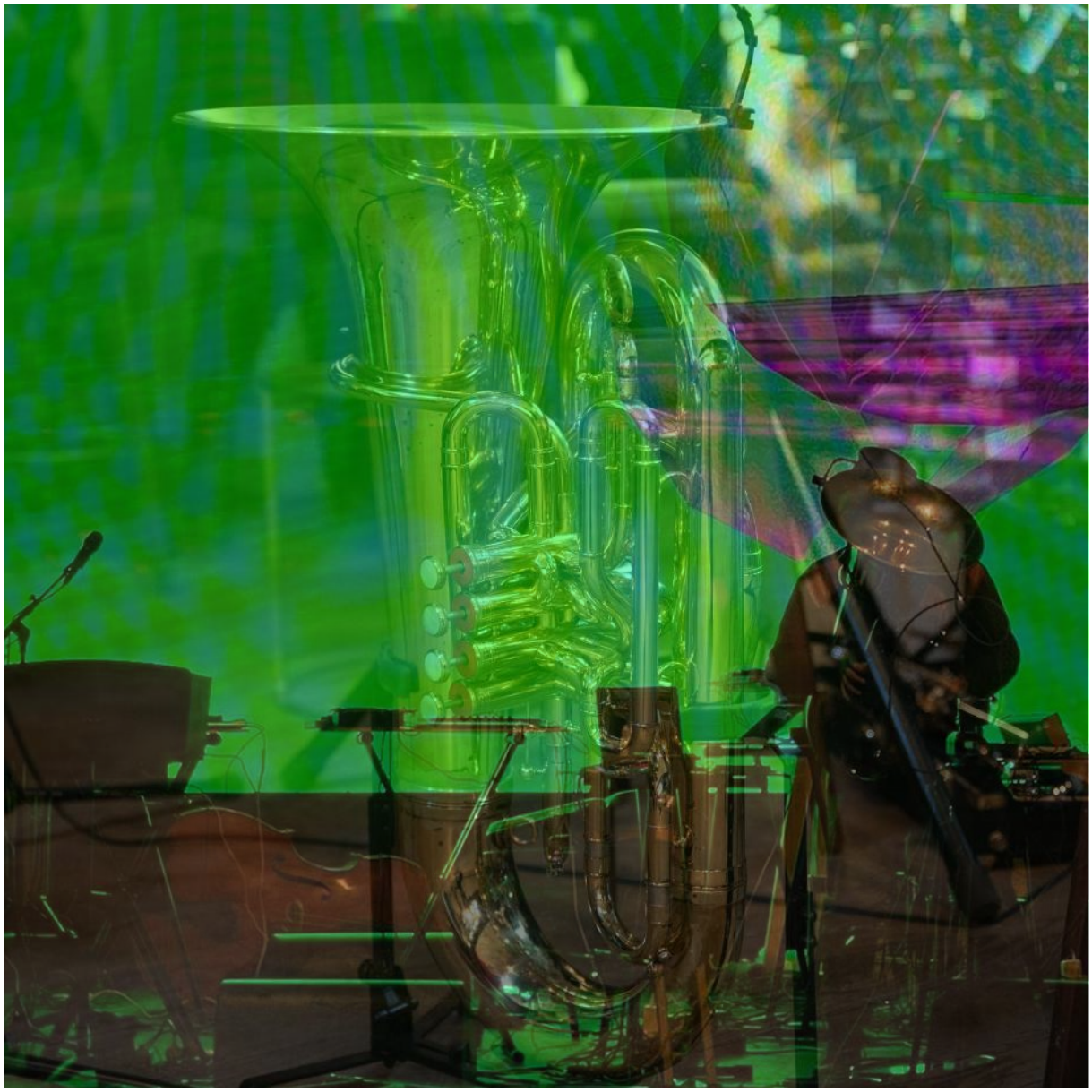
TUBA + LIVE ELECTRONICS

Past and Possibilities



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ABSTRACT

The tuba is a relatively new instrument with unique qualities, such as its harmonically rich large audible sound and wide dynamic range. Over time, various extended techniques and preparations for the instrument have been developed, and new possibilities for the tuba continue to be explored today. Similarly, live electronics, as we know it, was consolidated in the early 1960s and continues to evolve thanks to technological advancements. Given the limited amount of information and repertoire for tuba and live electronics, this is a topic worth studying from multiple perspectives. In particular, the creation of new repertoire and the technical challenges that a tuba player might face when combining tuba with live electronics are important areas to address. Through this work, I offer my own perspective and present the solutions I've discovered, to anyone interested in this largely unexplored field.

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PREFACE

My first encounter with Live Electronics was in 2019, when I performed *Post-praeludium per Donau No. 1* by Luigi Nono. I fell in love with the unpredictability of the piece, the freedom given to the performer to be part of the compositional process in real-time, and the challenge of interacting with seemingly random outcomes. The sounds created by long delays, unnatural reverberations, and microtonal "accidents" – intentionally planned by the composer to anticipate random possibilities – fascinated me. This initial experience sparked my curiosity, leading me to explore and research more, albeit in a casual manner at first. It wasn't until three years later, after searching unsuccessfully for pieces that could recreate that experience, that I decided to fully immerse myself in the world of Live Electronics.

The tuba is an instrument with a strong presence and is highly cherished in traditional Mexican music. However, I did not have a close connection with the musical traditions of my country. I first encountered the instrument by chance at the age of 13. My early exposure and initial years of training were entirely academic, and everything I discovered about the tuba was new to me, which fueled my curiosity and deepened my interest. Over the years, through practice and study, I have developed a deep fascination with the instrument's sound qualities.

Around 2004, I stumbled upon a score in a music store, tucked away in a somewhat dusty corner: *Cadenza VI by Henri Lazarof*. Cadenza VI is a piece for Tuba & Tape, featuring extended techniques, complex rhythms, and a score without traditional measures. It included lines and symbols that indicated things I didn't yet understand. From that moment on, I became determined to explore the possibilities of the instrument. This journey led me through various disciplines–performance, theater, and multidisciplinary and transdisciplinary approaches–until I eventually arrived at electronics. In 2018, I focused on my own project,

Tuba+Electronics, where I collected material until I encountered the work *Post-prae-ludium per Donau No. 1*, mentioned earlier in this preface. It was through this piece that my genuine interest in live electronics began.

INTRODUCTION

The world of Live Electronics is vast, especially when combined with an acoustic instrument like the tuba. It is difficult to predict the evolution and potential of this combination, as it depends on many factors. These include elements such as creativity, technique, and technology, all contributed by the composer, programmer, and performer. In some cases, all these roles are taken on by the same person, which can lead to new aesthetic experiences that have yet to be explored.

When I began searching for pieces, the seemingly infinite possibilities I expected to find on the Internet turned out to be rather limited, eventually leading me to just a handful of names. In the end, I only found pieces for fixed media, which felt similar to playing with something lacking the spontaneity and vitality provided by real-time processing.

It is at this moment that the main question is addressed:

What is the landscape of the tuba and live electronics in the past, present and future?

While gathering information, I noticed a significant issue: there are currently fewer than 20 works written for tuba and live electronics. With this in mind, I concluded that preserving and disseminating these existing works is crucial. Equally important is the promotion and creation of new pieces, given the limited repertoire available.

Chapter 1 examines the historical context of both the tuba and live electronics. It discusses the perception of the tuba during the emergence of the first works for

this combination in the 1980s and traces the evolution of live electronics during that period.

Chapter 2 presents the compiled works and offers a brief overview of the evolution of live electronics in both Europe and the Americas, based on the available information.

Chapter 3 builds directly on the findings from the previous chapter by addressing the scarcity of repertoire. In this section of the research, I focused on exploring a new generation of repertoire and identifying composers interested in working with live electronics. This involved hosting a workshop in collaboration with Anachrony Academy (members of the Contemporary Expressions Festival, held in Mexico), which led to the creation of compositions by two different composers, three of my own compositions designed as reactive instruments for the tuba, and a summary of the challenges encountered when integrating the tuba with electronics in real-time performance, along with the solutions I developed.

Chapter 4 delves into two proposed solutions I developed to address the integration challenges between the tuba and live electronics discussed in the third chapter. First, I examine various microphone placement options, exploring their potential benefits and drawbacks. Second, I discuss the implementation of a suitable device designed to facilitate the simultaneous performance of the tuba and live electronics in a comfortable manner for the performer.

CHAPTER I

HISTORICAL CONTEXT

"The first use of the term 'Live Electronics' dates back to the 1930s with Electroacoustic Improvisation (EAI)."[1] However, as Nick Collins notes, "the use of live electronics as a means of sound processing truly emerged with the creation of portable magnetic tape, which was finally marketed at the end of World War II. The major transition from electronic studio techniques to real-time sound synthesis occurred in Europe throughout the 1950s and early 1960s."[2] In 1964, Karlheinz Stockhausen began an intense period of experimentation that revolutionized live electronics. "Stockhausen's innovation was to introduce electronic transformation through filtering, which blurred the distinction between instrumental and electronic music."[3] Personally, I consider that this discipline continues to evolve and is worth exploring its capabilities for its future development.

1.1 The Tuba.

"The tuba is a relatively new instrument that began in military bands in Prussia, replacing the ophicleide due to its qualities … It was Berlioz who made the tuba known as part of the orchestra thanks to his tours … later Wagner gave it the most popularity thanks to his work *The Mastersingers of Nuremberg*".[4]

[1] Schrader, Barry (1991). "Live/Electro-Acoustic Music: A Perspective from History and California," in Live Electronics, edited by Peter Nelson, Stephen Montague, and Gary Montague.

[2] Nick Collins. "Live Electronic Music." In The Cambridge Companion to Electronic Music, edited by Nick Collins and Julio d'Escriván, pp. 38–54. 2007.

[3] Richard Toop. Karlheinz Stockhausen. In Music of the Twentieth-Century Avant-Garde: A Biocritical Sourcebook, edited by Larry Sitsky, p. 493–499, 2002.

[4] George Dalton. The History and Development of the Tuba, p. 18, 20, 21, 28.

Arnold Jacobs was one of the first tuba players to begin performing concertos originally written for other instruments on the tuba. By the 1980s, the tuba started to gain recognition as a solo instrument. “Roger Bobo was the first tuba virtuoso to perform at Carnegie Hall, sparking the interest of many composers and the creation of more than 50 works written and dedicated to himself. ”[5]

The tuba, considered a solo instrument only relatively recently, has been explored for its wide dynamic range, extensive harmonic possibilities, and intriguing extended techniques. These techniques, due to the instrument's qualities, produce distinctive and harmonically rich sounds that can provide unique material in live music. Examples of extended techniques include multiphonics achieved through vocalization or sound manipulation, percussive effects through various processes, and techniques such as growling and ingressive buzz, which became popular towards the end of the last century. These techniques are well documented in *The Composer's Guide to the Tuba*, which offers sound examples and detailed explanations. A link to the guide is available in the sources.

1.2 Tuba & Live Electronics.

It was not until the 80's when the tuba began to be explored with the use of live electronics, first with the American composer Morton Subotnick with an experimental work and later with the Italian composer Luigi Nono, this being the most representative work to date written for tuba and Live Electronics, where in the

[5] *IJM. “International Journey of Music”. 31 Important Dates in the Life of Roger Bobo (2021), Retrieve from https://ijm.education/winds/brass/tuba/roger-bobo/*

words of the composer: “The compositional course is fixed in its details, while the notation is thought of as a trace for the performer…” [6]

It is important to keep in mind that at this time in history, the tuba had little exploration as a solo instrument and most composers did not consider it seriously, but rather as an instrument that could be played with because of its deep and quite dynamic range rather than to compose in a more melodic character. Therefore, many works from the early period of live electronics may seem like works full of effects and only created for reasons of experimentation and exploration for the capabilities of live electronics, rather than for the tuba itself.

With the work of Morton Subotnick (considered the first work for tuba and live electronics) this is clearly visible since at that time he was exploring a device that he developed named *ghost box*, whose mechanism worked based on voltage loads in real time. In the words of Subotnick “an electronic device consisting of a pitch and envelope follower for a live signal with an amplifier, frequency shifter and ring modulator.”[7]

The third work created for tuba and live electronics, composed by Luigi Nono, is a very innovative work in which he explores and pushes the capabilities of the tuba player to the limit in terms of dynamics and register. Giving freedom to the tuba player to be a performer and composer at the same time. Also exploring the use of live electronics in terms of space, sound and the resources that were available until that period of time, such as the way to use simple elements such as delays.

[6] *Luigi Nono. Writings and interviews, edited by A.I. De Benedictis and V. Rizzardi, Ricordi-LIM («Le Sfere», 35), Milan 2001, vol. I, p. 505*

[7] *Computer Music Journal, Published By: The MIT Press, Vol. 12, No. 1 (Spring, 1988), pp. 9-18*

Nevertheless, Luigi Nono's period of experimentation with live electronics consolidated this new use of technology in music.

The repertoire for tuba and live electronics has developed over periods of 7, 8, or even 10 years between works, allowing new composers to briefly explore this combination. The repertoire evolved from experimental pieces to works that more fully consider the instrument's capabilities. There is a clear division between the works composed on the American continent and those composed in Europe. Works from the American continent often incorporate pedals, loops, and extensive improvisation by the performer. In contrast, European works tend to focus more on technique, sound quality, amplitude, and other aspects, which I will discuss in more detail in the next chapter.

CHAPTER 2
THE CATALOGUE PERIOD

Upon discovering the lack of material, several questions arose. However, I decided to focus on the most fundamental one that a classical musician in my situation would ask: What are the current pieces for tuba and live electronics?

2.1 The catalogue.

At the outset of this research, I expected to find pieces suitable for performance with this instrumentation relatively easily. However, I soon discovered that this was not the case. In reality, there is a scarcity of existing pieces, and even when they do exist, there is often a lack of readily available information about them. Despite using various resources, such as consulting composers, referring to repertoire guides for the tuba, and searching through forums and websites, I found no clear references on where to access these works. Recognizing the importance of disseminating these compositions and encouraging their performance, I realized the need to create my own catalog to promote the preservation and performance of these works.

I found a total of 17 works written for tuba and live electronics. Two of them are available through the composer or through a tuba player, seven can be available at an editorial or through the composer's website and unfortunately eight of them have not information available in order to acquire them. The works are:

1. *The First Dream of Light* composed by Morton Subotnick. 1980
2. *Collage 3* composed by Kenton Bales. 1985
3. *Post-prae-ludium No.1 per Donau* composed by Luigi Nono. 1987

4. *Still* composed by Jonathan Harvey. 1997

5. *Work for Tuba and Live Electronics* composed by Ricardo Sezudo. 2002

6. *Animus III* composed by Luca Francesconi. 2008

7. *Für Tuba mit Hege*l composed by George Katzer. 2008

8. *Music for Tuba and Computer* composed by Cort Lippe. 2008

9. *Death Be Not Proud* composed by Melvyn Moore. 2008

10. *Sonnet X* composed by Valerio Sannicandro. 2008

11. *Wouldn't Need You* composed composed by Nicholas Deyoe. 2011

12. *Si!* Composed composed by Karlheinz Essl. 2012

13. *Hindsight* composed by Ariane Miyasaki. 2014

14. *Perpetuum Mobile* composed by Mark Zander. 2014

15. *Colossus* composed by Monte Weber. 2014

16. *Breathe* composed by Fulton Ruby. 2015

17. *Alone on Repeat* composed by Douglas McCausland. 2016

* Refer to *Appendix A* for more information about the works, including websites where you can order them if available.

Regarding the works, as mentioned in the previous chapter, the tuba was initially used to experiment with effects and sounds that other instruments could not reproduce. This approach was more about experimentation between the composer and the tuba player rather than viewing the tuba as a melodic instrument.

Subsequently, Luigi Nono composed *Post-prae-ludium No. 1 per Donau*, a piece that not only defines the tuba as an instrument with great potential for live electronics but also represents a period in which Nono consolidates his compositional style for live electronics. At the same time, this work lays the groundwork for the emerging genre of live electronics in Europe.

Unfortunately, it took 10 years for another composition for tuba and live electronics to emerge. This was Jonathan Harvey's *Still*, composed in 1997, where the main idea is for the soloist to improvise over a series of eight chords. At this point, a pattern becomes evident: the improvisation of the tuba player becomes increasingly frequent, and the concepts of looping and amplification start to be widely utilized on the American continent.

While in Europe, thanks to Luigi Nono, there is a serious study of spatialization and the use of live electronics, not only for the tuba but for the genre as a whole, in America, live electronics often focus on creating effects through the use of pedals and free improvisation.

Again, the production of works for tuba and live electronics was minimal until 2008, when five new works were created. This surge was largely due to the request of tuba player Melvyn Poore. Interestingly, one of these works, *Music for Tuba and Computer* by Cort Lippe, is among the most current in terms of technology used for live electronics. Although it was requested by Poore, it was also commissioned by the Zentrum für Kunst und Medientechnologie (ZKM). This work could be considered one of the two most significant contributions to the repertoire of tuba and live electronics, as it views the tuba as a melodic instrument while also addressing the instrument's sound and technical qualities. It utilizes all available information from the performer to manipulate the sound generated by the computer in real time through algorithms, making it a 'reactive' work.

Cort Lippe makes his catalogue of works available for free download and interpretation to any interested performer through his website.

Following this series of compositions, some years passed again before the production of new repertoire, in this case, predominantly from the Americas. On one hand, works such as those of Ariane Miyazaki, Nicholas Deyoe, Mark Zanter,

Monte Weber, and Fulton Ruby are more improvisational in nature but using loops or sound sequences. On the other hand, works by Karlheinz Essl and the most recently composed work for tuba and live electronics in 2016 by Douglas McCausland seek to exploit the qualities of the tuba and create a dialogue that is partly interactive and partly very characteristic within the compositional style of both composers.

Two key works in the study of Live Electronics that helped define the future of this genre, which are not for solo tuba but for ensemble and live electronics are from the composer Luigi Nono.

In both works the tuba take part, however Nono studied the spatialization, the psychological effect of the positioning of the microphones as well as the evolution of new techniques he was developing. These works are:

1. *Guai ai gelidi Mostri* composed by Luigi Nono. 1983
2. *Risonanze Erranti* composed by Luigi Nono. 1985 - 1987

* Refer to *Appendix B* for more information about the works.

Noticeable, this works were written before *Post-prae-ludium per Donau No. 1* and the spatialization techniques developed here, were reflected on this particular solo piece.

After compiling this catalogue of works, I reached out to tuba players and composers to access their compositions. For tuba players, I sought to uncover any repertoire that may have been previously unknown.

When examining the performed works, it becomes evident that there are two main tuba performers who have explored Live Electronics: Melvyn Poore (currently inactive as a soloist) and Aaron Hynds, who has primarily performed pieces created for fixed media. Additionally, performers like Sergio Carolino utilize pedalboards and looping in improvisations, while Oren Marshall employs live processing for tuba with pedalboards and other techniques.

After conducting a search for the aforementioned repertoire, it became apparent that for many of these works, obtaining the score or a guide for the creation of the live electronics was not possible. Composer Douglas McCausland provided the score but not the live electronics material, which was created using now-obsolete software with no plans for translation into current software. Conversely, composer Cort Lippe offers his material for download on his website, compatible with current software.

During the compilation of the catalog, several challenges emerged:

- Difficulty in locating scores for certain works.
- Limited availability of a dissemination network for discovering new compositions.
- Obsolescence of technology utilized in many works.
- Preference among composers for fixed media over live electronics.

2.2 Technologic restauration.

Two examples of technological obsolescence are Nono and Essl, works that were made for certain technologies that we do not have right now. However, thanks to very precise instructions from the composers, I took on the task of making a restoration of the technological needs for Luigi Nono's piece. While trying to

respect the original material, the randomness of the electronics that the composer desired, I also took advantage of new technologies to make a completely autonomous patch without the need for an operator. Likewise, the restoration corresponding to composer Karlheinz Essl is already in process.

REGIA DEL SUONO

0' – 5'20''	Schema I (PGM 1) La regolazione dell'entrata e dell'uscita dei delays si effettua di quando in quando in modo indipendente e non determinato, aprendo e chiudendo l'entrata e l'uscita dei delays con maggior o minor rapidità. Vedere inoltre le spiegazioni unite (pagina A dell'autografo). Da 4'30'' circa aumentare il feedback dei delays fino al 100% circa.	*0' – 5'20''*
5'20'' – 7'00''	Schema II (PGM 2) Diminuire gradatamente a zero il feedback e l'uscita dei delays.	*5'20'' – 7'00''*
7'00'' – 7'53''	Schema III (PGM 3)	*7'00'' – 7'53''*
7'53''– 10'00''	Schema IV (PGM 4)	*7'53'' – 10'00''*
10'00''– 10'55''	Schema I (PGM 1) Aumentare gradatamente l'amplificazione del tuba, il livello di uscita e il feedback sui delays fino a 90% circa.	*10'00'' – 10'55''*
10'55'' – 11'12''	Livello massimo di amplificazione, feedback 100%.	*10'55'' – 11'12''*
11'12'' – 12'15''	Chiudere subito l'ingresso e diminuire gradatamente a zero il livello di uscita dei delays.	*11'12'' – 12'15''*
12'15''– fine	Diminuire gradatamente a zero il livello generale di amplificazione.	*12'15'' – end*

Figure 1. Luigi Nono - Post-prae-ludium per Donau No.1

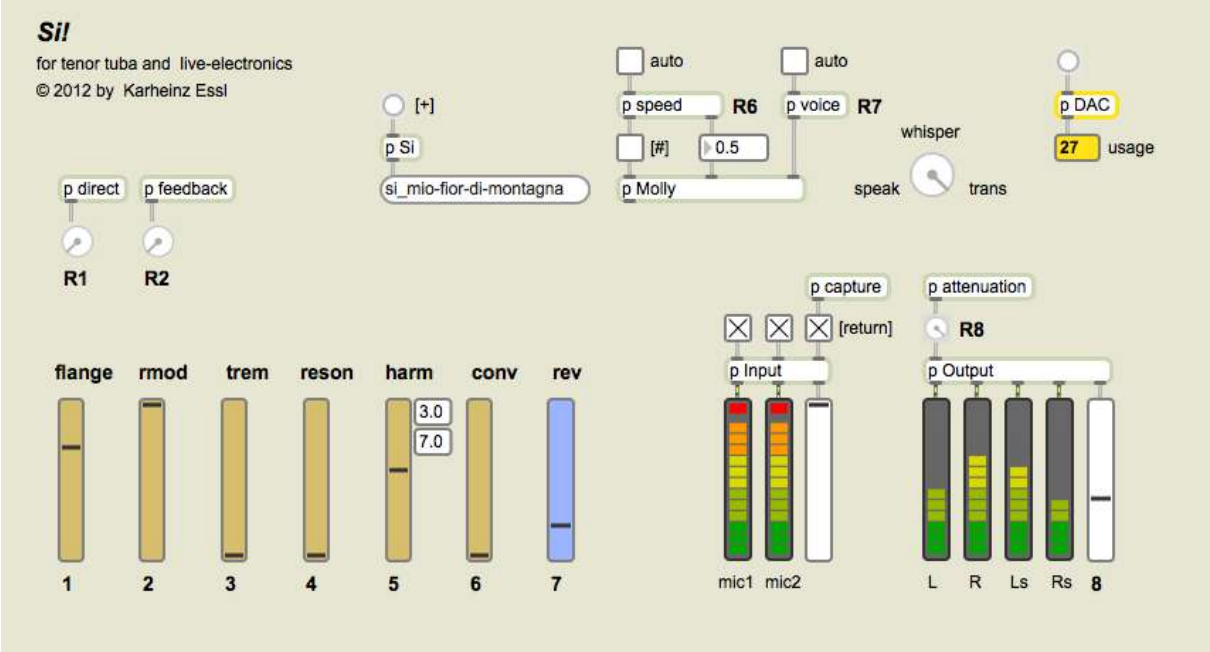

Figure 2. Karlheinz Essl - Si!

Unfortunately, there is not much documentation regarding what the other works intended with live electronics and in some cases there are no scores either since they were in a way the product of experimentation and development of the unexplored capabilities of the tuba by the composers under the creation of effects.

In the following chapter, I discuss how actively generating repertoire and experimentation firsthand with live electronics provided a more effective solution.

CHAPTER 3
NEW REPERTOIRE

Due to the issues discussed in the previous chapter and new insights gained from exploring live electronics—such as rapid technological advancements and evolving musical tastes—I became more open to discovering new sonic possibilities. The aesthetics of a piece composed 30 years ago are not the same as those of a work written today. Composers explore the possibilities and characteristics of the technology available to them at their time. Recognizing the importance of both promoting and creating new repertoire, as well as preserving existing works.

To achieve this, I devised a two-step action plan:

1. Generate new repertoire that embraces new possibilities and ventures into the unknown, as any experimental process would.
2. Continue collecting and preserving existing repertoire, including works that require technological restoration. This will allow me to understand the evolution of live electronics in relation to the tuba, which was a largely unexplored instrument at the time.

3.1 Commissions.

By reaching out to composers, it became clear that a significant number of these were not very familiar with live electronics, while others did not find it appealing due to their aesthetic or compositional preferences. This unfamiliarity led some to question why they should create a work involving live processing.

For this reason, it is essential to actively promote the field by collaborating with composers and performing their works, as well as engaging with more performers to build a community that fosters greater interest in this musical format.

It is also important to mention that, currently within the Live Electronics Department, thanks to the genuine and independent interest of colleagues, intriguing pieces for ensemble and electronics featuring the tuba are being created. My focus is on compiling and preserving these works.

I contacted several composer colleagues from the CvA and in Mexico through the

organizers of the International Contemporary Expressions Festival. This led to an opportunity to collaborate on a course whose main objective was to explore the capabilities of the tuba, along with an introduction to Max/MSP. The course, held in September 2023, was part of a promotional strategy to encourage tuba

composition and live electronics. During the course, I worked with the composers on the live electronics aspect.

As a result, three pieces can be added:

1. *Particle Construct* by composer Lauren McCall. 2024.
2. *O Czasie, Twe Piramidy* by composer Philip Przybyło. 2024.
3. *Seiltänzer* by composer Cesar Vidal. 2024

**For more information about the composers you can refer to the List Of Sources.*

From this first course, I realized that my experience as a tuba performer, but more importantly as a live electronics performer, provided composers with valuable insights on how to use technology to generate new pieces.

3.2 Own compositions.

Driven by curiosity, I have sought to generate my own repertoire for experimentation, which has provided me with valuable technical and artistic experience in implementing these tools as a performer. Developing three works for tuba and electronics, in which the electronics are fully autonomous and responsive, allowing the performer to focus entirely on the music—a beautiful philosophy learned at this institution. These works have been performed last year at the Conservatorium van Amsterdam's Live Electronics Department concerts and various festivals, although they are still undergoing revision and improvement. I hope they will eventually be useful for the creative process of other musicians.

This experience has also provided me with insights into technical challenges, such as miking the instrument, managing electronics with a large instrument, and utilizing tools to make the electronics more independent. These tools include

automation, event detection, and the creation of logical conditions that allow the performer to send instructions without leaving the instrument to operate a traditional interface.

The compositions are:

1. No Hay Banda. 2023

This piece was created around two axes. The first axis uses samplers of natural sounds from the streets of Mexico City, allowing the performer to control the electronics through their performance. These sounds are combined with samplers from traditional brass bands from Oaxaca, which also respond to the performer's playing.

2. OrangeRed Submarine. 2023-2024

This piece explores the interaction between the computer and the tuba player, aiming to achieve a natural dialogue between the performer's logical decisions and the processing of that information. I have developed a prototype of Artificial Intelligence that analyzes in real-time what the performer plays and transforms it into musical phrases. This AI can interact as a member of the ensemble with which the musician can play and even improvise, meaning a virtual musician. The goal is to generate an improvisatory interaction between the performer and live electronics.

3. Ehecatl. 2023

This piece is based on the concept of interaction between virtuality and reality. It creates a window into a virtual space, similar in size to the stage, facilitating a mutual exchange between both worlds through movements, colors, shapes, and sounds.

* Refer to *Appendix C* for more information about the works and my technical objectives.

It is important to mention that my compositions revolve around three main axes:

1. The performer focuses on playing their instrument naturally while interacting with the electronics, and vice versa. The goal is to achieve seamless integration between the electronics and the discipline of instrumental performance.

2. The performer is granted a certain degree of freedom and is encouraged to improvise, emerging from the mutual interaction between the performer and the electronics. It is crucial for the performer to perceive the electronics as dynamic and flexible, capable of generating unexpected creative expressions rather than as something static or unchanging.

3. Exploring the relationship between the virtual and the real is central to my compositions. This exploration arises from the interaction and responsiveness between virtual instruments and my instrument, with a primary focus on achieving optimal interaction between sound and visuals.

Based on my experience, musicians who are initially unfamiliar with live electronics often become intrigued after some exposure to it. However, in certain cases, a deep exploration has not been achieved, which significantly limits the production and development of this genre.

We must also recognize that technological obsolescence can be a significant issue when it comes to collecting and preserving works. Ironically, the most recent pieces that utilize advanced technology are often the most vulnerable to the passage of time due to continuous advancements and the creation of new software, which can lead to compatibility issues with older systems. Therefore, it is

crucial to thoroughly document the specific functions and processes of live electronics in each work to ensure future replication.

An example of the aforementioned is the work *Alone on Repeat* of the composer Douglas McCausland.

Working with tuba and live electronics presents additional challenges, particularly regarding the integration of the tuba sound with live electronics and its real-time control. While automation using a clock and event detection can be effective for managing live electronics, it is not always sufficient. Consequently, I opted to implement wireless microcontrollers to manage certain parameters based on my decisions during performance. Another challenge is miking the tuba, as the instrument's dynamic range and morphological characteristics require careful research and experimentation, which I have undertaken.

CHAPTER 4
THE SOLUTION

4.1 Control device.

Due to the size of my instrument, it is very difficult for me to use an interface (in terms of a device that may have sliders, buttons, etc.) since either I play the instrument or I focus on manipulating the interface. As a derivative product of the own creation of pieces, the idea of creating a tuba controller made with velcrum and sensors which adapts to the body of the tuba emerged. The main purpose is to have more options when manipulating the sound of the tuba with live electronics without the need to have contact with a computer and interface.

The heart of the interface is to have flexibility as well as easy manipulation of instructions routed through Max MSP. This interface can be suitable to any kind of tuba, without taking in account the size of the instrument because it's easily adaptable according the needs of the performer and the structure of the tuba.

Although the main idea was to create an interface made of fabrics, as experimentation was carried out, it was concluded that strategically arranged sensors that can be easy to replace and assemble.

Although it is still under development, the main components are two types of devices, which plan to be mountable on velcrum to be placed in different places on the tuba according to convenience, with the aim of being useful for any size and model of tuba. I will briefly explain the main functionalities of the devices.

The basis of the interface is a small controller model M5StickC Plus (48.2 * 25.5 * 13.7 mm) which connects to the other sensors. This controller was selected, among

other things, for carrying the 6-Axis IMU which is a 6-axis altitude sensor that includes a 3-axis gravity accelerometer and a 3-axis gyroscope that can calculate the angle of inclination and acceleration in real time as well as having perfect wireless connectivity to have mobility during a performance. This factor ends up being a parameter that can be perfectly used to control electronics in real time. I used this device in the *OrangeRed Submarine* works and more recently *Ehecatl*, mentioned in chapter 3. It is important to highlight that the M5StickC Plus was chosen, thinking about taking advantage of the integrated screen, the Wi-Fi, the easy connectivity with other sensors and their size in the future.

The other device considered is the PAJ7620U2 (24 * 32 * 8 mm), which is a 9-gesture recognition sensor, without the need for physical contact in a range of 5 to 15 cm. Each gesture can be linked to a different functionality, depending on the requirements of the performer and/or the work.

Figure 1. M5StickC Plus and PAJ7620U2

* For more information of both devices, refer to the List of sources where you can find a link to the official website.

Both devices are programmed in Arduino to serve as a source of information linked to Max/Msp/Jitter through a local Wi-Fi network. In such a way that it allows the performer to have more freedom of movement while granting a certain degree of theatricality if desired. The bridge between these two programs is the Arduino OSC and the data received by the devices is linked to different functionalities within Max. As a mechanism, the gyroscope (acceleration and distance) is used to measure different instructions that can be routed and adapted, so there is an extremely wide range of possibilities that can be configured by each interpreter to obtain always changing results accordingly to the needs or creativity of the performers and works.

My experience with this type of device is very positive, since despite requiring extra programming than one could find with a standard commercial controller, they allow the player to focus on playing their instrument at the same time as something as natural as a movement. can help you modify parameters without disconnecting from your playing focus.

4.2 Miking. Harmonic and event detection.

One of the principal issues was the pitch tracking. The tuba is a low register instrument and because of this, a lot of information is sent, and due the fact that the distances between notes are minimum, it’s more complicated to have an accurate pitch tracker which is essential to my compositions, due their responsive nature.

After a testing process through practice, corrections and tutoring from my teachers from the Live Electronics Department, I collect a lot of technical information on how to carry out adequate communication between the technical issues of the tuba and live electronics.

As the tuba is a large instrument, it is very difficult to have arms and legs to control parameters within the electronics and most of my personal work is nourished by performative or conceptual aspects, no matter how subtle they were, so in the subchapter I dedicated myself to talking about an interface made with a controller and sensors, but that was not the only resolution that I found effective to have control of parameters and moments within the electronics itself. A very practical solution was to use the instrument itself as an audio interface by detecting events (loudness, pitch, duration) of the playing on the tuba, and also take advantage of the mobility of my body by building a wireless microphone system, and the use of sensors with Wi-Fi communication (mentioned in the previous chapter) with the aim of taking advantage of the movement of my body also at the time of performance for the manipulation of electronics in real time.

In the cases of duration of the event (sound) with some objects of max and through microphones positioned in a successful way, the piece *No Hay Banda* is highlight, mentioned in previous chapters. In the case of pitch detection, since the tuba is a low frequency instrument with many audible harmonics, the precise detection of the low register and pedal of the tuba becomes somewhat complicated since to generate a more precise reading it is necessary to increase the size of the sampling buffer to do the analysis, which is inconvenient in terms of latency, which did not allow me to feel comfortable when playing the tuba.

When considering the use of frequency as a parameter to influence electronics in music performance, I encountered two primary solutions:

The first was to use a detector with a bit of latency due to the large buffer and with some conditions to obtain a stable reading between periods greater than 50 milliseconds (enough to not feel an apparently parallel response from the reading to the interpretation), being a period of time where the performer will not feel a response from using the pitch reading parallel to the performance, so it ended up being very effective for actions that required a precise reading (even in some pedal notes), but that solution didn't give me the feeling of real-time response, so I use this detector for some sporadic condition within the music.

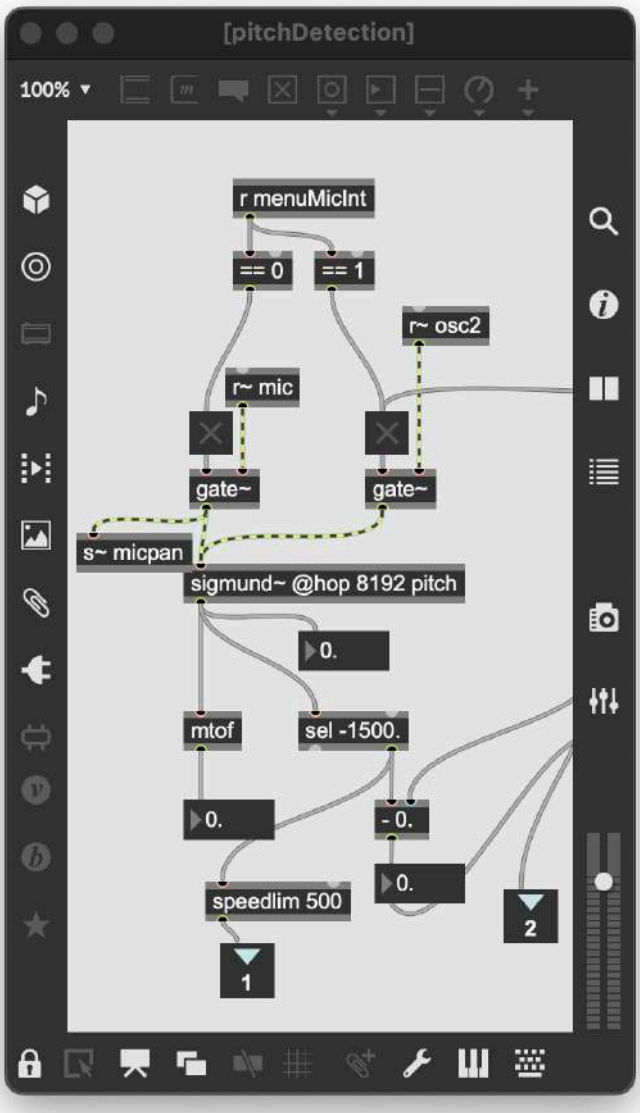

Figure 2. Illustrative of the above-mentioned configuration.

The second one I found very practical was to use a sinusoidal analyzer on Max/Msp with the external objet called Sigmund, originally created by Miller Puckette in a 32-bit version and actualized by Volker Böhm in a 64-bit version, which essentially "analyses an incoming sound into sinusoidal components, which may be reported individually or combined to form a pitch estimate"[1]. Using 10 partials I discover a useful low-latency and fluid response, (even in pedal notes) where the performer felt a natural response from the detector, apparently in real time (less than 30 milliseconds), latency is still audible but because of the slow attack of the tuba (in comparison with other instruments) it feels very responsive and able to capture some expressive changes on the pitch and loudness, like the vibrato, glissandos, crescendos and diminuendos, an example that would be very useful to control built synthesizers, such as the used in my composition *Ehecatl* mentioned in the previous chapter. My solution was to use a sinusoidal analyzer that took a minimum of 5 partials so that the ear could correct through the partials any deviation in the precision of the reading of the first partial (even in all the pedal notes of the tuba) through the upper partials, allowing me to play the entire range of the tuba with a latency that is totally acceptable at 128 samplers and moderately acceptable at 64 samplers at a sample rate of 44000 hertz for the previous mentioned sensation of precise response in the use of synthesizers controlled by both pitch and loudness.

[1] Sigmund_64-bit. "Sigmund_64bit-version" (2015). Github v7b1. Retrieve from https://github.com/v7b1/sigmund_64bit-version/releases

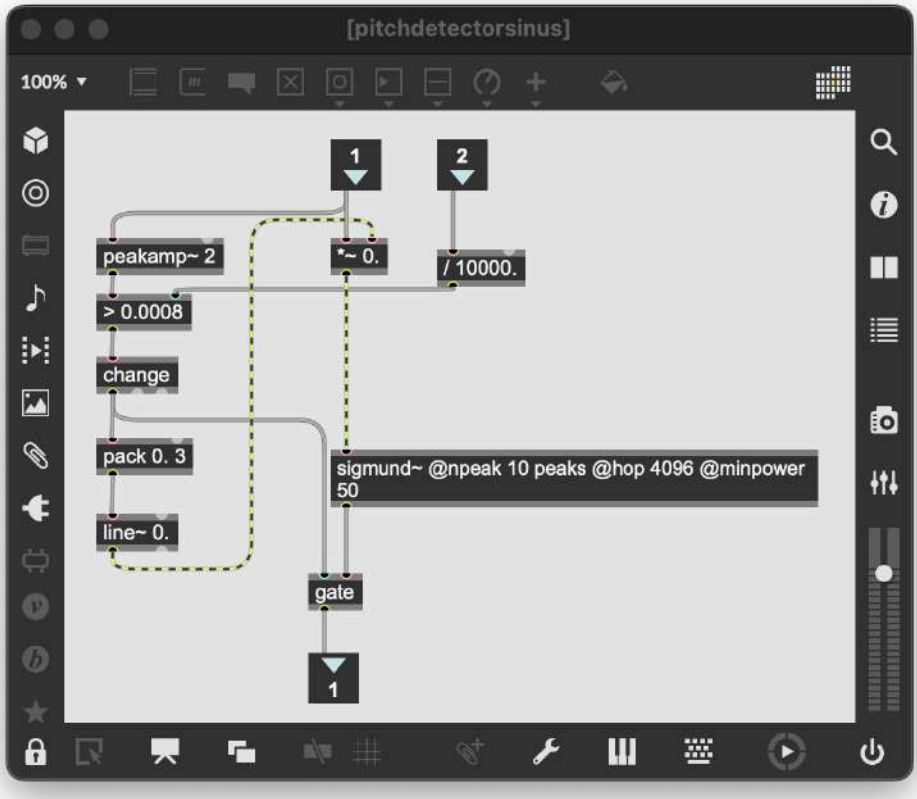

Figure 3. Illustrative of the above-mentioned configuration.

For the detection of events it is very important to get the maximum performance of the sensor (in this case microphone) and the tuba is an instrument with certain complications when being miked, since by having a wide dynamic range, when positioning the microphone to obtain greater precision in some cases the sound is obtained most similar to what we perceive as the natural tuba sound but it allows the addition of many sounds that can contaminate the final sample and in other cases there are positions for the microphone where one can isolate the sound with less external contamination but the sound can have saturation of harmonics not desired by the performer when interpreting. Due to the nature of Live Electronics, the above must be resolved from the approach of having a clean sample even in environments not isolated from nearby sounds.

Also, without correct miking techniques, all kinds of detection become almost impossible, as I mentioned earlier, due to the high dynamic range, register, and

localization of the tuba's bell. Capturing the real information of the tuba sound is a challenge. Along the way, I compiled some solutions that can offer good results, including:

The solutions I found are for this types of microphones with some positioning within the instrument:

1. Dynamic microphone. Top of the bell.
2. Dynamic or condenser microphone. Inside the mouthpiece.
3. Dynamic microphone. Immersed in the bell.
4. Contact microphone. Body of the tuba.
5. Dynamic microphone on mute.

* Refer to *Appendix D* for detailed information.

Each type of miking mentioned in the previous table has its strengths and weaknesses, which is why some may be more effective than others depending on the results you want to obtain. These are some suggestions that are the result of many tests in different situations, however, I consider that this area can be further developed through future tests, new ideas and even new technologies.

Finally, the automation of live electronics using it as an auxiliary or secondary tool with the aim of prioritizing the freedom of the performer. Based on experimentation in each work, a good automation technique is the use of an internal clock in combination with sensors and event detection according to the case that is most convenient for the performer and the work.

CONCLUSION

When I started this research journey, I encountered the initial challenge of comprehending the multitude of facets within the realm of tuba performance and its integration with live electronics in composition. However, delving deep into this discipline has enlightened me to the genuine intentions behind the works created thus far. Tuba players and composers alike have ventured into uncharted territories, exploring the vast possibilities of sound.

In the early 1980s, the tuba was seldom considered a solo instrument. Moreover, given its relatively recent addition to the orchestra, the classical repertoire for the tuba remains somewhat limited. Another noteworthy aspect is the tuba's role within various musical ensembles.

While the field of live electronics is relatively nascent, it is not devoid of complexities. One such challenge is the rapid obsolescence of technology. As technological advancements progress, we inevitably risk losing access to many compositions due to the unavailability of the necessary gadgets for performance.

Consequently, this research has underscored the significance of diffusion, restoration, and preservation efforts within the realm of tuba and live electronics compositions. Furthermore, there arises a compelling need to foster a community dedicated to sustaining and advancing this discipline, thereby enhancing its quality and diversity over time.

When aiming to build a community, it's crucial to get the interest of composers. In my personal experience, a notable characteristic of live electronics is its inherent element of randomness. Recognizing that composers may not naturally gravitate towards live electronics or perceive randomness as essential to their creative

process, it becomes imperative to foster experimentation and promote this fusion through avenues such as an information exchange network between composers and performers, a comprehensive catalogue for preserving works.

Perhaps by selectively incorporating elements from classical music and embracing the unpredictability of live electronics, alongside exploring diverse musical genres like jazz, pop, and world music, we can uncover new opportunities and potential avenues for future development. Engaging with ensembles also holds promise for further exploration and fostering greater appreciation for this unique instrumental combination.

Similarly, there's a need to develop new techniques for manipulating live electronics alongside a large instrument like the tuba. This minimizes reliance on others for control, a necessity depending on the composer's vision. Through my experience, I've discovered numerous ways to manipulate electronics without detracting from the performance, emphasizing the importance of seamless integration for performers like myself. Within the realm of live electronics, various established options exist, such as event detection and the use of pedals, offering comfort and control for tuba players. Additionally, employing sensors as interfaces allows for effective manipulation of information to control the live electronics. The focus should be on creating ergonomic devices that facilitate natural instrument playing. Furthermore, it's essential to explore theatricality and stage presence as avenues for enhancing performances.

Personally, I'm quite interested in exploring concepts mixed reality AI and the unexplored opportunities it presents. Embracing innovation involves not only utilizing established methods but also seeking out novel approaches. As a relatively new discipline, adapting to contemporary trends and tastes is crucial for preserving the relevance of this instrumental combination. This entails striving for

consistency in performances while also embracing a diversity of expressions in order to take advantages of the infinity of possibilities and expressions that we can find in this instrumental combination.

LIST OF SOURCES

R. Winston Morris and Daniel Perantoni. Guide to the Tuba Repertoire, Second Edition: The New Tuba Source Book. Chapter 6. Music for Tuba and Electronic Media. Indiana University Press, 2006

Birgit Johanna Wertenson, Luigi Nonos ¡Guai ai gelidi mostri!, en: Musik & Ästhetik , 15. Jahrgang, Heft 58, 2011, p. 49-67

Luigi Nono. Writings and interviews, edited by A.I. De Benedictis and V. Rizzardi, Ricordi-LIM («Le Sfere», 35), Milan 2001, vol. I, p. 491-492

Jürg Stenzl. Ingeborg Bachmann et Herman Melville. Booklet. 1987

Schrader, Barry. Live/Electro-Acoustic Music: A Perspective from History and California, edited by Peter Nelson, Stephen Montague, and Gary Montague, 1991.

Nick Collins. Live Electronic Music. In The Cambridge Companion to Electronic Music, edited by Nick Collins and Julio d'Escriván, pp. 38–54. 2007.

Richard Toop. Karlheinz Stockhausen. In Music of the Twentieth-Century Avant-Garde: A Biocritical Sourcebook, edited by Larry Sitsky, 2002, p. 493–49.

George Dalton. The History and Development of the Tuba, p. 18, 20, 21, 28.

Computer Music Journal, Published By: The MIT Press, Vol. 12, No. 1 (Spring, 1988), pp. 9-18

Hynds, Aaron. “Composers Tuba Guide” (2019). The Composers Tuba Guide. Retrieve from https://composerstubaguide.blog/repertoire-lists/tuba-with-electronics/

Tuba, David. “Cumpleaños de la TUba” (2021). Retrieve from https://amp.davidtuba.com/es/tuba/la-tuba-cumple-185-anos

Various authors. “Live Electronic Music” (2023). Live Electronics Music. Retrieve from https://en.wikipedia.org/wiki/Live_electronic_music

IJM. “International Journey of Music”. 31 Important Dates in the Life of Roger Bobo (2021), Retrieve from https://ijm.education/winds/brass/tuba/roger-bobo/

Sigmund_64-bit. “Sigmund_64bit-version” (2015). Github v7b1. Retrieve from https://github.com/v7b1/sigmund_64bit-version/releases

M5Stack. “M5Stack Website.” (2024). M5Stack official Website. Retrieve from https://m5stack.com/

PIECES AND COMPOSERS WEBSITES

McCausland, Douglas. “douglas-mccausland” (2023), Douglas McCausland Official Website. Retrieve from www.douglas-mccausland.net

Zanter, Mark. “sheetmusicplus” (2023), Sheetmusicplus Perpetuum Mobile. Retrieve from https://www.sheetmusicplus.com/title/perpetuum-mobile-2014-for-tuba-and-live-processing-digital-sheet-music/21857254

Essl, Karlheinz. “Si!" (2023), Essl At. Retrieve from http://www.essl.at/works/si.html#score

Ircam - Centre Pampidou. “Jonathan Harvey” (2012), Brahms.ircam. Retrieve from https://brahms.ircam.fr/en/jonathan-harvey

Harvey, Jonathan. “still purchase” (2023), Kobe Harvey Jonathan Still. Retrieve from https://www.koebl.de/de/category/Solo/Harvey-Jonathan-Still-_001530768/

Fulton, Ruby. “Breathe for tuba solo and pedals” (2023). Ruby Fulton. Retrieve from https://www.rubyfulton.com/musicstore/breathe-for-solo-tuba-and-pedals

Katzer, Georg. “für Tuba mit Hegel” (2023), Edition Gravis. Retrieve from https://www.editiongravis.de/verlag/product_info.php?language=en&info=p1850_fuer-Tuba-mit-Hegel.html

Lippe, Cort. “Cort Lippe Compositions” (2023), Cort Lippe. Retrieve from https://www.cortlippe.com/compositions.html

Miyasaki, Arianne. “Hindsight” (2014), Soundcloud. Retrieve from https://soundcloud.com/arianemiyasaki/hindsight-2014

Lauren McCall, "Lauren McCall, Composer and Music Educator" (2024), Lauren McCall. Retrieve from https://www.laurencmccall.com

Bandcamp, "Cesar Vidal" (2024), Bandcamp. Cesar Vidal. Retrive from https://cesarvidal.bandcamp.com/

Appendix A

Catalogue. Works for Tuba and Live Electronics.

	About the LE	Technology	Score
The First Dream of Light Morton Subotnick 1980	Recording and changing tones with voltage in real time but precise timing instructions are given to the performer to be able to perform the coupling.	Obsolete. Device no longer in circulation.	No information found
Collage 3 Kenton Bales 1985	Experiment with the characteristics of the tuba with processed live sounds.	No information about the live electronics available	No information found
Post-prae-ludium No.1 per Donau Luigi Nono 1987	Represents a model for the emerging genre of electroacoustic tuba music. The tuba must capture, elaborate and respond to the processes of sound expansion.	Obsolete Emulated by me on Max/ MSP.	The score is available under purchase. Refer to the list of sources.
Still Jonathan Harvey 1997	The soloist improvises around a series of eight chords, gradually building up a sustained background of reverberations.	Loop pedal	The score is available under purchase. Refer to the list of sources.

	About the LE	Technology	Score
Work for Tuba and Live Electronics Ricardo Sezudo 2002	Unknown	No information about the live electronics available	In consultancy with Sergio Carolino
Animus III Luca Francesconi 2008	A teatral piece that has the wild urges of improvisation and free exploration. Breath is the tie that binds human and metal and the computer mediates and formalizes the uneasy relationship.	No information about the live electronics available	No information found
Für Tuba mit Hegel Georg Katzer 2008	A pioneer of electroacoustic music that unites the electronics with East German music.	Available in the score	The score is available under purchase. Refer to the list of sources.

	About the LE	Technology	Score
Music for Tuba and Computer Cort Lippe 2008	The composer refer to his piece in this way "Commissioned by the Zentrum für Kunst und Medientechnologie ZKM. The computer tracks parameters of the tuba during performance, such as pitch, amplitude, spectrum, density, rests and articulation. It uses this information to continuously influence and manipulate the computer sound output by directly affecting digital synthesis and compositional algorithms in real time. "[1] [1] *Lippe, Cort. "Cort Lippe Compositions" (2023), Cort Lippe. Retrieve from https://www.cortlippe.com/compositions.html*	Vigent	The score is available at the composer website. Refer to the list of sources.
Death Be Not Proud Melvyn Poore 2008	As a tuba player and composer, Melvyn Poore looks for new possibilities to extend the potential of the tuba.	Vigent	No information found
Sonnet X Valerio Sannicandro 2008	Unknown	No information about the live electronics available	No information found

	About the LE	Technology	Score
Wouldn't Need You Nicholas Deyoe 2011	This piece consist of five unmetered fragments. The music features some extended techniques such as singing and long vibrato notes.	No information about the live electronics available	No information found
Si! Karlheinz Essl 2012	According to the notes from the composer "By filtering the sound of the tuba with the spectrum of a female voice (using a technique called convolution), the tuba can now speak in tongues. To obtain those results it was necessary to transform the sound of the bass tuba into a range that has more common harmonics with the voice." [1] [1] *Essl, Karlheinz. "Si!" (2023), Essl At. Retrieve from http://www.essl.at/works/si.html#score*	Obsolete With accurate instructions and in restoration process. By me	The score is available at the composer website. Refer to the list of sources.
Hindsight Ariane Miyazaki 2014	Using trigerated voices the piece reflect upon the tuba player past decisions and actions. Mostly improvised.	No information about the live electronics available	No information found
Perpetuum Mobile Mark Zanter 2014	By the use of surface rhythms, textural changes and the constant cycling of pitches occurring throughout the work replicates the characteristic of moto perpetuo.	Available in the score	The score is available under purchase. Refer to the list of sources.

	About the LE	Technology	Score
Colossus Monte Weber 2014	This work is not a solo tuba piece, but rather a vocal and percussive work that happens to use the tuba for amplification, exploring the properties of the instrument itself.	No information about the live electronics available	No information found
Breathe Fulton Ruby 2015	A protest piece that works with a loop pedal.	Vigent	The score is available under purchase. Refer to the list of sources.
Alone on Repeat Douglas McCausland 2016	Conceived with a series of ideas that centered upon using the tuba as a resonator, for the player to speak various phonemes, word fragments and sentences. Simultaneously working with the concept of incorporating the composer's love for noise and metal in a very purposeful but somewhat restrained way.	Obsolete Without accurate instructions of the electronics.	The score is available on consultanc y with the composer. Refer to the list of sources.

Appendix B

Ensemble Works with Live Electronics.

	About the piece	Technology	Score
Guai ai gelidi Mostri, Luigi Nono 1983	2 altos, flute, clarinet, tuba, viola, cello, bass and live electronics. Nono's first composition that thoroughly investigates the sound/space relationship, giving rise to results that flow into the spatial configuration of Prometheus. The sound and its trajectories not only increase the listener's awareness of the amplitude and structure of the spatial environment, but, above all, the electronic processing of sound makes present a whole series of secondary spaces that would not be perceptible in the usual conditions of listen. [1] “non-static mobile sound, due to the monolithism of the formants - microintervals of up to 1 Hz difference - various transpositions of the no longer unique acoustic spectrum - other vibrations, other diffusion filters with the compositional use of the space specifically to be studied” [2] *[1] Birgit Johanna Wertenson, Luigi Nonos ¡Guai ai gelidi mostri!, en: Musik & Ästhetik , 15. Jahrgang, Heft 58, 2011, p. 49-67* *[2] Luigi Nono. Writings and interviews, edited by A.I. De Benedictis and V. Rizzardi, Ricordi-LIM («Le Sfere», 35), Milan 2001, vol. I, p. 491-492*	Obsolete. Can be adapted to current technology due accurate instructions.	For Rent in Ricordi Editions

	About the piece	Technology	Score
Risonanze Erranti, Luigi Nono 1985 - 1987	Alto, flute, tuba, 6 percussion and live electronics. ”The instruments create violent contrasts of range and dynamics, but at the same time Nono experiments with imperceptible transitions between vocal, instrumental and electronically transformed sounds…a world both very close and very strange”. [3] The aim for the listener – according to Nono – is “to broaden everything, to deepen everything, to bring about other changes, human mutations, feeling, social, reform, thought…” [3] [3] *Jürg Stenzl. Ingeborg Bachmann et Herman Melville. Booklet. 198*	Obsolete Can be adapted to current technology due accurate instructions	For Rent in Ricordi Editions

Appendix C

Own Compositions

Work	About	Technology	Technical Objective
No Hay Banda Fabian Campuzano 2023	Conceived as a work to evoke sounds and reminiscences of Mexico City through samplers which are activated and modified thanks to the detection of events.	Max/Msp	Explore the foundations of note duration and pitch detection
OrangeRed Submarine Fabian Campuzano 2023 - 2024	This work explores the concept of real and virtual by using all the information the computer receives from the musician playing in real-time to generate sound. The more notes the performer plays, the more notes the computer can return in a semi-random manner. At certain moments, the instrument itself sounds like a synthesizer, while the computer-generated sound mimics a tuba, challenging our perception. This is combined with a virtual player, created through the real-time analysis of the tuba using a prototype AI. In the final section, the player's movements control a granular synthesizer, leading to a moment of silence after a brief period.	Max/Msp/ Jitter and a sensor with Arduino	This work explores pitch detection to control a synthesizer, along with the random rejection of collected data. It also incorporates a motion sensor to control various parameters and a prototype AI developed by me.

Work	About	Technology	Technical Objective
Ehecatl Fabian Campuzano 2023	Work conceived in remembrance of Ehecatl, a Mesoamerican god of air and winds, especially those which brought rains. He was also associated with the cardinal directions, colors, and several calendar dates, as a window to a virtual reality world, where colors are influenced by sounds and cardinal points are also important since the sensor is linked to the visual world and sound functioning as a window to this 3D world. Likewise, using a granular, it makes a series of combinations that are fused to the FM synthesis that replicates the frequency of the tuba at all times and that both are affected through the movement of the performer.	Max/Msp/ Jitter and sensors with Arduino	With this work, several previous techniques in event detection, the microwave and the use of sensors as controllers are perfected, the concept of virtuality is worked on through a 3D space generated in jitter as an important axis of the work's discourse.

Appendix D

Best solutions found for miking the tuba in different scenarios.

Microphone Type	Possible accommodation	Possible Utility	Extra Information
Dynamic microphone, top of the bell.	Located at a distance greater than 7 cm from the bell. Aiming between the bell and the center.	Because it is the most tuba-like sound that the audience could hear, I recommend it for audio processing and event analysis.	To obtain the best results from this type of microphone, it is advisable to be able to control the threshold by some means and even better if it is accompanied by another exclusive microphone for event detection.
Dynamic or condenser microphone, inside the mouthpiece.	Located inside a specialized nozzle, in which a hole has been drilled (requires being done by a professional)	It is recommended only for accurate detection of laudness.	Use it in environments with a lot of noise.
Dynamic microphone immersed in the bell.	Glued to the bell with a damper (common and very effective technique in Mexican folklore music)	This technique can replace the two microphones mentioned above.	Some harmonics can be saturated and contaminate the accurate reading. Likewise, the timbre recorded by the microphone varies a little from what the listener perceives in a purely acoustic environment.

Microphone Type	Possible accommodation	Possible Utility	Extra Information
Contact mic on the body of the tuba.	In the metal body of the tuba, but I continue to explore other possibilities.	Capture percussions and things that happen in the body of the tuba.	Keep in mind that since it is a contact mic, all the movement that happens in the body of the tuba can be recorded more than the notes that are emitted from the instrument.
Dynamic microphone on mute	Place the microphone inside the mute (requires being done by a professional)	It can replace the first two microphones on the table, obtaining good isolation from external noise.	It registers a different sound than a person would perceive in an acoustic room. The audience would not be able to hear the sound of the instrument without amplification.