic. A model encoding inter-event dependencies, such as a first-order Markov chain, would require controlling a number of parameters that grows with the square of the number of samplers. Even with the virtualisation discussed in the next section, I have not found a way to make that controllable in live performance.

3.3 MIDI virtualisation

[1] https://youtu.be/p2HJeEnBQB4



Figure 2. Snapshot of solo performance with the Chaos Conductor [1]. Hands on the controllers, eyes on the one-screen performance interface. Left column: routing matrix and mixer. Right column: virtualised sampler and effects. The left hand is on the density control, the right hand on the pads that select the sounds.

With almost 200 parameters controlling the samplers and effects, plus 24 mixing faders, it is difficult to map the control space to any reasonable MIDI setup. It would be possible to use control banks on a single controller, but this would just be a one-to-one mapping to the software without any consideration for how the performance evolves.

Let's consider a situation where I am controlling a sampler sending metallic sounds to a resonator and a reverb that feed back into each other towards a saturation climax. Using MIDI virtualisation, I can choose to make the sampler and the two effects directly controllable from my control surface. The choice itself is controllable via the interface. No need to access the keyboard or the mouse.

This dynamic remapping implements the multilayered architecture that Hunt and Wanderley advocate [8]: the physical controls address abstract parameters that represent musical actions rather than software values. Virtualisation switches which abstract parameters the controls address.

To make reconfiguration viable under performance pressure, the mapping preserves functional consistency across contexts. The same physical knob position always controls the same category of parameter: frequency, resonance, time constant, saturation. Switching from one effect to another changes the sonic result but not the gestural logic. This consistency is an attempt to preserve the stable cue-outcome relationships that Kahneman and Klein identify as necessary for competency acquisition [5].

As the piece progresses, I reconfigure which samplers and effects are at my fingertips. The controls follow the logic of performance, independently of the underlying software architecture.

4. USING THE CHAOS CONDUCTOR

As a digital instrument, the Chaos Conductor sits squarely within what Magnusson calls the "continuous oscillation" between *design* and *use* [6]. But in my work with the instrument, a third term emerged: between designing the system and performing with it, a distinct *practice* stage proved essential. It is an exploratory mapping of a sonic space

whose behaviour cannot be fully predicted from its configuration alone. The three stages of design, practice and performance form an iterative cycle in which each stage feeds back into the others.

To make this concrete, I trace the stages through a single project: *Barreiro Improvised*, [1] a series of performances built from field recordings of Barreiro, a city across the Tagus from Lisbon. The project was selected for the 2024 OUT.RA creative grant; the use of the Chaos Conductor on the sounds of Barreiro was central to the proposal. I performed with Bruno Afonso (drums) and Sara Zita Correia (drums, voice and sound objects). The artistic objective was to reframe how we listen to urban and natural soundscapes and offer the audience a fresh perspective on familiar sounds they may encounter every day without *listening* to them.

4.1 Design: creating the sonic space

The Chaos Conductor is not a piano. It carries no built-in timbral identity; each project begins from silence and an empty sample bank. This flexibility demands strong constraints. Before any sound enters the system, the design must already look past the performance to its effect on the audience: what can they take with them when they leave? How can I change their relationship to their familiar sonic environment?

For *Barreiro Improvised*, I was mostly working with an existing sound archive, [2] complemented with personal recordings. Sound selection and cleanup are only the beginning of creating the sample collection. Each sample must work within the stochastic triggering logic: it will be repeated at unpredictable intervals and superimposed on other samples doing the same. The editing decisions shape how each sound can function in performance. Knives scraping mollusc shells during a collective fishing expedition at low tide were chopped up into short percussive elements to use in dialogue with the live drums. Longer dramatic sounds, like the groaning and clanking of a metal pontoon at the ferry terminal, became events with a clear structure and a prominent place in the soundscape. Ambient sounds, like the crackling embers of a sardine barbecue, were smoothed out as long background textures.

Sound selection is only part of the design work. Choosing and configuring effects is where the performer's artistic opinion becomes most visible. My approach is built on the tension between raw and processed sounds. A bitcrush on the sardine crackles brings out their granular texture. A delay on the knife scrapes makes the rhythmic content more organic. A resonant bandpass filter on the metallic pontoon emphasises its overwhelming quality.

The virtualised MIDI mapping encodes these choices into the interface. This is where design becomes opinionated in Magnusson's sense: the instrument's affordances for a given project are defined here, shaping what the performance can and cannot become.

[1] `https://noisewrangler.art/articles/barreiro-improvised/`

[2] `https://cidadesom.pt/`

4.2 Practice: mapping the territory

During the design stage, the instrument is not playable. Sounds and effects are configured, parameters are mapped, but they lack context. Practice is where the real surprises happen as the design decisions meet the stochastic character of the instrument.

Practice puts the design to the test. This is one of the reasons I chose to build a software instrument: at any moment, I can go back into design mode and change its behaviour. The current features of the Conductor are the fruit of these sonic encounters. Some are specific to a performance, others have become part of the core functionalities. This flexibility, inherent to software, carries the risk of over-engineering. I can choose from an inexhaustible palette of effects and sounds (including recording new ones) and I can also literally rewrite the whole program. On top of this, whatever choice is finally made propagates unpredictably through the sonic space thanks to the stochastic behaviour. The performance deadline becomes a necessary external constraint to close the design loop.

What practice produces is a shared topological knowledge of the sonic space. This is where the Chaos Conductor earns its place as an instrument. Just like a clarinet has a different timbre from a double-bass, the current instance of the Chaos Conductor has specificities and abilities that both I and the other players need to learn. We discovered that, for the opening of the second half of *Barreiro Improvised*, the drummer could create gong resonances that I would resample and loop as a background for most of the set. He had to know that the instrument could do this, so that he could perform *with* the Conductor. This kind of coordination goes beyond a score or a fixed sequence of scenes. It requires that each performer has become familiar enough with the shared territory to know what to expect from the others. The influence runs both ways: the instrument shapes what the ensemble can attempt, and the ensemble's discoveries reshape the instrument.

4.3 Performance: sharing the exploration

I know I'm ready for performance when I can trust the instrument's behaviour, when novelty is not surprise any more. In a group, we meet and recognise sonic landmarks with a practised understanding of what to present to the audience before moving on, confident in the stochastic offerings on that day. We are following the original intention, an Ariadne's thread laid down at the outset, and shared with the audience in its sonic form.

Walking on stage is another practice session with better lighting and more people in the room. The risk-taking is the same as in practice. The point is to share the fruits of our exploration with an audience. Some performers thrive on the adrenaline of tightrope-walking through a piece; the Chaos Conductor is designed without that edge, because I did not want it.

4.4 Reflections on use

This section discusses my experience after two years of solo and group performance with the Chaos Conductor, as

well as the outside perspective from one of the musicians I played with in concert.

Stepping back from event control to parameter control eliminated the dread of being on stage. The "set and let go" approach requires learning. There is still a desire to play a note *now*. But hearing the soundscape evolve and tweaking the densities feels more musical to me than playing the guitar, because I am working with my fuzziness. Through practice, I gained a memory of each knob's function on my controller (a Behringer BCR2000, visible in Figure 2). By assigning specific effect types to given physical slots, I built a gestural consistency that the virtualisation mapping could preserve across configurations.

The ability to change the control landscape proved essential. In hindsight, I realise I did this instinctively before formalising it in the design. In *Barreiro Improvised*, I used a resonant filter to excite the subbass: a rumbling texture with high-pitched transients cutting through. Once the filter self-oscillates, its resonance, frequency and feedback parameters are at hand, along with some extra processing. I could play for a few minutes, establish a dialogue with the other performers, and then calm the filter down or fade it out when ready to move on. The virtualisation afforded a coherent set of controls that didn't require a context or control bank change during the scene.

The most unexpected discovery came from short sounds at high event densities. The stochastic variation in timing, start point and sample length produced organic percussive patterns tight enough to respond to the drums. The randomness kept the rhythm novel while the timbral consistency of the sample pool held it together.

The absence of motif and memory, identified in Section 3.2, was the clearest limitation in practice. The lack of temporal structure in the early solo video presented in Figure 2 now feels like juxtaposing sounds without a purpose. Playing in a group mitigates the problem, because the human performers can provide extra structure. The Conductor becomes a source of novelty over a groove that the ensemble maintains. I experimented with a resampler to introduce some recurrence, but this fell short of the structural continuity that the instrument lacks by design. It was more useful as an echo of the live instruments.

The wandering mind, for its part, found what it needed. Curious about a region of the sonic space, I could explore it without having rehearsed my way there. Repetitiveness was rarely a problem, because at any point I could set off in a different direction. The friction lay elsewhere: the back-and-forth between design and practice felt sluggish when it required redesigning effect chains or re-editing samples to fit the stochastic logic. The performance deadline, as noted above, remained the necessary constraint that closed the loop.

Bruno Afonso, who drummed alongside the Conductor in the trio, offered the following reflection on the experience (personal communication):

> "I have to be more attentive to the sounds, to what [Jean-Philippe] records when I'm playing and then replicates throughout the set. This creates a strangeness, but at the same time it's enticing and mysterious. I learned how to listen and how to respect silences so that I can understand what is going on and where I can contribute. Experimentation and spontaneity require being very present. I think I improve my ear by trying to communicate this way."

The limited temporal structure of the Conductor's output strengthens the listening demand. Because there is no score and no expected pattern, the ensemble operates closer to free improvisation: spontaneity within the context of the sounds present. Bruno hears his own drumming returned through the resampler and the stochastic engine, transformed and redistributed across the set. He listens and responds to material that is partly his own.

The curiosity that focuses the wandering mind on the Conductor's side also helps the co-performer to stay present. Bruno only experiences the sounds, yet the stochastic output invites him to find his place through listening. The Chaos Conductor accommodates the performer by design and the co-performer by consequence.

5. DISCUSSION AND CONCLUSION

5.1 Performing electroacoustic music

The Chaos Conductor offers a new mode of interaction that flattens the learning curve. The need to practise remains: the performer maps the sonic territory instead of conforming their body to the instrument. They strategise over how to organise the sound events, and the underlying software makes the millisecond decisions. This expands how electroacoustic music can be made, a practice generally tied to a composed piece spatialised live on an orchestra of speakers. The Chaos Conductor brings the sounds themselves, and their transformations, into live performance. This change is centred on the performer, and it relocates Treviranus's mismatch [11] into the instrument, the one part of the pair a designer can change. The instrument reflects their mind and motion, and its novelty is lived in the making even where the audience treads familiar sonic ground.

5.2 What the current architecture cannot reach

Section 3.2 identified the cost of stochastic independence: each sampler fires in its own void, so the architecture's only memory is timbral through the effects and the routing matrix configuration. The current choices for the interface and the event triggering mechanism make motif structurally impossible.

This limitation reveals something about the grammar of the instrument. The performer controls density, frequency, gain. These are nouns: states of the system at a given moment. Remembering a motif, developing a structure: these are verbs, actions that unfold across time and require the system to reference its own past. With the Conductor, the performer decides where they are in the sonic space, not how they are travelling through it.

This distinction is the subject of ongoing work. Statistical models to encode temporal and cross-sampler dependencies, as well as neural networks to abstract effect parameters further, could introduce verb-like behaviours without changing the performer's relation to the interface.

5.3 The interplay spectrum

Using further grammatical framing clarifies where the Chaos Conductor sits on a broader spectrum of instrument design. A classical instrument operates in the first person: I pluck a soft C#, I blow strongly to produce harmonics. At the other end, Lewis's *Voyager* [2] operates in the third person. It listens, decides and plays. The human is a peer, an interlocutor or a witness. Just like Morris's Conduction [9], the Chaos Conductor operates in the second person. Where Morris addresses musicians, I address pieces of software that produce sounds. I set conditions, delegate execution, shape the probability field from which sonic events emerge.

Every digital instrument designer makes a deliberate choice about where human agency sits in the control chain, whether explicitly or by default. For the Chaos Conductor, it was the starting point: a definite wish to create an instrument, but to delegate precise execution to the machine. Yet it has its own instability. Just as a scuba set allows breathing in an inhospitable environment, mediation works with fuzziness but at the cost of autonomy. Accommodate the performer too far and the instrument slides toward third person; the scuba set becomes a submarine. Pull back toward precision and the instrument collapses into first person, where fuzziness is undesirable.

The evidence that the Conductor holds its balance is in the practice. The unnamed regions of the sonic space, configurations I recognise through my hands and ears without the need to label them, are embodied knowledge that only forms through engagement with an instrument that resists full prediction. It is with practice that I learnt to tune the shell scraping into hi-hat hits. This is Ericsson's associative phase [4] respecting the performer's fuzziness: skill acquisition driven by exploration and guided by the instrument's stochastic feedback.

5.4 The boundary of second-order control

The second-order framing is unambiguous for the stochastic parameters: density and period shape the conditions under which sound events emerge. The boundary is less clear for effect parameters. A filter frequency or a reverb feedback time is acted upon directly, closer to first-order interaction. What preserves the second-order character in practice is that these parameters do not require high precision to produce musically satisfying results. The tolerance is built into the control, not into the performer's hands. Whether this tolerance is sufficient to call the interaction genuinely second-order, or whether it is simply first-order control with a forgiving response curve, is a theoretical question. As with the mixer faders, it works in practice.

5.5 Conclusion

The Chaos Conductor started from a simple premise: letting a fuzzy human walk on stage and perform. Solo and group performances confirmed that second-order control can sustain musical interaction, with sounds and with other performers. I am back on stage, creating live improvised concrete music on an instrument that accommodates my skills.

The design principles presented here (stochastic event triggering, virtualised mapping and a three-stage workflow) are transferable to any environment capable of stochastic triggering and MIDI routing. What matters is the design decision to place human agency at the level of conditions that shape the probability field from which sonic events emerge. This is, in essence, an interplay between human intention and machine execution, where the quality of the musical result depends on their synergy.

The open problem is temporal structure. The architecture currently offers nouns but no verbs: states without memory. The next stage of the work is to abstract parameters further so they become musical gestures, and to create motifs through inter-event dependency and temporal correlation, while preserving the second-order relationship between performer and instrument.

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