

The Computer as a Musical Instrument

On the influence of instrument design on musicality and liveness.





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In fulfillment of the requirements: Master (in the Arts) Live Electronics

Chapter 0: Startup

0.1 Acknowledgments

First and foremost, I would like to thank my loved ones and friends who supported me before and during this journey. You continued to believe in my motivation to face the challenges that came with it.

In particular, my family, who patiently helped me grow, and my mentor, Benjamin Van Esser, who helped make my dream a reality.

0.2 Abstract

Over the past two years (2024–2026), I have specialized as a computer musician within the Master's program in Live Electronics at the Royal Conservatory of Brussels (KCB). During this period, I deepened my practice as a performing musician in contemporary classical music, with the computer at the center as an instrument. The research in this thesis stems from the pressing and common question: how does one play the computer during a musical performance? Naturally, there is no single or all-encompassing answer to this.

The configuration of a computer performance setup is typically determined by the musician's personal preferences, the specific musical genre, and the resulting technical requirements. In electronic music culture, this results in a versatile set of tasks spanning the entire musical-artistic chain: from initial composition to the final live performance. In this paper, I analyze the various roles that the computer musician assumes during this process. After all, such an analysis within a personal framework can significantly enhance the quality of performance (Van Esser, 2016).

In Chapter 1, I define my position as a computer musician within the current artistic field, explaining the content and relevance of the methodology used. Chapter 2 contains a detailed analysis of my personal portfolio using this methodology. Here, the focus lies on my development as a performer and the formation of my own performance setup. Finally, Chapter 3 offers a reflection on the entire research, supplemented by an overview of the portfolio, the repertoire performed during the program, and the sources used.



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Chapter 1: More than an Instrument

1.1 Introduction

This thesis is based on crucial experiences gained during my educational trajectory, stemming from projects in both educational and (pre-)professional contexts. The extensive discussion of these projects forms the basis for my choice to profile myself specifically as a computer performer, despite—and partly because of—the diversity of fields. In the first chapter, I frame my artistic practice based on personal aesthetic preferences within contemporary classical music culture. The second chapter offers a reflection on the multidisciplinary tasks I consider essential for a specialist in the lead-up to a live performance. The accompanying portfolio illustrates diverse methods for employing the computer as an instrument. Other forms of computer music are briefly touched upon for completeness but fall outside the core of this research.

1.1.2 Personal Background

My artistic trajectory started in 2017 with an initial exploration of Digital Audio Workstations (DAW) and film editing software. These early experiences with experimental sound productions and hip-hop production provided the foundation for my technical mastery of Ableton Live¹. Gradually, my focus shifted from production to the role of the musical interpreter. After thorough specialization in the basic techniques of sound production and computer composition, my research turned toward the broader performance-oriented applications of computer music within contemporary music practice.

My professional training began in 2021 with the bachelor's degree in Music & Technology at the KCB. Here, I was technically trained as a musician, supported by a classical-theoretical foundation of harmony and music history. In the instrument lessons of Benjamin Van Esser, I learned to master the computer as an instrument through the synergy between Ableton Live and Max². His approach, strongly rooted in his own research into artistic performance strategies, formed a major source of inspiration. It is from this basis that I decided in 2024 to further immerse myself in the performance-oriented aspects of computer music during the master's program.

¹ Ableton Live: DAW software, <https://www.ableton.com/>

² Max: DAW software, <https://cycling74.com/>

1.1.3 General Subject Domain

To delineate the context within which this educational trajectory takes place, I often use general terms such as "computer music" and "live electronics." Because these terms encompass a very wide range of meanings and characteristics within electronic music culture, some basic concepts are clarified below. This creates a clear starting point for the rest of this research.

“We will not try to state what computer-based instruments should be or how “computers should be played”. However, we will try to define and study concepts such as efficiency, apprenticeship, the learning curve and the path to virtuosity or expressiveness; concepts that may help in describing and identifying the dynamic relations that exist between players and their instruments.” — Puig, 2005

1.1.3.1 The Computer

The computer functions as a versatile electronic instrument that, thanks to processing power, can perform complex data processing simultaneously. Within computer music, hardware units are often offered in a specialized form. For example, ready-made DJ controllers and synthesizers have dominated the commercial market of both pop and experimental music over the past decades. The design of these devices is typically based on conventional methods of sound production and signal processing, where the interface is often inspired by analog technology from the last century, such as modular synths³, effect pedals⁴, or mixers⁵, etc. With the rise of powerful laptops, however, it has become possible to develop more compact and efficient setups. Software offers the freedom to execute specific programmable functions, which is both a financially and ecologically sustainable choice. Although aesthetic differences with traditional hardware remain, I focus on the laptop as the pivot of musical performance, emphasizing the wide span of possibilities for multitasking and real-time control.

³ An example of computer-controlled musical instruments based on mathematical principles is a Euclidean modular synthesizer sequencer by vpme.de - Vladimir Pante Musikelektronik: <https://vpme.de/euclidean-circles/>

⁴ Commonly used effect processing modules come in the form of pedals by e.g. Boss: https://www.boss.info/nl/categories/effects_pedals/

⁵ Digital mixing consoles are also used for effect processing, but are primarily designed for sound diffusion in a space. An example of a digital mixer is the Wing by Behringer: <https://www.behringer.com/en/products/0603-aen>

1.1.3.2 Cultural Context

Jos Zwaanenburg (2006) proposes a method in a research report in which he attempts to standardize the use of live electronics, at least with the aim of developing repertoire and debunking the idiosyncrasy surrounding live electronics within contemporary classical music. Within contemporary performance practices, we can achieve live electronics performances in various ways using countless already developed and refined electronic musical instruments. Zwaanenburg makes that connection in his practice through direct collaborations with acoustic instruments (trusted tradition) and live electronics (tradition already being established). He categorizes electroacoustic setups as follows:

1. Electroacoustic music with tape⁶.
2. Combinations of traditional instruments and tape.
3. Live electronics with specifically designed controllers and processing equipment.
4. Live electronic music where traditional instruments form the source for activation and control.

Note that point 3 is not necessarily "electroacoustic" here. As suggested by Zwaanenburg and confirmed by existing live electronics repertoire, the computer is often used as an extension of an acoustic sound source or for complex sound diffusion (the spatial projection of sound). In electroacoustic compositions, the composer usually captures the desired sounds and manipulation processes precisely. Because computers within live electronics lend themselves to exact registration, a practice often arises that works with tapes or fully automated processes. As a result, the performer's task is frequently limited to managing the balance between analog and acoustic sound projection. In such repertoire, the performer's role often shifts to that of a *Tonmeister*⁷.

In the early electronic repertoire, mainly tapes were used since live performances with analog computers and synthesizers were expensive and time-consuming. Thanks to contemporary commercial accessibility, real-time processing with the computer has meanwhile become the standard. Nevertheless, the electronics performer is still

⁶ By tapes, we mean recorded media whose signals originate from acoustic, analog, or digital source files.

⁷ A *tonmeister* (or sound director) is a highly skilled expert who bridges the gap between the artistic world of music and the technical world of audio technology. Unlike a regular sound engineer, a *tonmeister* possesses an in-depth understanding of both music theory and score analysis as well as advanced audio engineering.

frequently in a technical position behind the mixing console in the hall. In this role, the performer acts more as an artistic sound manager than as a directly steering force. Although musical interaction is present, the influence on the final result remains indirect. This reinforces the persistent misunderstanding among laypeople that the electronics performer is not a fully-fledged instrumentalist or musician. In ensembles, a strict distinction is still often made between real instruments and electronics, a perception fueled by the static character of tapes and the visual absence of the performer. This research therefore also focuses on techniques that increase the representativeness of the computer musician.

Zwaaneburg (2006) makes an inspiring reflection in his research article (regarding the previous statement about being a musician) on one of Trevor Wishart's three assumptions about composition with sound (1994), namely:

“The ways in which this sound may be transformed are limited only by the imagination of composer.”— Wishart, 1994

Zwaanenburg reacts to this by stating that the term "composer" could be replaced by "musician(s)," simply because, in an electroacoustic setup, the contribution between composer, performer, and sound engineer would be equally important for the efficient operation of a live electronics performance. He suggests that bundling artistic and technical tasks in a live electronics performance could be named as one task: *being a musician*. My analysis in this research relies on almost exactly the same connection.

Despite my ambition to stand on stage as an engaged performer, the question arises: is the computer performer in a live electronics context merely a symbolic addition? Given the rise of automation and AI, the computer could theoretically realize a full-fledged performance almost entirely autonomously. Moreover, the computer lacks the tangible properties of an acoustic object, making it tempting to present the instrument merely as a tool. In the current post-COVID era, the relevance of physical cultural gatherings has also become a subject of debate, partly due to the rise of streaming services and digital alternatives. We are more aware than ever of the time and space we invest in art consumption. However, Beckerman and Boghossian (2021) argue that, despite technologi-

cal shifts and socially disruptive events, the human need for social contact within music culture remains undiminished—a tendency clearly visible during the revival of the cultural sector. It is precisely in a technological context where our perception of place and time is under scrutiny that the physical presence of a performer in the "real world" remains a fundamental and evident choice.

Essentially, every computer-controlled task requires some form of human mediation, whether it is a prompt to an AI model or a DJ's track selection. Without human initiative, the computer remains inert. In a concert context, the performer functions as the essential link between the composition and the performance. The musician is not merely a symbolic addition, but an active interpreter who translates the score into a performance and engages in interaction with the instrument in space. By way of illustration: replacing a musician in a string quartet with a tape would not only be technically problematic but would also lead to an alienating aesthetic experience. After all, the score is inextricably linked to the live performance. This logic applies equally to live electronics: the presence of a performer on stage transforms the technology into a truly live medium. Without this visible human mediation, any form of playback could be labeled as "live." In this view, computer music is only truly live through the synergy between real-time processes and the physical presence of a performer. As this is not an all-encompassing definition, I have attempted to refine this vision based on my interests and perception as a musician in a room with my instrument, facing an audience.

1.1.4 The Instrument

When asked what instrument I play, I answer: I play the computer. This statement sparks the imagination and evokes associations with gaming, among other things. However, that comparison is not unfounded. There are striking parallels between digital game development and computer music. In both disciplines, the computer functions as a real-time interpreter of a player's input, acting within the framework of game rules or a composition. This underscores the fundamental physical interaction between human and machine.

At the same time, the statement "I play computer" emphasizes the instrumental and musical nature of the medium. It conjures the image of a musician with specific

expertise: the virtuoso computer performer. This vision aligns with the artistic practice I strive for, where as a performing musician I focus on the physical energy required to generate a sound. This type of athleticism is inherent to the practice of any instrumental study, but within computer music, it forms a discipline that is more deeply rooted than mere performance.

“Virtuosity in new digital instruments thus relates to the understanding of the system’s core, an understanding typically achieved from the process of being its designer. This type of virtuosity is not a relationship by a performer and the perceived affordances of the instrument (an association found in acoustic instruments), but rather a habituated (Bourdieu 1990) incorporation (Hayles 1999) of the system’s constraints achieved through a knowledge of its material, its mapping engine, and the exploration of its expressive limits.” — T. Magnusson, 2010

Magnusson (2010) states that virtuosity in digital instruments does not merely lie in performance, but is deeply rooted in the design process. The computer performer preparing for a live performance thereby transcends the role of mere programmer. This virtuosity stems from an embodied knowledge of system boundaries and technical architecture. In doing so, it is crucial to emphasize that instrumental virtuosity is not synonymous with an impressive spectacle. After all, the core of musical virtuosity primarily lies in the complete mastery and thorough understanding of the instrument.

Despite the evocative statement "I play computer," the computer as a physical object cannot be compared to an acoustic instrument. After all, a computer does not invite intuitive, physical exploration in the same way seen with traditional instruments, such as blowing, bowing, or striking. The hardware does not respond to such unguided interactions. Instead, we burden the computer with the programming of sound-generating and sound-processing processes. To make a musical performance possible, the computer must be integrated into a performance setup that allows interactive control via external hardware. In this context, the computer functions not as a solitary instrument, but as the central component within a broader instrumental system of input and output media.

“Musicians interact with a computer music system through its ‘user interface’—a combination of hardware and software that determines how information is presented to

and gathered from the user. Information can be conveyed to the musician through several senses.:

- *Sight: via display on graphics terminals, display panels, meters, and indicator lights, as well as switch and fader settings.*
- *Touch: via settings of knobs, switches, potentiometers, and the “play” and “feel” of the feedback from responsive input devices.*
- *Hearing: via sounds and silences generated by the system.”*

— Roads, 1996

Curtis Roads (1996) states that the interaction between a musician and a computer system takes place via the user interface: a synergy of hardware and software that regulates data transfer. This interaction appeals to several senses: sight (via displays and meters), touch (via the physical feedback of knobs and faders), and hearing. Depending on the genre or context, within electronic music we make conscious aesthetic choices for audiovisual forms of expression that intensify the experience of the work (Ciciliani, 2014). The physical dialogue between the performer and the input medium is crucial in this regard. To effectively project the energy entered by the performer into the space, an output medium is required that creates an interactive feedback system of visual, tactile, and auditory stimuli (Roads, 1996). In the following subsections, I apply Van Esser's (2016) instrument framework—designed to increase the artistic impact of a computer performance—to explain my own choices and methodology.

1.1.4.1 Input Media

Input media can be categorized according to various classifications. Puig (2005) makes a distinction here between:

5. Controllers modeled after traditional instruments.
6. Complementary controllers in a hybrid setup.
7. Alternative controllers.

In this research, I strive for a certain purification in the representation of the computer as an instrument. Due to the lack of prior training in a classical instrument, I consciously avoid imitating control forms, such as controllers with a piano keyboard. Instead, I focus on the taxonomy of alternative controllers. Given the great variety

within this category, I discuss two fundamental types of digital input devices below. These form the theoretical framework for explaining my own setups in Chapter 2.

Input media could be divided into tactile and non-tactile measuring instruments. Non-tactile instruments⁸ utilize sensors that register environmental factors such as proximity, warmth, or light without requiring direct physical contact. In contrast, there are tactile instruments⁹, where physical contact is necessary to perform measurements such as pressure sensitivity, velocity, or contact. Although both types of controllers are common within multimedia contexts, bodily expressions do not always need to be measurable to add artistic value to a performance (Thompson et al., 2005). Nevertheless, direct physical contact with an input device provides a visual framework within which action is bounded. For both the performer and the audience, this clarifies the causal relationship between the physical action and the resulting sound image (Fyans, 2015). As I indicated earlier, for this reason I will focus on instruments with a tactile user interface.

The choice of specific parameter control is dictated by the genre or artistic concept of a work. For example: in the practice of live acousmatic music¹⁰, where the focus is on timbre, texture, and spatial diffusion without visual distraction, the mixing console functions as an essential instrument due to precise spectral and dynamic control functions. Within a computer setup, MIDI equipment¹¹ is often chosen to realize this control. MIDI controllers translate physical actions into a universal computer language (notes and control data), which can be coupled (mapped) within a DAW to specific sound parameters. Although the design of these controllers often refers to traditional operating systems, the focus here is on their functional deployability. In an acousmatic

⁸ Examples of tactile instruments include the Theremin (Moog), Arduino microcontroller sensors, or the Leap Motion.

⁹ Examples of tactile instruments include instruments that provide some form of haptic feedback, such as pressure-sensitive pads. Haptic feedback is deeply anchored in daily interaction with electronic equipment and can consist of the user's physical interaction with the instrument and/or vice versa. Well-known applications include the vibration function of smartphones upon notifications or the force feedback in game controllers, which makes digital events physically palpable. Within acoustics, we find a hybrid form of sonic and haptic feedback in sub-low frequencies. These tones are barely audible, but are experienced as physical vibrations due to the powerful air displacement. In more sensory contexts, such as 4D cinema, this immersiveness is further expanded by the integration of scent, kinetic chairs, and atmospheric effects like wind.

¹⁰ In the performance practices of live acousmatic music, the focus is on the spatial arrangement of tapes, with the acousmonium as the output medium representing a "loudspeaker orchestra."

¹¹ MIDI: Musical Instrument Digital Interface

music context, for example, a MIDI fader controller¹² is preferred for managing multichannel sound. Here, we make a fundamental distinction between discrete and continuous parameters (Figure 1): push buttons are used for discrete data, while faders and rotary knobs are suitable for continuous data streams. This differentiation inherently determines the physical energy the performer injects into the system.

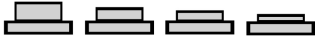
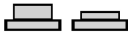
	Discrete data	Continue data
Knoppen	 Drukknop met bijv. <i>poly pressure</i> meting	 Drukknop met evt. <i>velocity</i> meting
Faders	 Fader knopfader	Drukgevoelige faders

Figure 1: MIDI control data, parameter types

1.1.4.2 Output Media

The output medium defines the degree of visual, sonic, and haptic feedback within a performance. These sensory gradations are shaped by deploying techniques such as projection, lighting design, sound amplification, and motorized (haptic) equipment. According to Van Esser (2016), the deliberate combination of these three aspects is crucial for optimizing the live experience. Some controllers can function as both input and output medium (for example: luminous controllers¹³), which I delve into in this research because of its advantages regarding the needs of my personal computer setup.

1.1.4.3 Instrument Framework

Based on the preceding analysis, it can be concluded that the computer musician's **instrument** does not consist merely of the computer itself, but of a tripartite hardware module system (see Figure 2). Within this framework, the musician activates the desired media via the input device. This action communicates the throughput¹⁴ via the software

¹² An example of a MIDI fader controller: Novation, Launch Control XL, <https://eu.novationmusic.com/products/launch-control-xl>

¹³ An example of a luminous controller is the Monome Grid, <https://monome.org/>

¹⁴ The throughput forms the software part of the instrument: the processing brain that converts input into output.

(DAW) on the computer to the various output media, creating a closed feedback loop. In this instrumental framework, the computer therefore functions as a modular and connecting element.

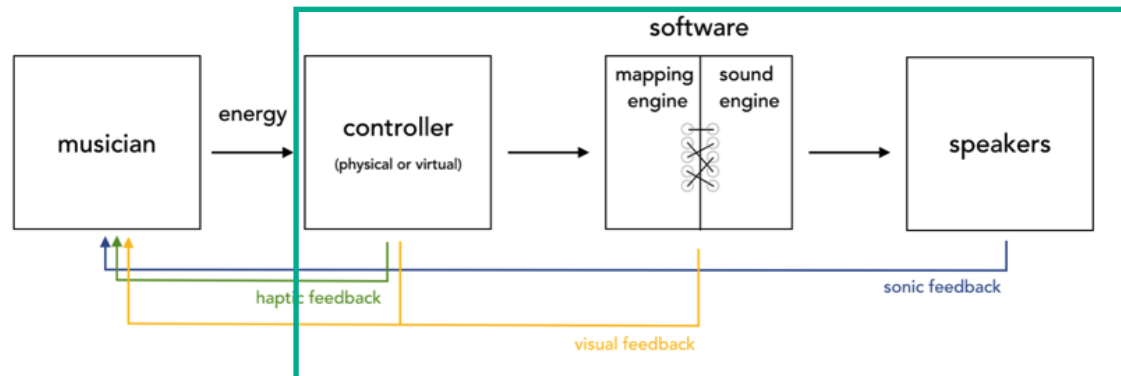


Figure 2: “General computer musician’s instrumental model with throughput split (after Wanderley 2000; Leman 2008; Wessel and Wright 2001)” — Benjamin Van Esser, 2016

1.1.5 Communication: Two Levels

Although computer-driven processes can essentially be fully automated, the focus in my practice lies precisely on visualizing human influence on sound generation. This requires a careful selection of parameters and a corresponding bodily gesture that physically portrays the sound change. John Croft (2007) underlines this necessity in his eight conditions for a successful computer performance, establishing a direct causal link between the applied mappings and the physical energy of the performer:

1. *“The response of the computer must be proportionate to the performer’s action.”*
2. *“The response must share some energetic and morphological characteristics with the performer action.”*
3. *“The onset of the response must be synchronous with the performer’s action.”*
4. *“There must be a timbral continuum, affinity, or fusion between the untreated instrumental and the response of the electronics.”*
5. *“The relationship between the computer and the performer must be stable”*
6. *“The relationship must be scrutable.”*
7. *“The relationship must be learnable by the performer.”*
8. *“The mapping must be sufficiently fine-grained.”*

— Croft, 2007

When selecting a MIDI controller as an input device, the configuration of feedback systems between the device and the performer plays a crucial role. On one hand, an

effective mapping translates the physical intensity of the performer into a corresponding sound generation. For instance, mechanical pressure on a button can be directly linked to the amplitude of the sound. On the other hand, luminous controllers provide a direct form of visual feedback on the instrument itself. Because the performer can visually monitor the status of the mapped parameters, a transparent interaction is created that aligns with the findings of Fyans (2015) and Van Esser (2016) regarding the comprehensibility of live performances. On a communicative level, haptic feedback can be subdivided into: tactile response and spatial resonance. In my practice, I consider the physical interaction of the performer with the interface essential for estimating the causal relationship between input and output. In addition, digital systems can externalize multiple forms of feedback simultaneously into the space, causing the sound to be perceived by the audience as a tangible, physical presence.

For me, physical interaction with an instrument is more than a visual control factor. Its tangibility functions as a direct extension of my musicality. In the humanities, musicality is defined as an innate biological trait that emphasizes human creative linguistic capability. According to scientist Harris (2019), musicality transcends this biological basis as soon as we cultivate and study it. On a cultural level, we can deduce from this that musicality translates into the artistic capacity to understand and practice music for both audience and musician. I consider the performing musician as the translator of the composition, specifically according to their own musicality. Thus, in a performer's linguistic capability lies not only the written language (and therefore the composer's musicality) but also the motor skill to use the language of the instrument involved. By analogy with this definition, a live performance only feels genuinely musical to me when the perception of liveness¹⁵ is guaranteed. Here, we can conceive of liveness as a certain form of perceptibility that establishes a sensory link between a causal live action (input) in relation to a resulting output (Croft, 2007).

From a spatial perspective, the musical live performer's focus on the interface is decisive for public perception. When a performer reads information from a shielded computer screen, it gives an impression of mental absence or isolation. However, by explicitly sharing the feedback system between human and machine—for example, by

¹⁵ De term *liveheid* verwijst naar de term *liveness* (engels) zoals gedefinieerd door John Croft (2007).

projecting screen processes into the concert space—presentation-oriented transparency is created. According to Ciciliani (2014), sharing these intentions enables the spectator to verify the liveness of the electronic actions with greater certainty.

In addition to direct feedback systems, artistic or conceptual visualizations can also function as indicators for liveness. In his master's thesis (2022), L. Lebrun distinguishes three core reasons to integrate visual elements into a live performance:

1. Visuals can compensate for a lack of physical expression in the performer, which Lebrun defines as: a form of increased virtuosity.
2. The synchronicity between image and sound can clarify complex sound changes, making the internal logic of the composition transparent.
3. Visuals contribute, depending on their scale, to the immersiveness of the experience. In this context, the center of gravity of the performer's physical action shifts toward a visual accentuation of the musical content itself.

Internal communication between the various modules of a computer setup is facilitated by data mapping. The interplay between the performer and the instrument can hereby be regarded as a primary feedback system between the configuration's input and output. When the performer is physically placed in the space, a second communication level arises: active interaction with the environment (e.g., the hall, fellow musicians, and audience) as well as the (passive) spatial resonance of the feedback the instrument produces.

1.1.5.1 Synchronicity

A fundamental aspect of musical communication is the synchronicity between the physical action and the response of the instrumental feedback system. This synchronicity is interwoven with all facets of a live performance. When the bodily actions of the performer match audiovisual events, it enables the audience to understand and evaluate the performance (Fyans, 2015). Moreover, synchronous feedback facilitates a direct response to the performer's energy, enabling immediate artistic adjustment.

In an acoustic context, the interpretation of compositional frameworks forms the core of the rendition. A composer can, for example, consciously differentiate between relative

and exact tempos. It is subsequently the performer's task to subjectively interpret relative tempos, while exact tempos are realized with the highest possible precision. Here, one must continuously account for minute temporal fluctuations inherent to human performance.

Depending on the musical concept, within computer music, certain processing methods force the performer to use fixed tempos. When using tapes or loopers with a rhythmic indication, the tempo is initialized in advance. Communication of this to fellow musicians often proceeds via audible patterns. Pioneers like Luigi Nono and Karlheinz Stockhausen used abstract graphical scores and time indications (Figures 3 & 4) for this purpose, translating the content of the tapes into traditional notation or visual sound representations.

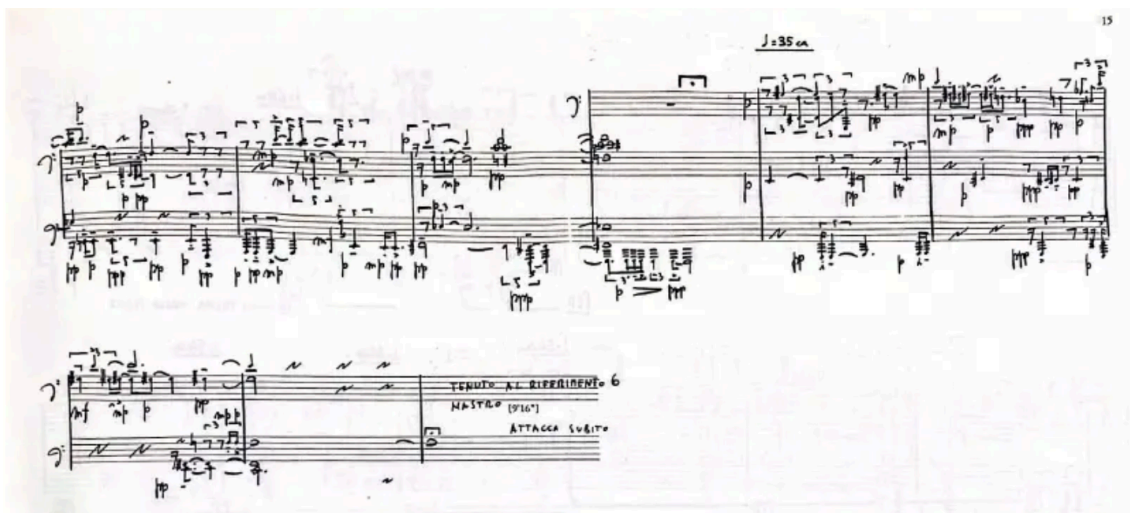


Figure 3: Synchronization of tape and acoustic: Luigi Nono - *...sofferte onde serene...*
Relative synchronization via time indication of the tape duration. © L. Nono 1977, Ricordi

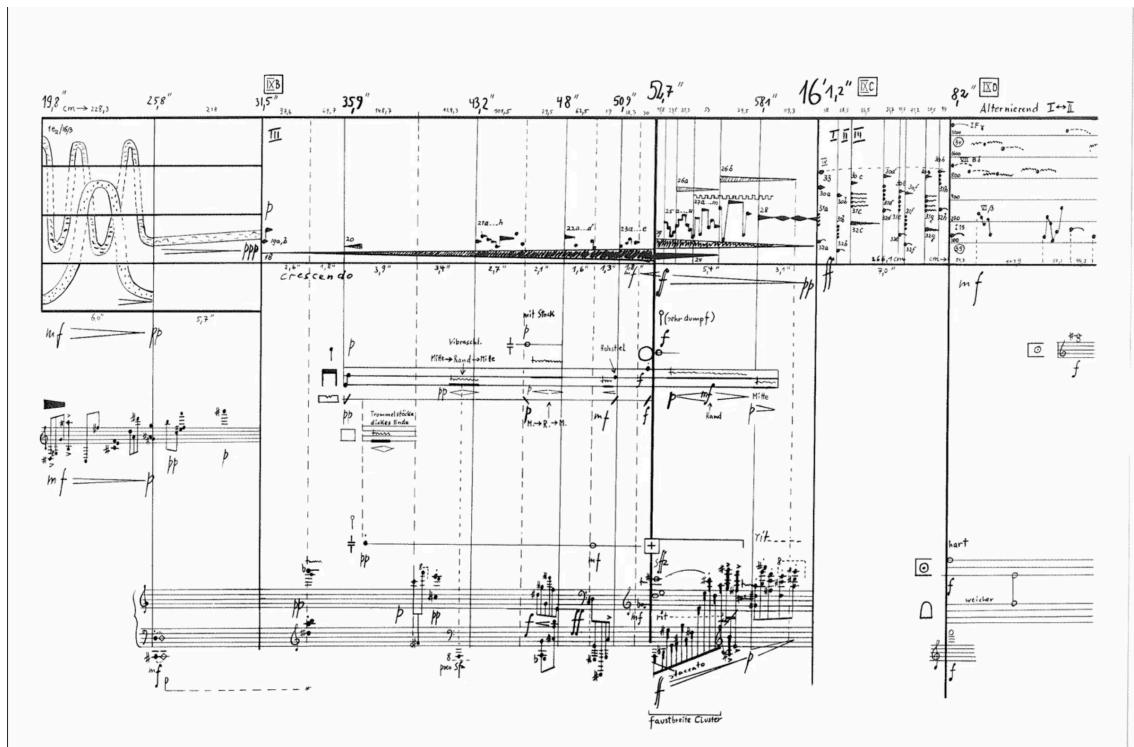


Figure 4: Synchronization of tape and acoustic: *Kontakte* - Stockhausen
 Linear, horizontal abstract visualization of the tapes with exact timestamps.
 © K. Stockhausen 1995, KONTAKTE

Depending on complexity, auxiliary tools such as metronomes or click tracks via In-Ear Monitoring (IEM) may be necessary for flawless synchronization. Synchronicity here implies an inevitable focus on temporal strictness, where technical limitations are an inherent part of the execution process. As Stroppa (1999) argues, tools such as a click track can be a conscious methodology that safeguards the aesthetic integrity of the composition without negatively affecting audience perception. In my practice, I use comparable methods to achieve synchronicity, striving for minimal technical limitations. This is a kind of freedom that I consider fundamental to safeguarding a performer's musicality.

1.1.6 The Tasks of a Computer Musician

The technical aspects that determine the preparation of a computer-based performance can be accommodated into three core domains. The connection between these elements is captured by Van Esser (2016) in a triangular model that unites the essential ingredients of a live electronics performance (Figure 5). In contrast to traditional performance practice, this model marks a fundamental distinction: the central role of instrument

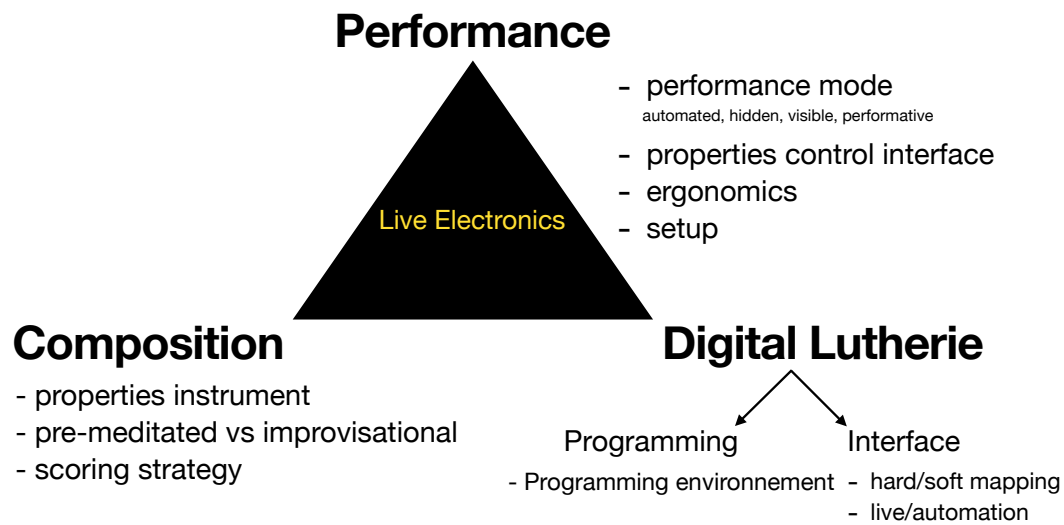


Figure 5: Live Electronics model by B. Van Esser, 2016

design, also known as digital lutherie. The computer performer who masters these domains consequently takes on a broad set of tasks.

1.2 Research Question

Unlike most traditional instruments, an electronics performer's instrumentarium is inherently modular. This means that every component of the system (the input, the throughput, and the output) is variable and can change in form. The specific configuration of these parts determines the scope of possibilities regarding the musicality of a performance. Consequently, instrument design (digital lutherie) and the choices of the designer or programmer have a fundamental impact on the experience of both the performer and the audience. Within this framework, I formulate the following research question: *What is the influence of instrument design on the possibilities regarding the musicality and liveness of an electronics performer?*

The necessity to investigate the influence of instrument design on musicality and liveness stems for me from the realization that an electronic instrumentarium is never neutral. Because the performer is often personally responsible for developing the setup (especially given the lack of standardized setups for repertoire work), the architecture of the setup dictates the possibilities in terms of execution. The research question therefore focuses on the causal relationship between technical choices in design (mapping,

feedback, visual transparency, etc.) and the ultimate artistic expressiveness (musicality) and persuasiveness (liveness) of the performance.

1.2.1 Methodology

In this thesis, I analyze various artistic case studies that I have gone through as an electronics musician over the past few years. From a hybrid role as instrument designer, composer, and performer, I investigate the fundamental influence of instrument design on academic and (pre-)professional artistic practice. The goal of this research is to demonstrate that the design of the interface has a direct impact on both the expressive capabilities of the performer and the audience's experience of their performance. After all, the integration of the computer as a fully-fledged part of a digital instrument setup brings specific challenges that fundamentally redefine the creation process of a performance with the computer.

The methodology of this thesis rests on a critical reflection of the preparation process toward a live computer performance. The analysis emphasizes the unity between various performing and designing tasks. Central is a newly developed model that, in contrast to Van Esser's triangular model, prioritizes the influence of instrument design (Figure 6). Given the artistic character of the research, this concerns a qualitative interpretation of the process. The motivation behind this analysis is explained step-by-step to clearly show the impact of instrument design on the final performance. In this thesis, I will refer to the analysis model as the CIP¹⁶ ratio. Measurability is relative and motivated from a personal experience, which is why I further explain how I arrived at the respective ratio for each analysis.

¹⁶ CIP is an abbreviation consisting of the initial letters of the task set that forms the foundation of the applied analysis model. (See figure 6)

Legende:

C = Composer

I = Instrument designer

P = Performer

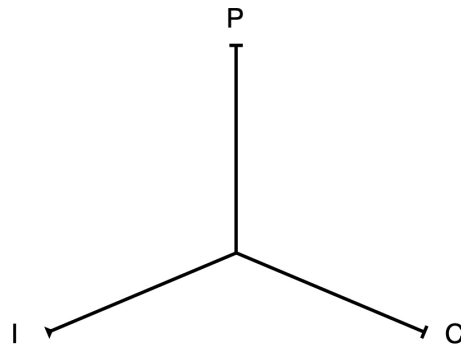


Figure 6: Analysis model inspired by the Live Electronics model (B. Van Esser, 2016)

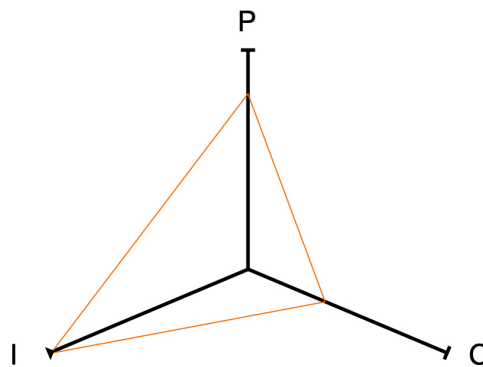
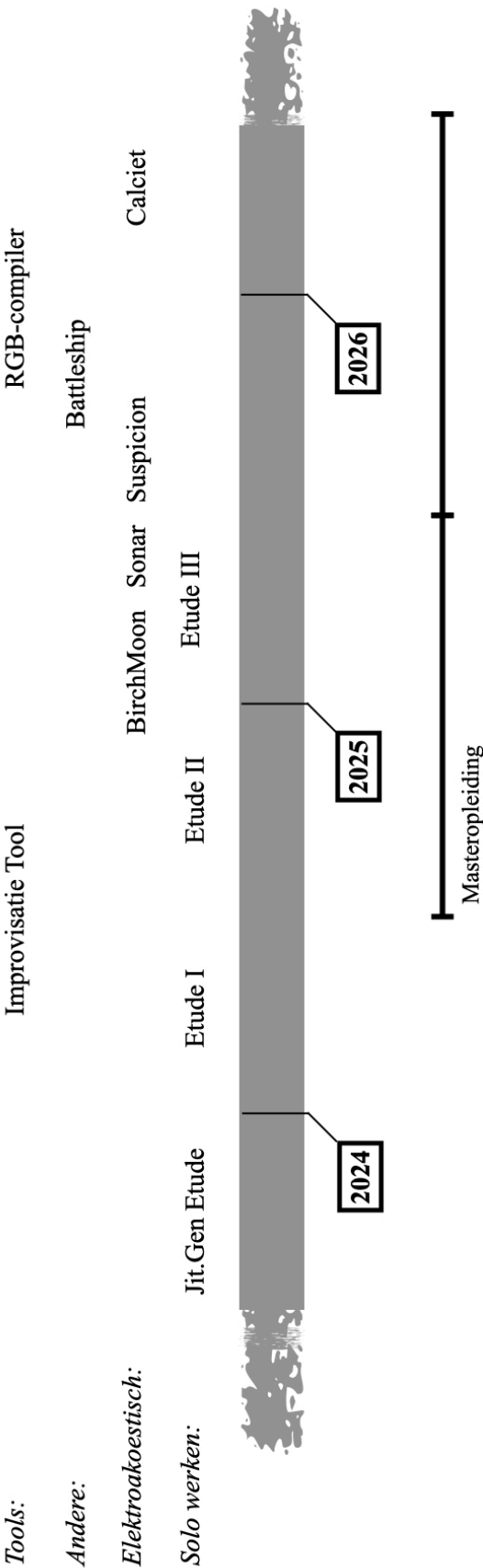
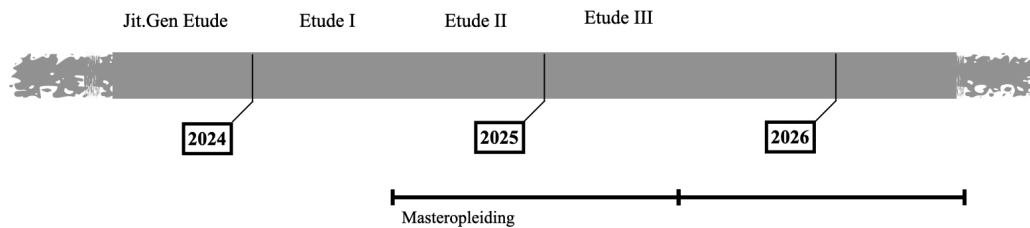


Figure 7: A simulation or example analysis in which the role as instrument designer was the largest, the role as composer was not large, and the performance was largely in the hands of the instrument designer.



2.1 Solo: Launchpad Etudes



These four solo works, which I term *études*, map out the most influential part of my trajectory. I primarily studied the relationship between the performer and their setup in the service of a solo performance. In the form of structured improvisations, a refined technical challenge is investigated in each one. With a view to developing as a creative performer, I work toward technical instrument developments and compositional tools. These solo works demonstrate the relevance and power of instrument design within the task set of the live electronics performer. During the creation process of *Étude II* and *III*, I delved into a specific controller: Novation's Launchpad X¹⁷. The motivation for this is strongly comparable to the findings and methods from Benjamin Van Esser's research (2016). He demonstrates his choice for a similar grid-based controller through various findings on luminous controllers and the mapping of gestures and expressions. Since the studied strategy aligns with my personal preferences, I utilize his instrument model. More details on this can be found in the respective chapters.

Note that I do not provide an extensive analysis (in terms of methodology) of the first two *études*. *Jit.Gen Étude* and *Étude I* were created during the bachelor's program and are therefore in a premature phase for this research. At the very least, the objectives of the *études* created during the master's program differed widely from the experimental approach of the first two. However, they are fundamental to my personal trajectory and an inspiration for the later *études*: *I* and *III*. I therefore discuss them only by way of introduction. The first *études* were described extensively in the two-part portfolio of my bachelor's thesis.

¹⁷ Novation - *Launchpad X*, Weblink: <https://novationmusic.com/products/launchpad-x>

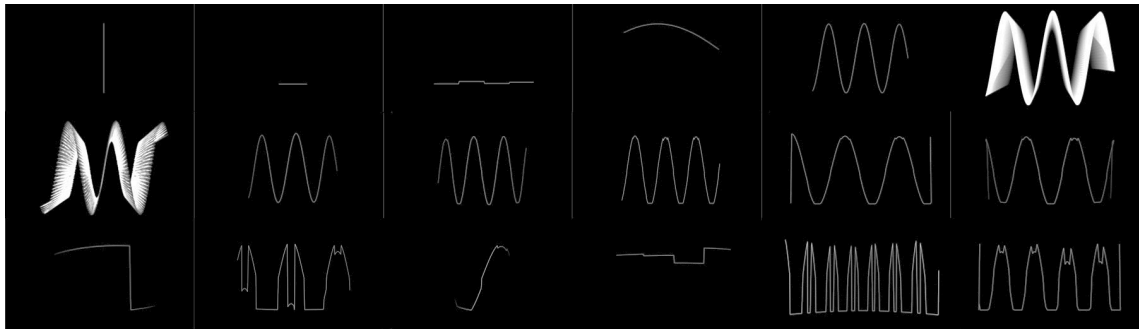


Figure 8: A collage of various animations from *Jit.Gen Étude*

2.1.1 Jit.Gen Étude

Jit.Gen Étude is a work in which (simple) animations form the basis of a musical narrative. The performance consists of live manipulation of the animations, which are linked to musical parameters. The mapping strategy was thus the opposite of that in audio-reactive music. In audio-reactive music, images, lights, or effects react to sound in real-time. In this piece, sound parameters react to the manually controlled changes in the animations. The resulting forms are projected, visible, and therefore also audible to the audience. Initially, the goal of the étude was the discovery of *jitter*¹⁸ in Max. The structure of *Jit.Gen Étude* arose from a gradual progression of the monochrome animations and the parallel development of the sound.

2.1.2 Etude I

For the second part of my bachelor's thesis, I created *Étude I*. This piece focuses on combining several methods of sound generation with the computer. I drew inspiration from a chamber music program I was preparing at the time, which featured various live electronics setups. The electronics setups (see repertoire below) were mainly based on the control of real-time processing and tapes. The live aspect had various levels of complexity regarding the electronics. I was not necessarily looking for a balance between these methods but was rather inspired by the electroacoustic implementations of the

¹⁸ Jitter is the visual programming component in Max and offers the possibility of performing real-time video manipulation, 3D rendering, and matrix-based data processing. There are two fundamental types of objects with which one can generate visuals in Jitter. Jit.gen ensures a higher processing capacity for parallel pixel data processing. In contrast to jit.gl objects, which process textures on the computer's GPU, gen works on the basis of texture layouts in matrices on the CPU. Jit.gl is therefore still needed to make the animations visible, but by compiling visual processing code into native machine code (gen), we can improve processing speed and program more compactly. It makes the data more accessible for parameterization. Throughout the creation process, I was confronted with several aesthetic questions. The visuals were projected enlarged and were thus somewhat immersive. But, to my dissatisfaction, this camouflaged the role of the performer even more. The connection of the applied mapping strategy to the instrument was not visible.

computer to create a solo performance setup in function of a composition. The setup consisted of an external feedback system (Figure 9) and two MIDI controllers to control discrete and continuous parameters (Figure 10).



Figure 9: feedbacksystem *Etude I*



Figure 10: Full instrumental setup of *Etude I* with the feedbacksystem

- *Coalesce 4* - Benjamin Van Esser.

This work for piano and live electronics was one of the pieces resulting from Van Esser's research (2016). In this piece, the live electronics performer can play in real time and interact with the pianist. Tapes and live processing are featured, providing a challenging and dynamic performance for both performers. The computer musician is thus partly dependent on the piano's live input and uses their own samples. The electronics can in principle be performed with an input device (controller) of choice. To interact with the piano, the electronics performer is located on stage.

- (*...nada.*) - Daan Janssens.

This composition was written for cello, piano, and live electronics. Prepared tapes are activated at indicated cues in the score. They must be mixed into the playing of the amplified cello and piano. This creates a quest for the listener because it is no longer clear what is played live and what is not. The position of the electronics performer is rather that of a sound engineer because almost all artistic elements are fixed on tape, responding only to the artistic interpretation of the acoustic instruments in the space.

- *Laconisme de l'Aile* - Kaija Saariaho.

In this piece, where the flute uses contemporary playing techniques, live sounds are manipulated by electronics via real-time processing. The electronics are thus fully depen-

dent on live input. The live electronics performer is located in the hall to create a balance with the room's acoustics alongside the effects.

2.1.3 Further Development of Instrument Design

The designed setups are unique for both études, but the input device (controller) is, by contrast, replaceable. The MIDI controllers were only used for controlling the software and did not contribute to the reinforcement of the visual performance aspects. At least, they were not composed for that purpose. Only the presence of the performer indicated physical control over the music. A clearer link is needed between the input device and the software to be able to contribute musically to the interpretation of the music. Specializing in one controller could therefore be beneficial for a computer-based performance (Van Esser, 2016).

In the upcoming études, I transcend the focus on a personalized interface. These case studies serve as proof that instrument design is a fundamental core task of the contemporary computer musician. By using a framework that closely aligns with my musical concepts, the emphasis shifts from mere parameter programming to all-encompassing design. In this, the modular computer setup functions as an integral instrument, where the visual representation contributes directly to both the composition and the live performance. Although there is still a physical distinction between the input device (the controller) and the processing unit (the computer), I approach the instrument in the études as one inseparable whole. Where the computer previously functioned as an external processing station, a conscious fusion emerges in the following études between the development of the instrument and the compositional process. This approach allows us to analyze the profound impact of instrument design and evaluate how this specialization redefines the other responsibilities of the live electronics performer.

2.1.4 Etude II

Consult performance below: Video recording *Étude II*



Video recording *Etude II*: https://youtu.be/_th_IfzACtM

For *Étude II*, I created a personalized instrument (Figure 12) according to Van Esser's methods. The model used is comparable to that of his case study: *CollidR* (Figure 11). Here, mapping gestures and expressions is central to obtaining a personalized instrument. These mappings can be linked to two types of processes according to the computer-controller relationship: the player's physical input or internal computer processes.

In this case study, I chose the Launchpad X as an input device. An instrument with a simple, flexible user interface. The device communicates via MIDI and consists of an 8x8 grid of pressure-sensitive buttons. The LEDs are individually controllable in programming mode. The physical input of a performer can thus be decoupled from the visualization on the Launchpad. Using Max, I linked the incoming data, according to the necessary mapping strategy, to the parameters that control the visualizations. The grid can be interpreted in multiple ways. For example, a row of buttons can serve as a fader and control the speed of an animation. In this, the animation visible on the grid shows no continuous connection with the invisible fader controlling it. Only the physical actions of the performer provide the link to the animation. Thanks to this controller, the visual aspect is in every respect in the hands of the performer. In a sense, this strengthens

the connection between the performer, the invisible computer processes, and the audio-visual output.

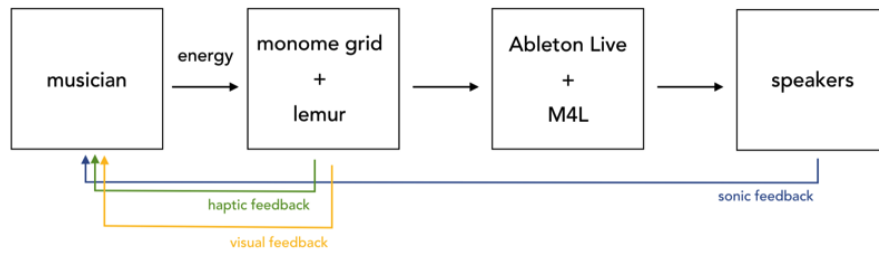


Figure 11: instrument model by Van Esser, *CollidR*, 2016

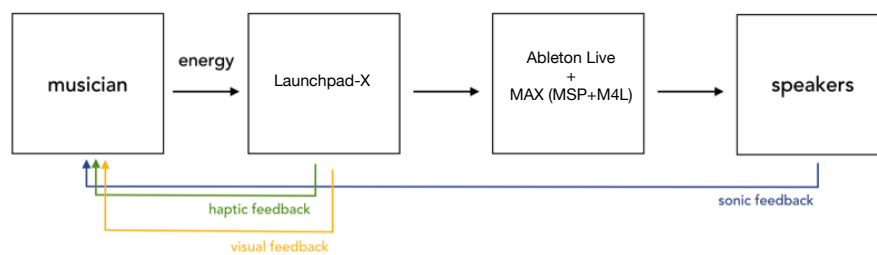


Figure 12: Adapted model voor *Etude II*, inspired by Van Esser's instrument model

2.1.4.1 Concept

“While creating the instrument, the choice for using either discrete or continuous value changes is greatly influenced by the aesthetics of the composition to be performed.”

— Van Esser, 2016

Aesthetically, *Étude II* shows similarities to *Jit.Gen Étude*. There is a clear separation between the performance on the instrument and the animations interpreting the music. The composition is developed for two important components of the instrument: the sound and the visual elements. Unlike *Jit.Gen Étude*, this piece was built from a musical point of view. The technical connection that ensures synchronicity between the music and the animations is an audio-reactive system. There was also inspiration from the design of the animations in *Jit.Gen Étude*. In that, the artistic/compositional elaboration found strength in simplicity. A visually perceptible performance with a complex, invisible computer process.

“It is salient to consider that if we were to address these questions in relation to the performance of an acoustic instrument, many of the answers are self-evident due to our in-

herent understanding of acoustic systems. It is not necessary to question if a performer of an acoustic instrument is, for example, directing communication to the instrument or if the instrument is responding correctly. However, within the diverse ecology of novel electronic musical interactions many of these answers are not readily available and therefore must be addressed. For example, how does a spectator form an accurate understanding of the response of a key press from a laptop performer? Alternatively how does a spectator gain an accurate understanding of the correct operation of a musical system where a single, discrete action may trigger a longitudinal algorithmic process?”

— Fyans, 2015

In his thesis, Andrew Cavan Fyans compares the approach of a model regarding issues for designers (Belotti et al., 2002) and a model of the ways of interaction between a mechanical system and its user (Norman, 1988). He motivates how these issues for designers can be solved through an analysis of the spectator's experience. For instance, a spectator who can distinguish between an action and an accident will better understand the instrument/performer interaction. It is therefore not necessary to highlight a complex process implemented in a mechanical system. As long as the effect of the performer's actions on that system is clear, the spectator will be able to make connections independently. Those actions can be very impactful for a spectator through strategic mappings to synchronized audiovisual elements. In this way, the visualizations supported the structural progression of the composition, which has a direct impact on the comprehensibility of the performance for both the performer and the audience.

In *Étude II*, the macrostructure consists of a linear progression in a three-part form. At

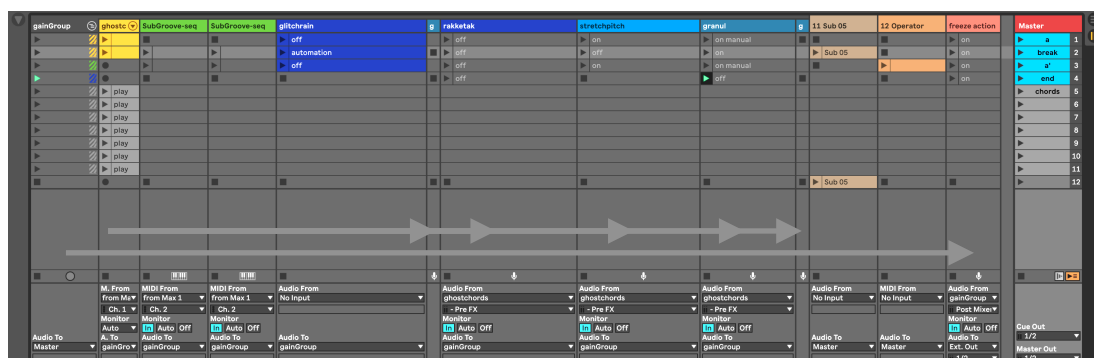


Figure 13: Routing scheme of *Étude II* in Ableton Live

the basis of the auditory material lies one digital synth as a sound source, which is directed in Ableton Live over various tracks through additive or subtractive sound effects

(Figure 13). All these versions of the source sound combined created a complex texture. Each effect contributes to a part of that texture. Due to this subdivision, each effect can be controlled on an individual track. For the first part, a musical process was developed with this material. As an interruption to this free structure (free in time), I use a looper that records the obtained texture. By fixing the texture in the looper, a kind of virtuoso solo could be played with the pre-built material using the playback possibilities. The texture parameters are therefore no longer controlled. There is, however, an automated rhythmic support to indicate time. I resume controlling the textures in the reprise (*a'*). Unlike the first part, the changes to the textures happen more abruptly. Habituation to the musical material from *a* is quickly and repeatedly broken off.

2.1.4.2 Separating Input and Output

A cue system can be used to navigate through the parts. In instrument design, this system ensures the mapping of different scenes and thus possible layouts of the instrument, both functionally and visually. There is therefore a clear separation between the visualizations on the instrument and the visual interaction with the instrument made by the performer. I therefore discuss the two domains: the input and the resulting feedback before explaining their intersection. The input maps the functional operation of the instrument. It summarizes the performer's possible actions on the instrument. The feedback ensures how the instrument will respond to the performer's input. Finally, I provide a complete overview of the mappings to map out the synchronicity. The colors next to the titles serve as a legend.

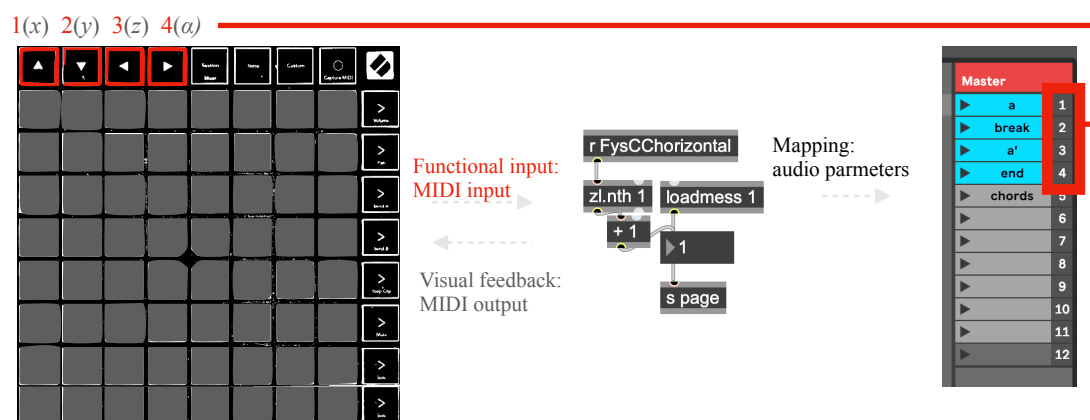


Figure 14: Data mapping scheme of the scènes in *Etude II*.
left: input device (controls), middle: Max patch (data mapping and visual feedback, right: Ableton Live set (sound generation)

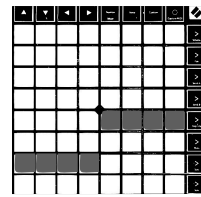
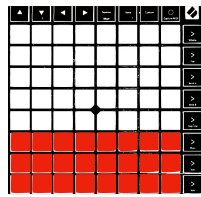
The instrument consists of a menu of scenes that activate the different layouts of the surface (both visual and auditory) (Figure 14). The first scene makes x number of buttons active on the surface, the second makes y number of buttons active, etc. The functions of those buttons are linked to audible and/or visual parameters. They activate mapped parts of an Ableton Live set and send out the visualizations on the instrument. For each scene, the functional layout of the buttons on the instrument is not visible.

Output feedback ■

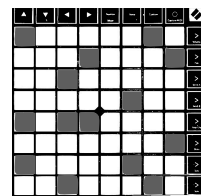
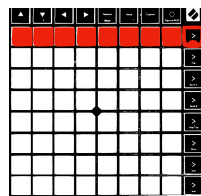
The synchronicity of input and output can stimulate the sense of orientation for both the performer, any fellow musicians, or the audience. While designing the animations, the choice arises to show, among other things, the literal visualization of the (discrete and continuous) parameters or to display an artistic interpretation of the processed sound. In *Étude II*, I chose an artistic interpretation with the goal: discovering the virtuoso aspects of the instrument. Given that there is no physical interaction with the computer—by mapping everything to the input device (a separate module)—we can, in principle, choose to remove the computer from the performer's sight. The performer must master the instrument to do this. By showing on the input device that only the performer knows how to generate the sounds and by maintaining the audience's attention, a certain form of virtuosity arises. In **Sight and Sound**, L. Lebrun describes the possible benefits of a visual performance as promoting virtuosity, maintaining attention, and immersion.

Visualizing the sound effects creates the link between the sound and the image. The performer's actions take place in the same place as the visualizations. Through the mapping strategy, we can choose to focus attention on specific parameters. In this case, the immersion lies primarily in the visual appeal of the controller. The spectator's eyes focus on the glowing surface and the performer's hands. This clarifies the instrument/performer relationship and the interaction/reaction.

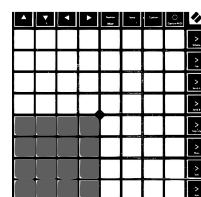
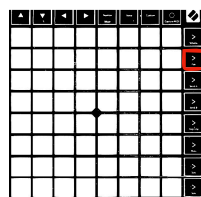
Realization: Intersection of Input and Feedback



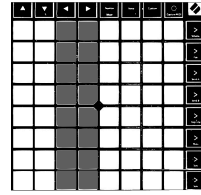
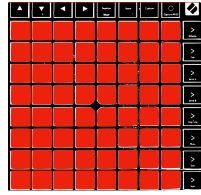
- At the basis of the piece lies a synthesizer. For the opening of the piece, two filtered and one dry version of the source sound are played. One of those filtered versions is always present and is animated. The bottom row consists of individual buttons that activate MIDI clips with chords. The two faders above are initially closed. The top one controls the volume of the dry synth, and the other controls a filtered version. The animation reacts to the "rattling" of the filtered synth sound. According to the panning orientation (left/right), two horizontal lines move up a row per rattle.



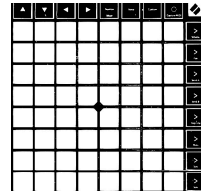
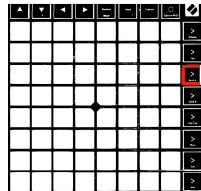
- The button to the right of the first row activates the "glitch visuals." When the animation is active, squares light up at random. They are distributed over the surface according to a fixed density. The speed of the glitch effect is controlled both auditorily and visually with the fader formed by the first row of buttons on the visual grid.



- The "grain looper" is used in the first and last part to manually play grains from a looped part of the dry synth. These are short but striking interruptions. They occupy 1/4th of the surface for the short duration of the sound. A grain is activated by the button to the right of the second row. During the middle *b* part, the looper is used to indicate a tempo during the solo on the scanner. (See next animation)



- The visual animation of this looper is comparable to a scanner and can be operated with the entire central surface. The parameters are divided across an X and Y axis and control different parameters of the looper. The X-axis was linked to the start point of the playback. The speed of the scanner and the loop length/speed are linked to the Y-axis. When one is at the very beginning of the loop, a short fade-in is heard that takes away the sharpness of the sound. Because this auditory difference is to be magnified, a soft blue tint is added.



- I trigger the bass sample at a certain moment in the climax. I use the deep sub-sound to give an extra heavy feeling to the scanner. In combination with the scanner, this is only audible, not visible.

2.1.4.3 Performance Focus Points

In *Étude II*, the performer interacts with an instrument on which the composition is, in a sense, already laid out. Since the buttons are not labeled, the performer must study the instrument in advance. In the design phase, the cue system was prepared to release parts of the musical material. In those parts, the mapped parameters are used to link the given structure together. The interaction with the instrument is inevitable for the performer. Since there is no time indication, the performer is free in the choices of their actions. The soloist can decide entirely autonomously on the development of the piece.

2.1.4.4 Étude II Version Two: An Alternative Visual Form Factor

Consult performance below:

Private link: Étude II in Metropolis by Muziektheater Transparant



Creation process Étude II in Metropolis © Nika Prokopenka

I reused *Étude II* in the production *Metropolis*¹⁹, developed by Muziektheater Transparant. *Étude II* was woven into the climax of the entire production and linked to a poem by the other performers. The poem is first accompanied by an acoustic guitar, after which the electronics take over and give the verses a different context or dimension. This étude aligned with the theme because of the visual computer-driven processes. For reinforcement, the animations were projected in an enlarged format onto the performers. This ensured the reinterpretation of the immersion (with respect to Lebrun, 2022) of the étude in function of the production's narrative. The human influence on the computer system seemed more insignificant (than in the original performance) in contrast to the

¹⁹ *Metropolis* is a music theatre production created by 14 young people under the artistic direction of Benjamin Vandewalle and four coaches with roots in music theatre. Berlinde Deman, Stef Heeren, and Els Mondelaers are responsible for the musical guidance, and Fatou Traoré for the choreography. A full-length evening performance is created in two weeks around an overarching theme. The young people present their own experience of the theme within their artistic discipline and work together on the design under the guidance of the coaches, who bring all the ideas together and refine the transitions and aesthetic aspects of the performance. The overarching theme of this edition was *Metropolis*, a 1927 film by Fritz Lang. In this science-fiction thriller, a prediction is made of what the world would look like in 100 years. In the production, this vision is compared with what the world looks like today and how we (as young people) look ahead to the evolution of the world in the next century.

overshadowing computer-generated animations. Despite the fixed programming of the composition structure, a transition could be made in the interplay from the introduction of the guitar to the solo.

2.1.4.5 CIP-Model (Etude II)

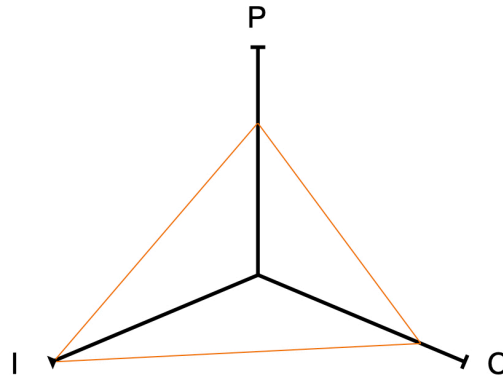


Figure 15: CIP model *Etude II*

Étude II transcends the mere development of a personalized performance setup. Through the active role of the instrument designer, a unique symbiosis arose between the composition and the instrumentarium. In this process, the composition was not written in the traditional way. Instead, the score was intertwined with the instrument design. Via an integrated cue system, a macrostructure was laid down that frameworks the performer on the one hand, but on the other hand offers the freedom for an autonomous concatenation of the different sections. The transferability of the system is guaranteed: through recordings or instructional videos, a performer can learn the specific methodology of the instrument. The strict separation between the button functions and the diverse output resulted in a powerful performance, driven by the synchronicity with the audiovisual material. In the alternative version of *Étude II*, enlarged visuals strengthened the immersive experience for the audience, although this did not directly influence the performer's playing style. In this, the performer functions as the mediating link within a fixed design in which the composition is enclosed, without the need to add extra physical dynamics.

2.1.5 Etude III

Consult performance below:



Video recording Étude III: <https://youtu.be/yb8dc4TzCII>

Étude III builds on prior case studies, focusing on expression during solo computer performance. I redesigned the Launchpad interface for tighter physical input/visual output bonds. Visualizing musical processes directly on the instrument makes parts playable only after completing specific processes (e.g., sound 2 available when sound 1 is active), replacing linear cue systems with layered compositional delineation. Finally, polyphonic key pressure was implemented, reading individual key depression force as a continuous parameter.

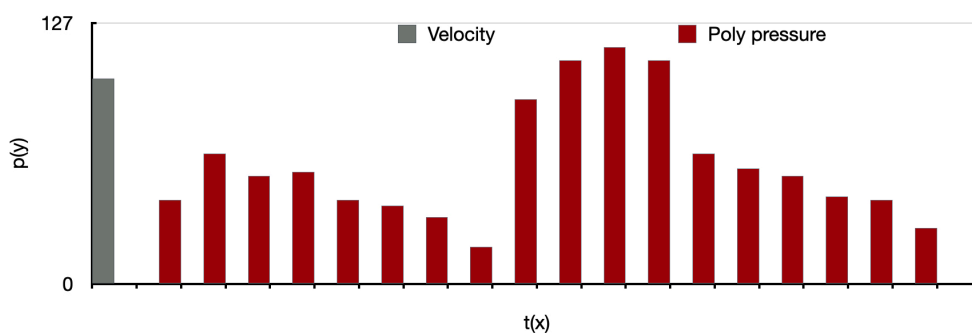


Figure 16: graph, simulation MIDI communication of velocity and poly pressure

Figure 16 simulates 20 datapoints for velocity and polyphonic key pressure on a single button. Velocity is discrete (sent on press/release; byte 1: 100, byte 20: 0), whereas poly pressure measures continuously on every pressure change. Acting as a z-axis (depth),

this parameter maps single physical movements more directly and expressively, adding dimensions to the Launchpad surface.

2.1.5.1 Polyphonic Structure

In Étude III, performers unlock musical material by stepping through programmed processes. Software order dictates microstructural composition form during sound development. Each row represents a process; using 8 rows simultaneously yields polyphonic instruments. Each voice has 3 layers, where layers become playable only when preceding ones are active, offering wide macrostructural shaping options. Unlike prior études, source sound and processing develop via polyphonic, chronological processes rather than parallel ones (Figure 17).

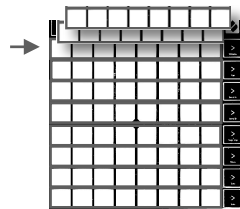


Figure 17: Chronological polyphonic system Étude III

Visualizing technical operations during continuous input surface movements makes auditory complexity transparent. Rather than abstract artistic representations, musical processes take center stage, inextricably linking instrument design and composition. Serial layer visualization reinforces sound control, empowering performers to use key combinations knowledgeably and creatively.

Musical processes are implemented in Max using multithreading²⁰. Audio control relies on spatial Launchpad distributions. Layer 1 restructures the 8x8 grid into 4x4 matrices where each 2x2 unit drives oscillator clusters. Multiplying row X and column Y audio yields ring modulation signals whose timbre and amplitude poly pressure directly influences.

²⁰ A technique in computer science that allows a computer program to execute multiple tasks (threads) simultaneously. It divides a process into smaller, independent parts that are processed at the same time, which significantly improves performance.

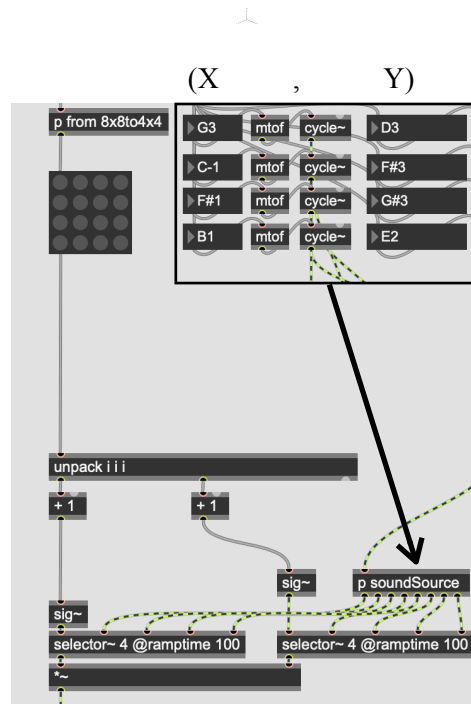


Figure 18: layer 1, ring modulation

Looping integrates: pressing buttons for times determined by velocity records/ reproduces pressure curves, visually confirmed via interface animation. Once active, row layer 2 (X, Y) unlocks. Deactivation resets status.

To illustrate: when button (3,6) is pressed long enough (Figure 19a), an animation appears for confirmation (Figure 19b). As soon as this process is complete, the second layer for the respective row is activated (Figure 19c). Deactivating the button resets the status and the system returns to the initial phase.

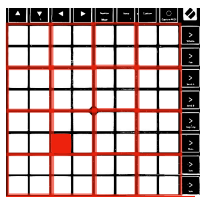


Figure 19a

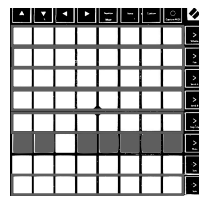


Figure 19b

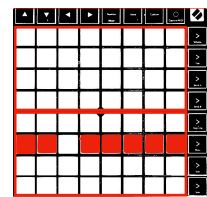


Figure 19c

The second grid layer is subdivided into three components:

- Layers 1 and 2: These are activated via a single button per row. In the top four rows, this drives a second synthesizer. In the bottom four rows, the column position determines the intensity of an effect, with the source sound originating

from the corresponding row. Depending on the button position, the pitch or a specific effect parameter (such as the intensity of a glitch looper) is affected.

- Layer 3: This layer is controlled by simultaneously pressing two buttons within a row. The relative position of these buttons determines which segment of the poly pressure loop feeds the glitch pattern. While two layers process the audio input or the data of a looped row, the third layer adds an additional instrumental part.

The visual animations on the interface reflect the row-based architecture of the instrument. As soon as a button is activated with a specific velocity, the remaining cells in that row fill with white light at a constant interval. The loop only becomes active once the entire row (except for the active button) is filled. Here, the poly pressure acts as a controller for color intensity, providing a direct visual translation of the looper status: the performer sees exactly when the loop is completed and with what pressure strength it is driven. This visual feedback runs completely synchronously with the audio signal. Upon activation of the second layer, the corresponding interactions are displayed on top of the existing animations. Thus, with every audible glitch (via the two-button combination), random rows light up. Compared to Etude II, this design shows a more significant relationship between functional operation and visual feedback, which clarifies the rendering of the compositional material for the performer.

At a later stage, I developed an RGB tool (see chapter 2.4.2 RGB-compiler), with which the color and brightness of the Launchpad LEDs can be controlled more efficiently and in greater detail. This enables the input device to visually display the executed and recorded expression with a higher resolution. In the attached link, two methods of lighting control are compared using an identical poly pressure loop. While the first version of Etude III (based on MIDI event communication) was limited to only four brightness levels, the updated RGB tool unlocks the full color spectrum. Although standard lighting equipment works with 24-bit RGB, this is downsampled to 7-bit MIDI values (0-127 per color channel), making 128 brightness gradations available for each color within the spectrum²¹.

²¹ $128^3 = 2,097,152$ possible colors within the SysEx RGB spectrum.

2.1.5.2 Performance Focal Points

Velocity and poly pressure are directly dependent on the performer's physical input. This requires physical training and motor control comparable to studying a traditional instrument. Because the entire central surface serves as the playing field, the performer must be able to orient themselves flexibly within the various polyphonic layers. Because the visual feedback now also reflects the physical force during sustained parameters (poly pressure), the expressive actions of the performer are magnified. The energy that the performer puts into the instrument is thus made directly visible and tangible to the audience.

2.1.5.3 CIP-model (Etude III)

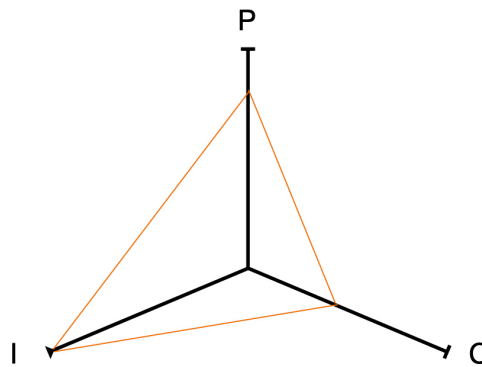


Figure 20: CIP model *Etude III*

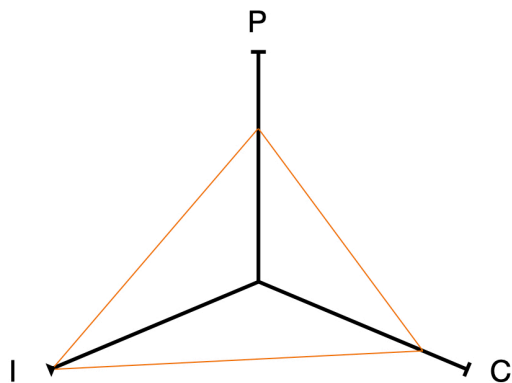
The most important shift compared to Etude II is the increased emphasis on the performer rather than the composer. Because the instrument design and visualizations focus heavily on physical input, the performer has a direct, determining influence on the end result. Furthermore, the composition stems more readily from the instrument design.

If a work were to be composed specifically for this instrument in the future, the balance between these roles could tilt. Thanks to the fixed architecture of the instrument, the sound material could easily be replaced by other synthesizers or effects. Combined with the variable structures, this leaves room for countless interpretations of a musical progression. Provided a clear notation and structure is developed, it is therefore hypothetically possible for a composer to write all kinds of works for this instrument.

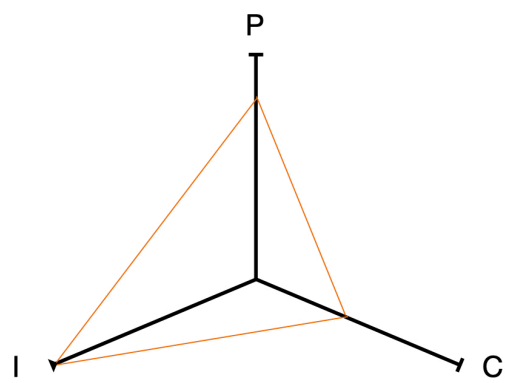
2.1.6 Future Études

Unlike Jit.Gen Etude and Etude I, where the focus was on developing compositional material and integrating multimedia elements, Etude II and III start from instrument design. The goal here was to create an instrument with unlocked musical material for a performer. In these Launchpad études, the architecture of the instrument determines the musical structure, with a cue system establishing the framework for the performer. As the structure is subdivided into polyphonic processes, compositional control shifts: the designer determines the operation of the instrument, but the elaboration of it could in principle be done by an external composer. Moreover, the visualization of expression parameters gives the performer a more prominent role.

This research has broadened my expertise as a computer musician. Given the inspiring results of this personal setup, I plan to continue the series. By dividing the grid surface into different layers, a process is created that can be recorded with a simple notation system. I therefore want to delve further into compositional methods for grid-based instruments. Although a computer musician remains necessary for the technical translation, a fixed writing language (for example based on coordinates and time indications, comparable to mathematical notations in microtonal music) can increase



(Copy) Figure 15 : CIP-model *Etude II*



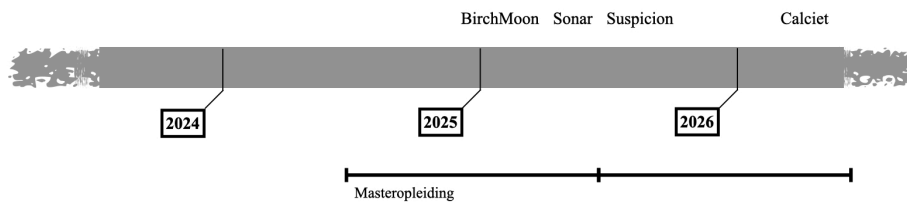
(Copy) Figure 20: CIP-model *Etude III*

accessibility for performers.

In addition, I see opportunities in the development of specific tools for the control system, such as the later developed RGB Tool for precise data communication. Because visual aesthetics and instrument design are closely intertwined with the composition, this remains a fascinating intersection for me as a computer musician. Finally, physical

input offers unexplored possibilities. By not only using finger touches, but also measuring the surface area of contact, gestures such as a flat hand (percussive) or a punch (powerful/concentrated) can add new expressive dimensions to the performance. The right sound mapping within these dimensions makes it possible to take the purification of the computer music setup, as proposed by Croft (2007), to an even higher level.

2.2 Ensemble: Electroacoustic



Interaction with acoustic instruments is a logical step within live electronics in the context of classical music. This is not only inspiring due to the performer-instrument relationship—for example, for the extraction and enhancement of musical expression—but also because of the established communication techniques that facilitate ensemble playing. In the context of group performances, the inter-performer relationship is crucial. In this area, I position the computer within diverse, electroacoustic, and multidisciplinary ensemble settings. I focus on the development of the computer as a fully-fledged instrument, without emphasizing a general specialization in composition. Although I learned to compose for instruments that were previously unfamiliar to me during this process, the analysis and development of computer performance remains the core of this thesis. For that reason, the technical aspects of the other involved instruments or disciplines are not explored further.

When composing for electroacoustic ensembles, I was confronted with the need to fathom and integrate acoustic composition methods into a shared score, with the specific goal of ensuring synchronicity. This revealed a fundamental conflict: traditional acoustic notation often strictly delineates parameters such as rhythm, tempo, and pitch. As a computer musician, however, I am accustomed to thinking in parametric ranges and action-based techniques. The challenge lay in designing scores that bridge the gap

between these contrasting organizational structures. A traditional layout often seemed the clearest method to streamline the interplay. For this, I used an interplay between music notation software and sound design in a DAW. Due to the diverse nature of the building blocks, this process proceeds in stages. In my practice, this means that I use Ableton Live for both sound creation and the final performance, in combination with MuseScore²² for finalizing the score.

When the computer is used as an instrument for live performances, we must distinguish two phases according to Marco Stroppa (1999): the composition phase and the interpretation phase. In the composition phase, the composer not only determines the formal rules for sound generation but also creates the sound material itself. Subsequently, the score must be made suitable for interpretation by a performer. Clear notation is essential here, as the composer cannot always adjust during the performance.

This interpretation phase constitutes the decisive moment for both composer and performer. Within the academic tradition of classical music, there is a tendency toward musicological immersion research, which strengthens the authenticity of a performance. In this context, I have investigated methods that increase the room for interpretation and authenticity in computer performances, with specific attention to the physical positioning of the computer player in relation to fellow players and the integration of expressive parameters. Moreover, notating absolute dynamic indications is inherently relative. As soon as there is interaction with live musicians, one becomes dependent on their presence in a certain sense, and the dynamic aspect must adapt to the context. A fundamental choice must be made regarding the role of the computer. Depending on the artistic goals, I will employ the computer in three (combinable) ways:

- **Tape (non-influenceable²³):** Pre-produced tapes or a hybrid form of fixed media and live source sound. There is no live-perceptible musical influence by the electronics performer. Live manipulation can be caused by external factors (such as amplitude following).

²² MuseScore is free composition and music notation software, <https://musescore.org/en>.

²³ Non-influenceable sources are tapes that serve as playback and will only be managed in terms of sound engineering. That is, edits that have no directly perceptible musical impact.

- **Instrumental:** A live performance where the computer functions as a fully-fledged instrument and obeys the performer's energy input. It is the performer who interprets the musical live events.
- **Installation:** Interaction with tactile autonomous systems²⁴.

2.2.1 Sonar

Consult score 1

Sonar is a chamber music composition for cello, piano, and live electronics, based on the instrumental architecture of Van Esser's *Coalesce 4*. The instrument design is characterized by a twofold sound production: real-time processing of the acoustic instruments and digital sound synthesis. In terms of performance, *Sonar* strives to refine this model by minimizing technical dependencies. Whereas the use of samples in *Coalesce* requires a rigid tempo and the use of a click track, *Sonar* attempts to circumvent this obstacle. After all, the use of IEMs (In-Ear Monitors) can cloud the perception of dynamics and intentional sound gestures, which hinders the natural interaction between performers.

To increase the autonomy of the computer performer, *Sonar* employs a model in which the computer functions just as independently as the acoustic instruments. This relies on classical chamber music techniques, such as non-verbal communication and body language, to shape the sound result collectively. Although certain electroacoustic genres (such as *(...nada.)* by Daan Janssens) use atmospheric tapes of longer duration that do not require a strict tempo, *Sonar* focuses precisely on maintaining interactive freedom within a rhythmically active context.

2.2.1.1 Parameter Score

As this was my first electroacoustic composition, where I fulfilled the roles of composer, performer, as well as instrument designer, a thorough analysis of the instrumental possibilities of the piano and cello was essential. In close cooperation with the performing musicians, I developed a fully-fledged score. To realize an organic fusion between the electronics and the acoustic instruments, I used a production-oriented method in Ableton Live. Here, the musical layers were subdivided into real-

²⁴ An autonomous system is an instrument that not only responds to the performer's input but also generates a form of feedback that actively influences the performer's artistic choices.

time sound synthesis on the one hand and real-time effect processing of the acoustic input on the other.

To shape the composition, I first developed a listening demo with programmed automations and MIDI parts (Figure 21), which then served as the basis for the score. It was crucial that all parameter changes remained executable live after the creation process. A schematic overview provided the necessary structure to determine which parameters were included in the final mappings. To guarantee the dual nature of the instrument (sound synthesis and manipulation) in the score, the electronics were given their own system of two staves. This maintains the overview between the different sound sources during the performance.

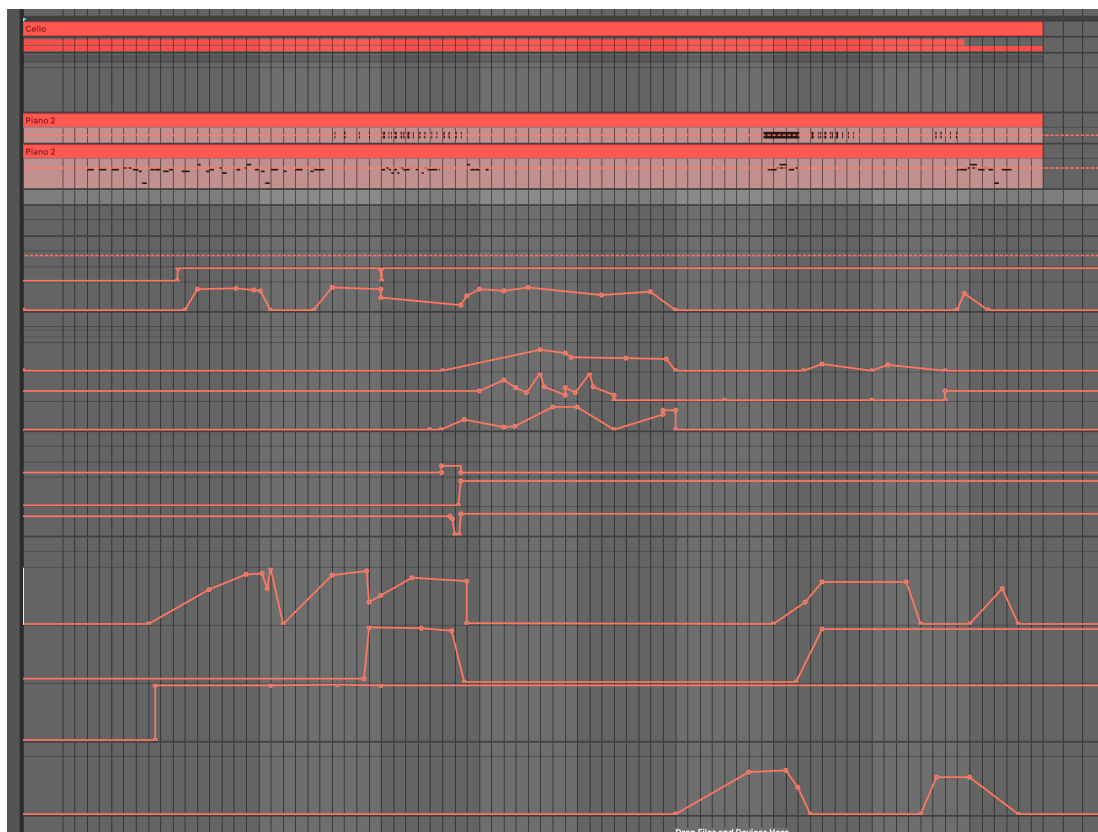


Figure 21: The layout of MIDI instrument parts and the live-input manipulation scheme.

The electronically generated sounds consist of a series of sub-bass tones and a single sine wave in a much higher register. For these elements, a traditional notation system for pitch, duration, and dynamics suffices. The real-time processing of the acoustic input is focused on the imitation and manipulation of timbre, using looping and freezing

techniques. Control over DSP²⁵ parameters takes place via both discrete and continuous variables.

The synchronicity within this performance stems from direct interplay, where precise control over dynamics is essential. For the bass notes of the synthesizer, a MIDI controller with polyphonic key pressure is used, allowing the dynamics of sustained notes to be modulated expressively. In addition, parameters such as volume and effect intensity are continuously adjusted to ensure an optimal balance with the acoustic instruments. These mappings result in an increased dynamic range and strengthen the non-verbal musical communication between the performers.

2.2.1.2 Reflections

During the first performance, I limited the hardware setup to one MIDI controller: the Launchpad X. Although the large number of programmable buttons and the presence of polyphonic key pressure seemed sufficient at first, in practice, the control over continuous parameters proved inadequate. Despite mutual communication, the balance with the acoustic instruments could not be adjusted with the desired precision. Using a row or column of eight buttons for fader functions resulted in too coarse a resolution (down-sampling) of the available 128 MIDI values. To realize the necessary dynamic refinement, I will expand the setup in the future with a MIDI fader controller or a specific controller for poly pressure.

2.2.1.3 CIP-model (Sonar)

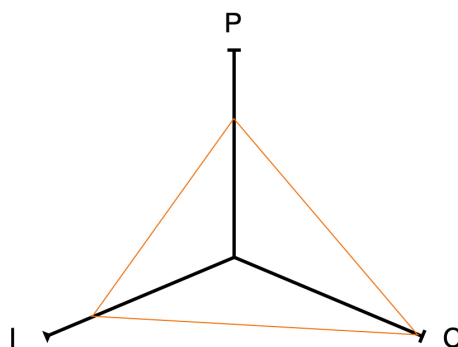


Figure 22: CIP model *Sonar*

²⁵ DSP: Digital Signal Processing

In *Sonar*, the focus shifts compared to the solo études: the complexity of the digital setup lies not in the instrument design itself, but in the underlying composition model. The emphasis is on clear notation of the dynamic interaction between instruments and the separation between sound generation and processing. This creates a communicative setup that allows for free synchronicity. This gives the performer a central role. The choice for the right interface lies largely with the performer, provided they respect the established expressive parameters. Although the instrument design is simpler than in the solo études, the composition utilizes the system's modularity to form a unique, work-specific interface.

2.2.2 MANA²⁶

Private link to *MANA* in première

For the musical substance, the instrumentation of Benjamin van Esser's **R. Aquarii** (bass clarinet and live electronics) formed the starting point, while the choreographer's own illustrations provided the visual guide. In this context, I composed the music for the first two chapters, with a specific focus on the tension between the (bass) clarinet and the electronic processing.

1. Onschuld (innocence) (*Birch Moon* - S. Indigne)

²⁶ MANA is a project by Laura Daelemans, created under the supervision of I Solisti. As the final piece of her trajectory as a young creator, she developed a solo dance performance based on the tragic life of Cathelyne Van Den Bulcke, the witch of Lier. The performance draws parallels between Cathelyne's exclusion and the position of the independent woman in today's society. More information about the project can be found on the I Solisti webpage: <https://www.isolisti.be/en/producties-blog/mana>

The fundamental role of music in this context is not only to evoke the dance but also to structurally support the choreography. Based on this insight, the composition was reworked into a rigid form with multitrack tapes (subdivided by sound type and register) and an integral click track. Although this somewhat limited the organic musicality, it provided the dance with the necessary stability.

2.2.2.2 Suspicion

Consult score 3 and the video above (7'30" - 16'17"):

Based on the findings from *Birch Moon*, *Suspicion* was based entirely on tapes and a click track. The only control the live electronics performer has is mixing the multitracks into the diffusion of the clarinet and the tapes within the space. We could say that the performer's role here is rather technical, which does not complement the musicality of the computer performance throughout the performance.

2.2.2.3 CIP-model (MANA)

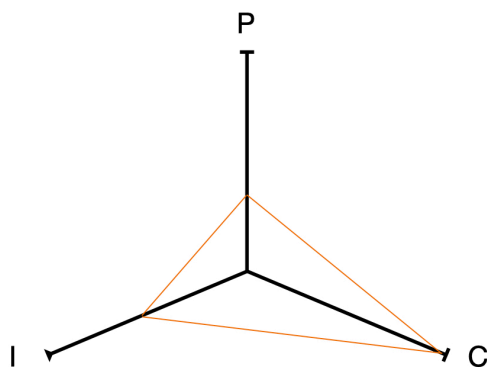


Figure 24: CIP model *Birch Moon* interactive (chamber music) version

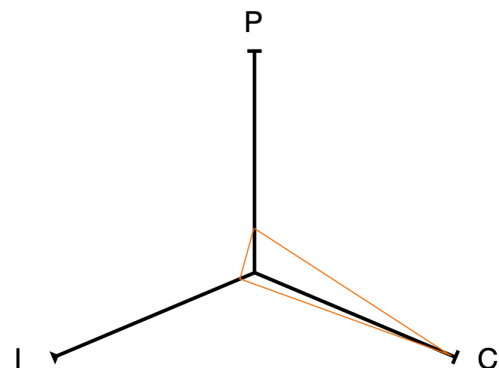


Figure 25: CIP model *Birch Moon & Suspicion* tape version

The compositions in *MANA* were largely created based on a specific commission for a dance performance. Because the music serves a purely supporting function within the concept of the show's creator, musical freedom for both instruments was limited. For the electronics, this meant concretely sacrificing certain facets of live interaction, with consequences for the inability to perceive musicality. Although these strict frameworks were necessary from the artistic primacy of the dance, this did not hinder the artistic intention of the main creator and thus the experience of the performance (Stroppa, 1999). Given the pre-determined nature of the final performance, the deployment of a live

computer performance—and thus the role of the instrument designer—proved superfluous in this context. As this was my first professional experience with a (solo) dance performance, I focused technically on the possibilities within the given framework. In such interdisciplinary collaborations, we ideally strive for a performance in which every involved artist makes a meaningful contribution. My contribution lay mainly in supporting and resonating the dance, the visualizations, and the clarinet, primarily through composition and live sound management.

2.2.3 Calciet

Consult score 4 and the performance below:

Private video of *Calciet* in *Onderwereldse Klanken* by Malatya in De Bijloke

Calciet was composed by Siebe Thijs, commissioned by Trio Malatya for the performance *Onderwereldse Klanken* at De Bijloke. The program is rooted in *musique concrète* and originated from an inspiring masterclass by pioneer Helmut Lachenmann. After the trio performed his work *Allegro Sostenuto* under Lachenmann's guidance, they were given the opportunity to curate a program at De Bijloke around three generations of composers within this style. Besides Lachenmann, the program includes work by D. Janssens, who processes piano and cello resonances into spatialized tapes (4-8 channels) into a virtuoso whole. Thijs complements this generational line with a new creation for clarinet trio and live electronics, in which the electronics are explicitly presented as an instrument on stage.

<i>Allegro sostenuto</i>	(1987)	H. Lachenmann (1935)
<i>(...nada..)</i>	(2015)	D. Janssens (1983)
<i>Calci et</i>	(2026)	S. Thijs (1999)

During preparation, I was given the opportunity to explain my vision and needs as a performer to Thijs, similar to the dialogue regarding extended techniques for acoustic instruments. As a result, not only the technical possibilities of the computer but also my performative influence formed the starting point. Building on the framework of *Etude II* and *-III* that I used for illustration, we developed an instrument design based on complex audio (ADC²⁷/DAC²⁸) routing. The composition concept and the sound material were developed entirely by Thijs himself. After consulting on the instrumental role of the computer, he drafted a score with specific instructions for the electronics performer. These directions mainly concerned the activation of sound tapes (Figure 26) and the

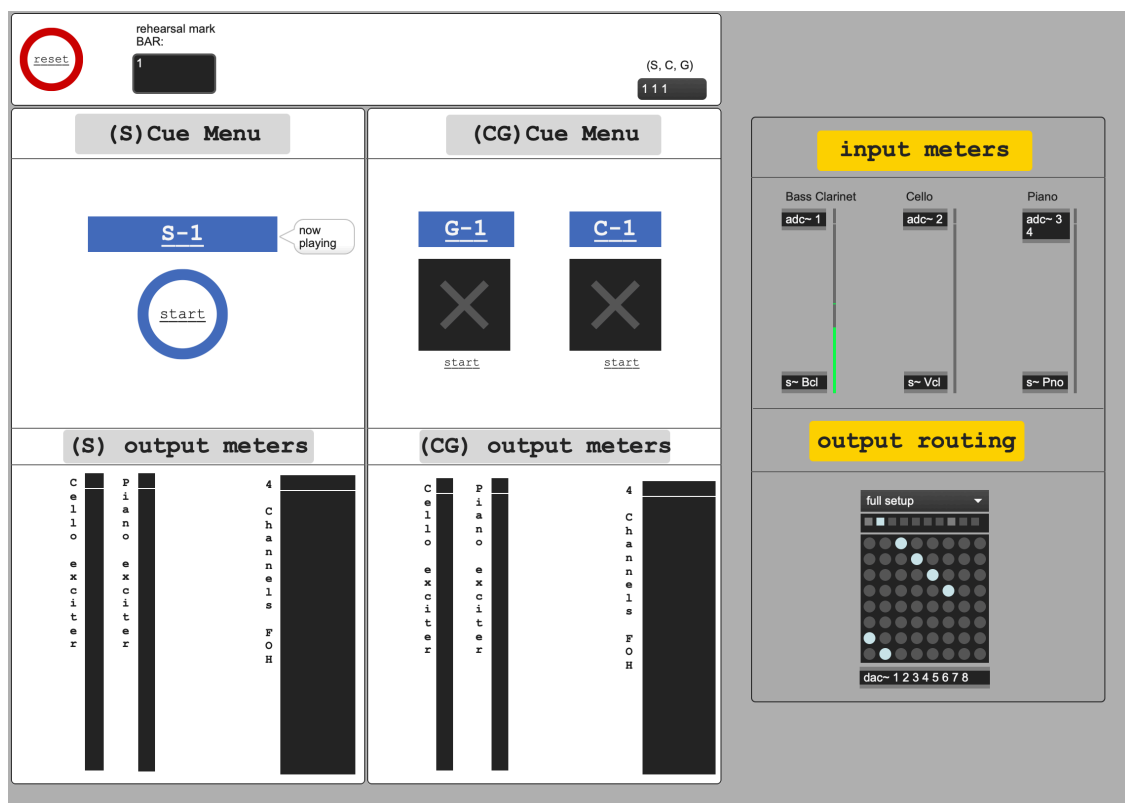


Figure 26: Max (throughput) interface *Calci et*

management and combination of the routing system for input and output processing. Sound generation starts from samples selected by the composer, with a Launchpad ser-

²⁷ ADC: Analog to Digital sound conversion

²⁸ DAC: Digital to Analog sound conversion

ving as the input device for a chronological cue system. This system manages three types of output: raw samples (S), samples combined with live amplitude following (G), and samples combined with a live input signal for ring modulation (C). Additionally, one-fourth of the Launchpad's surface functions as a matrix to route the samples and the live amplification of the acoustic instruments to the desired output channels. A crucial aspect of the design was the function of the tapes as an extension of the piano and cello soundboards. In addition to the four-channel spatial sound projection in the hall, exciters were mounted on the piano and cello. This resulted in a hybrid setup in which the interplay between analog and digital (ADC/DAC) was central.

2.2.3.1 CIP-model (Calciet)

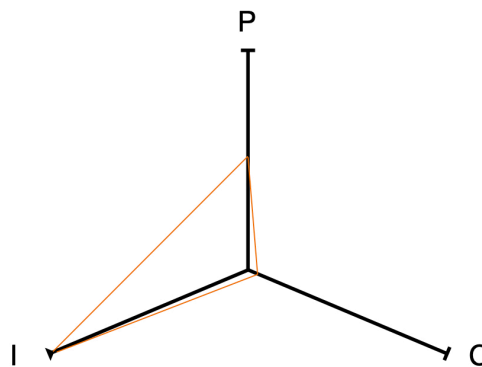


Figure 27: CIP-model *Calciet*

In this process, I originally acted as a performer, with the composition commission for clarinet trio and live electronics fulfilled by Siebe Thijs. From my artistic expertise, I conducted a constructive dialogue with the composer and was thus able to influence the technicality and musicality of the live electronics performance. This process illustrates that the developer of the computer performance may have a say, but is not necessarily responsible for the sound material. The quality and perception of the performance (liveness) here arises from the collaboration between composer and instrument designer. However, the degree of musicality remains highly dependent on the composer's technical knowledge regarding electronic sound generation. For optimal musical expression, it is essential that the computer musician is involved in electronic sound design, a role that shows strong parallels with that of a producer in studio productions.

2.3 Ensemble: Battleship in Multiple Forms

Battleship is a composition that stems from a singular concept but was transformed into different forms of performance: as an installation and as a chamber music work. I developed *Battleship* as a musical arrangement of the classic game *Battleship* (Starex, 1931) for two Launchpad players. This process is rooted in the research into "ludified music" (2016) by Marko Ciciliani. In his work, he describes how game-based structures can result in fully-fledged live electronics performances.

When an instrument designer approaches a composition from a game concept, the performer is bound to a programmed rule system. The focus shifts to completing the composition within the frameworks of the game methodology. Because game attributes—such as interactive actions that can be "right" or "wrong"—are an integral part of the instrument design, the role of the musician changes. In this context, the player is no longer the sole executive power. The instrument plays along by providing direct feedback on the operator's input, thereby co-determining the form of the performance. In programming, this translates into a structure with different levels, where progress is not purely linear: players can move up, down, or have to repeat sections based on their actions. The game is played with two Launchpads and speakers for the musical output.

2.3.1 Battleship Version One: Installation

In the installation version, *Battleship* is performed by casual passersby. Instructions on a computer screen, loaded with a Max version of the game, explain the game controls. The interface reacts with a sound to every key pressed. Furthermore, from the moment the ships are placed, the grid is read out synchronously per coordinate (key). The filling of that square (ship, missed shot & hit shot) activates sounds that provide a musical undertone. As the game progresses, musical parameters such as tempo and sound sources change to increase the tension. The players sit across from each other (without seeing each other's playing field), with a speaker between them to amplify the sound generation. As a composer and game developer, I provide elements in the installation that add a musical perception for the inexperienced (non-musical) performer. The composition and instrument design ensure a collaboration of input and output media that influence the performer's energy input.

2.3.1.1 CIP-Mmodel (Battleship - Installation)

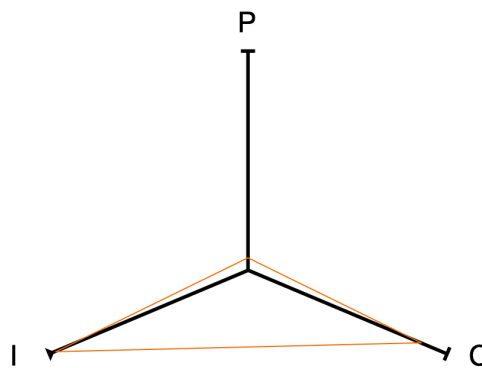


Figure 28: CIP-model *Battleship* - installation

The samples that sound during the game were pre-composed and recorded. Although the game progression is often non-linear, the musical experience remains guaranteed. The performance lies entirely with the player, regardless of their prior knowledge or skill level. Thanks to the design of the instrument, the user can only make music within the frameworks of the composition. Whether the player follows the instructions or proceeds intuitively, the musical quality remains the same. Because the interface is not designed for rehearsed performances, strict programming of the composition is necessary. Although I, as a composer and designer, did not participate in the performance myself, I judge the piece based on the observed musicality and liveness. The musicality was effectively already captured in the composition and can hardly be influenced by the performer. After all, the progress of the installation, in whatever form, is entirely dependent on the actions of the operator, which realizes the liveness. In my experience, the performance is stimulated not only by the live aspect but also by knowledge of the game concept and the dynamic between the spectator and the player (who was a spectator themselves just a short time before). The composition functions here merely as a catalyst to trigger interaction with the instrument.

2.3.2 Battleship Version Two: Chamber Music

Consult score 5

Unlike the installation, the chamber music version of *Battleship* is more than just interactive. A communicative performance takes place for the benefit of musicality. Although both musicians play the same game live, the sounds of their sequencer squares can be distinguished from each other tonally. This allows the players to locate their op-

ponent's ships by listening carefully. In addition, a bonus level is activated each time a ship is sunk. During this level, both players can fire, but a shot is only registered if they execute it exactly synchronously within a short timeframe.

2.3.2.1 CIP-model (Battleship - Chamber Music)

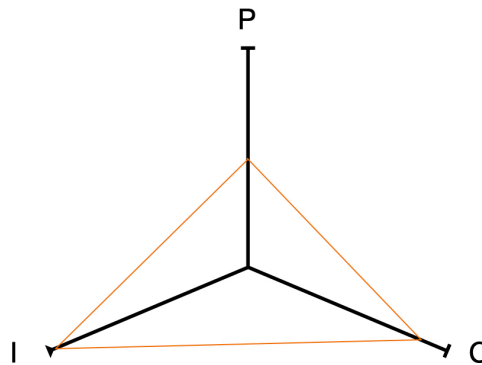
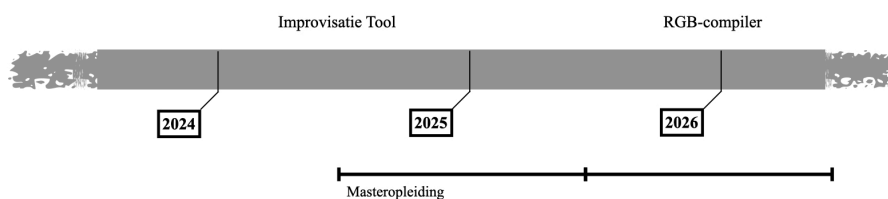


Figure 29: CIP-model *Battleship - chamber music*

In this version, the compositional progression is less strictly automated because excessive complexity would hinder auditory localization. The performers use their musical hearing to make strategic game advances, which contributes directly to musical progress. As a result, every live performance is unique. The changed compositional context has a direct influence on the performance. The development of this, as usual, has its origins in the instrument design.

2.4 Tools



The two tools discussed in this chapter do not belong to the compositions in my portfolio. They are aids that I developed within my role as an instrument designer and that offered clear added value regarding the proposed analysis model. The improvisation tool consists of building blocks for musical effect processing, partly developed by other designers, and provided valuable insights within co-creative ensemble contexts. The

RGB tool is specifically designed to simplify the control of light animations on the Launchpad X. In general, these tools function as modules within the throughput of my instrument. With these building blocks, we could come closer to a fully-fledged instrument design for a live performance that would also be flexible enough to be placed in different compositional contexts. I plan to make these tools publicly available in the near future to support other computer musicians in designing their instruments.

2.4.1 Improvisation Tool

When we perform a live performance, a composition process—whether written down or not—often precedes it. The task of a composer is primarily to provide a framework with which a performer can interpret the concept of the composition. This can arise, among other things, from co-creation or a composition commission, through which the computer musician is already involved in that process to a certain extent. The performer will then form a musical interpretation according to the context provided in that collaboration. The level of interpretive freedom, within the given context, results in different degrees of improvisation methods. For example, a micro-form of improvisation in a (classical music) performance is choosing dynamics when they are not written. A more explicit form of improvisation at the other end of the spectrum could be, for example, free improvisation from jazz culture.

In this chapter, I do not elaborate on all possible applications of the tool within improvisation or composition methods. Instead, I focus on how this tool can contribute to the development of an instrument design for compositions within various improvisation and co-creation contexts. As a performer, I understand the ideal improvisation context to be a performance in which I can make musical choices live and spontaneously, without my role as an instrument designer limiting me in that regard. The tool, therefore, stemmed from the need for an instrument design with which I could ideally step into any conceivable improvisation context without prior coordination. Although mastery of the instrument obviously remains essential, I should, in principle, be able to join in and play along without any preparation. In addition, I have deployed this improvisation tool as a compositional aid to eventually arrive at a more refined instrument design from my role as a designer. After all, in a context where the performance is the starting point, a design still precedes it.

In an acoustic ensemble, every player is primarily dependent on their instrument mastery and the sound possibilities of the instrument itself. Although this theoretically also applies to the computer, the potential sound production there is many times greater. However, the process of arriving at the appropriate or desired sound within a specific context is time-consuming and often tied to rigid parameters such as tempo and key. This makes it difficult for devices such as drum computers and synthesizers to take on a truly (inter)active role. They often function merely as a leading or supporting element according to a potentially automated (non-live) sound generation.

My tool consists of a Max patch (Figure 30) in which both internal and external sound sources can be independently routed through different effect modules. By processing live sound material in a procedural way, a timbre is created that is powerful enough to blend me in as a fully-fledged counterpart in the ensemble with other instruments. The internal sources, consisting of noise and clicks, offer a specific computer timbre that contrasts with the other instruments. Both the internal sources and the processing modules can be divided into sustained or percussive sounds. I first used an oscillator instead of noise, but quickly noticed that this worked against the tuned nature of acoustic instruments.

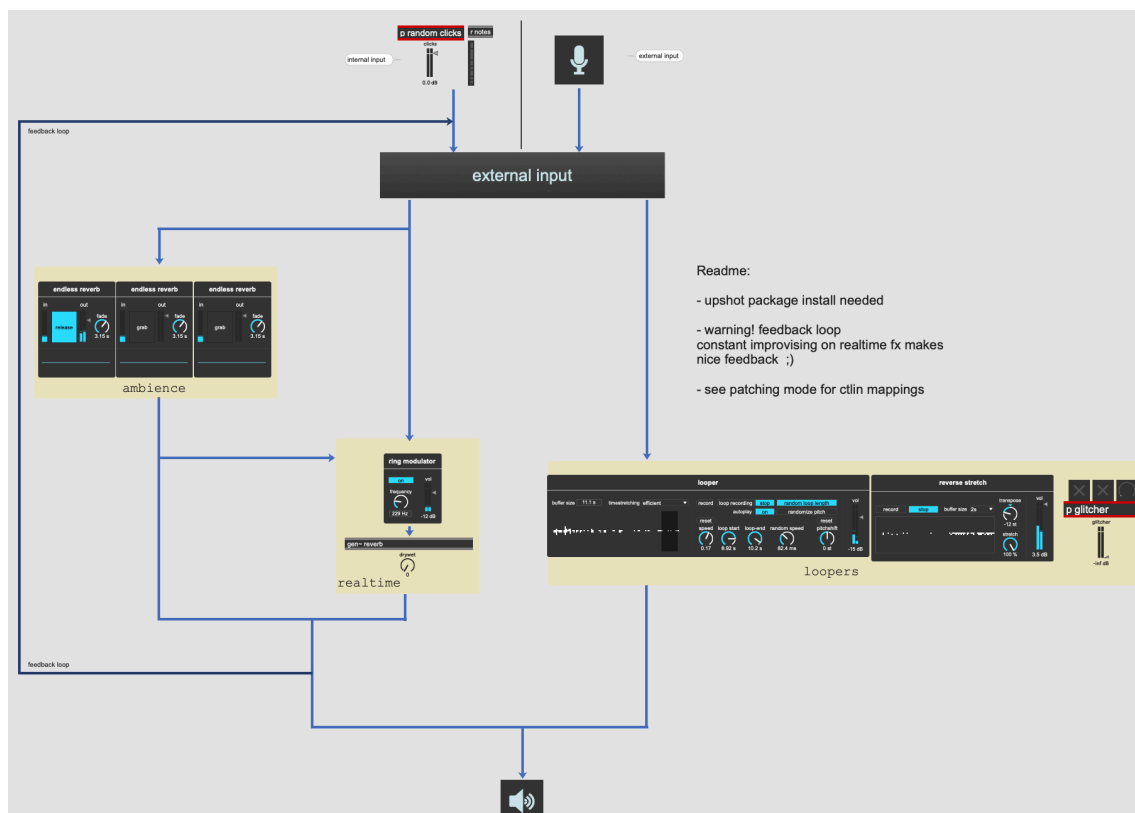


Figure 30: Improvisation Tool

2.4.1.1 In Practice

I deployed the tool for the first time during the *Metropolis* project to arrive at compositional material during the earliest phase of the creative process via improvisation with dance, theater, and music. In a later phase, during *Etude II*, I converted the modules and the routing system into a functional and visual interface in Max, combined with sound processing in Ableton.

In addition, I have repeatedly used the tool during the *Free Improvisation* course. Experiments with sound projection showed that a guitar amplifier, as a simulation of an instrument's own soundbox, yielded the most complementary results for ensemble playing. Using a PA (Public Address) system, on the other hand, often created the feeling that I was "boxing in" the ensemble. Although the guitar amplifier provided for more intimate ensemble playing, this did entail a loss of sound quality. A speaker that both maintains audio quality and projects the sound locally would be a better option for the future.

I have also deployed a similar patch for free improvisation in various collaborations. For example, I played with it during the opening ceremony of the Erasmus Brussels University of Applied Sciences (EhB) with cellist Benjamin Glorieux, and during the two-week *Metropolis* workshop (see *Etude II*) by Muziektheater Transparant. For the EhB ceremony, Glorieux used themes from the work of François Servais as source material, which resulted in a structured, improvised reworking.

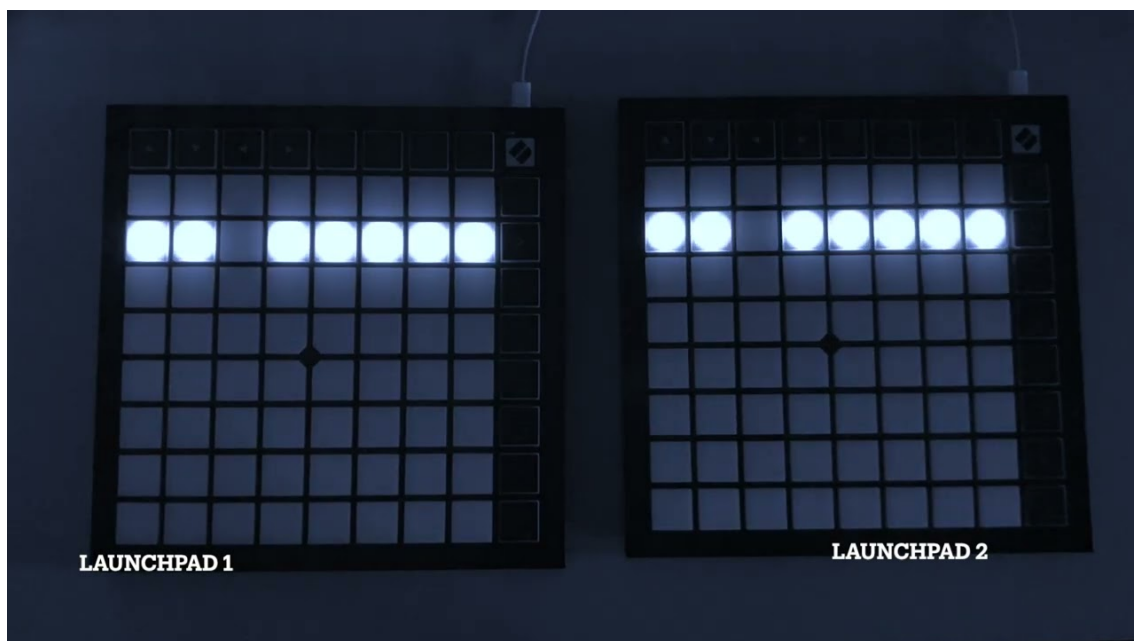


Figure 31: photo performance Erasmushogeschool Brussel opening ceremony September 2025.

2.4.2 RGB-compiler

Consult the demonstration video below:

I developed the RGB Compiler to refine and scale light-controlled expressions communicated via MIDI 2.0. By way of illustration: where **Etude III** initially made use of standard MIDI data—distributing 128 values across a limited palette of colors and brightness levels—this module unlocks the full potential of the Launchpad via System Exclusive (SysEx) communication.



Demonstration video: RGB Compiler compared to standard LED communication via MIDI: <https://youtu.be/buxiU-3lL2Q>

Although SysEx communication is typically used for system changes, within the Launchpad architecture, it offers the possibility to communicate RGB and brightness values (r, g, b, α) for all LED buttons in a single data string. Even though this quintuples the amount of data per button, a correct organization of these data streams results in significant efficiency gains. MIDI events or voice allocation are communicated according to a specific sequence per changing voice (contrary to SysEx communication) (Figure 32). This creates a data string that must be processed for every light button.

The power of the RGB Compiler therefore lies in bundling data. By utilizing the maximum capacity of the event data string, the processing system needs to handle fewer

individual messages. This optimization is crucial for hardware stability. Experiences from *Etude II* showed that inefficient communication—often caused by constant audio signals or reading complex matrices for visualizations (jitter) within the MIDI event protocol at too high a speed—can overload the Launchpad's processor. In such cases, errors occur, such as data loss or system crashes. In practice, this means the device may skip information, leading to incorrect visual feedback, or the Launchpad may block completely and stop processing new input. By using the RGB Compiler, the data stream is streamlined and communicated at a constant interval, ensuring responsiveness and accuracy even during complex, detailed lighting control.

I designed two different compilers: one that provides SysEx communication from the input of a classic MAX matrix, and a second that reads out Jitter visualizations.

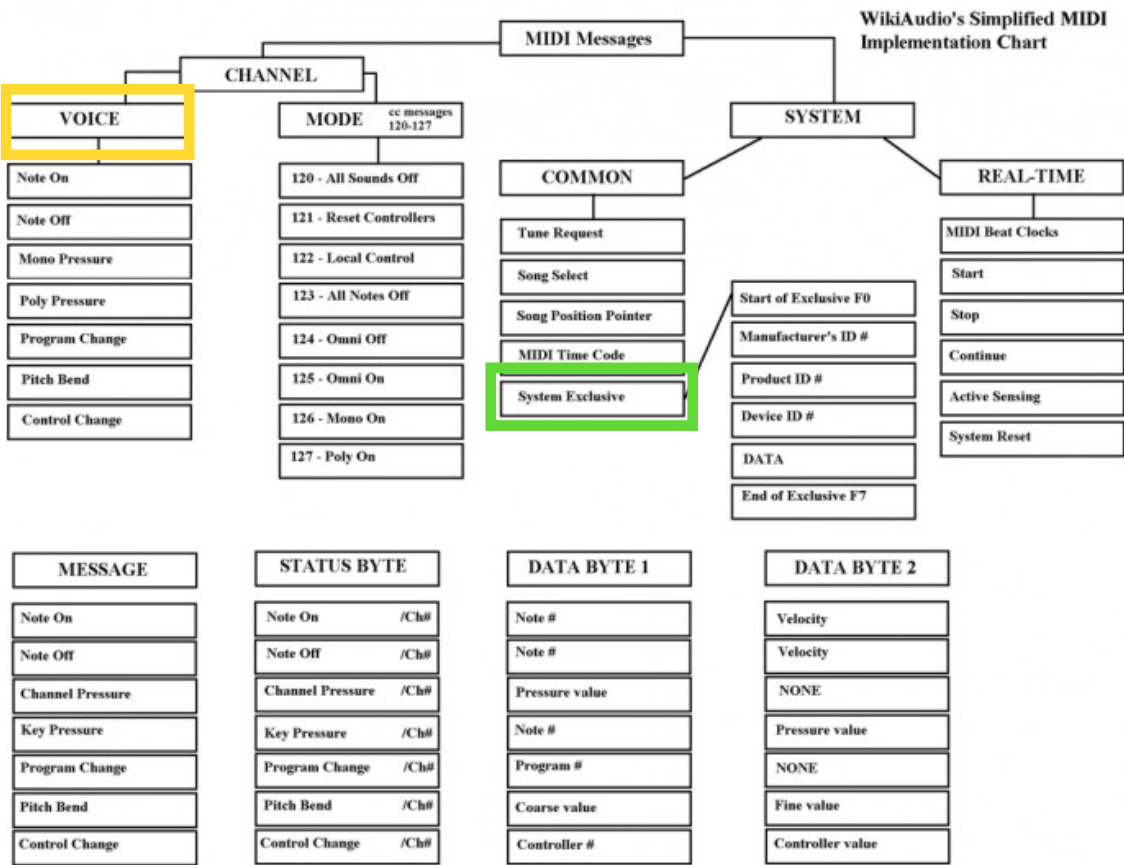


Figure 32: MIDI message types overview shared by WikiAudio on the official MIDI Association platform, <https://midi.org/audio-wiki-midi-message-diagram>



Chapter 3: Reloading / Recharging

In dutch both meanings fit one word.

3.1 Conclusion

This research shows that the practice of the computer musician lies at the intersection of programming and artistic conception. Within this dynamic, instrument design functions as the crucial bridge between composition and performance. When the computer musician shapes both the instrument and the music, a high degree of artistic control arises. However, in the context of repertoire work, or in collaborations where the computer musician is not the composer, this design takes on a different dimension. The lack of standardized electronic setups forces the performer to rethink the setup. Moreover, because technical expertise among composers often appears limited, the role of the computer musician in practice shifts from a purely technical advisor to a (co-)developer of a performance-oriented instrumentarium.

Driven by contemporary technological developments, the virtuoso instrument designer (Magnusson, 2010) focuses on programming tools that stimulate sensory experience factors (Roads, 1996). This research makes it clear that different media and disciplines lead to divergent perceptions of liveness and musicality. Although the choice between an abstract or concrete performance remains an artistic freedom, ensuring classical performance techniques within a computer setup appears to lead to greater appreciation of the artistic contribution, especially in compositions that lean heavily on liveness and musicality.

At the same time, practice shows that liveness and musicality are idiosyncratic parameters that can strengthen one another, but can also work against each other. For example, when the compositional aesthetic does not allow for traditional musicality (as in *Suspicion*), liveness may become superfluous. Conversely, in an inherently live work such as *Battleship*, the perception of musicality can only be increased by adding performers who interact with the instrument in a sound-driven way. Although musicality remains an abstract concept in academic literature, it is measurable through audience perception, where the listener judges the craftsmanship of the musician and their mastery of the instrument.

Ultimately, this research demonstrates that the artistic contribution of the computer performer cannot be seen apart from instrument design. This threshold value forms a target point for bringing design and performance closer together. The experiences in

developing tools for performers and instruments for composers therefore culminate in a relevant question for follow-up research:

While creating the études, I focused mainly on the visual aspects of instrument design that increase musicality and liveness. As an extension of these case studies, I now want to shift the focus to the various form factors of sound reinforcement (sonic feedback). I will investigate how these factors influence the live experience and the musicality of a computer performance. To what extent can, for example, a simplified approach to sound reinforcement contribute to deeper musical relationships within multimedia live performances?

Furthermore, I will continue to develop tools that not only simplify the design process of my instruments but also complement their musicality and liveness. The RGB Compiler is an example of a first step in this. This tool sharpens visual animations on the Launchpad and simplifies the development process. This can improve mutual communication between instrumentalists and interaction with the audience, and additionally serve as a resource for other computer musicians.

3.2 Portfolio

For questions regarding, or requests for access to, scores or other documents concerning the portfolio, please contact: info@seppeindigne.com

3.3.1 Own works & co-creations

<i>Birch Moon - MANA</i>	L. Daelemans, I Solisti	2025
<i>Calciët</i>	S. Thijs, Trio Malatya, De Bijloke	2026
<i>Etude I</i>		2024
<i>Etude II</i>		2024
<i>Etude II - Metropolis</i>	Muziektheater Transparant	2025
<i>Etude III</i>		2025
<i>Jit.Gen Etude</i>		2023
<i>Sonar</i>		2025
<i>Suspicion - MANA</i>	L. Daelemans, I Solisti	2025
<i>Zeeslag - installatie</i>		2025
<i>Zeeslag - kamermuziek</i>		2026

3.2.2 Repertoire

	<i>Componist + instrumentontwerper</i>	
<i>Cardiophonie</i>	H. Holliger, (IRCAM ²⁹)	1971
<i>Coalsesce 4</i>	B. Van Esser	2016
<i>Laconisme de l'Aille</i>	K. Saariaho, (IRCAM)	1982
<i>(...nada.)</i>	D. Janssens, (CHP ³⁰)	2015
<i>Play By the Rules</i>	H. Akbulut	2024
<i>Revelations</i>	W. Henderickx, (Jorrit Tamminga)	2017
<i>...Sofferte Onde Serene...</i>	L. Nono (SWR-Studio Freiburg)	1976
<i>Solo</i>	K. Stockhausen, (IRCAM)	1966
<i>Talia</i>	M. V. Agresti	2024

²⁹ IRCAM: Institute for Research and Coordination in Acoustics/Music

³⁰ CHP: Centre Henri Pousseur, Center of research, realization and diffusion of electronic music works and especially of mixed music

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