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Multiple Paths: Towards a Performance Practice in Computer Music

Juan Parra Cancino

Multiple Paths:
Towards a Performance Practice in Computer Music

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Juan Parra Cancino

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Prof. Richard Barrett	2e promotor
Dr. Marcel Cobussen	co-promotor

Prof. Clarence Barlow	
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Prof. Dr. Simon Emmerson	Leicester Media School, De Montfort University
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Dedication

I would like to dedicate this thesis to my parents, to Cata, my favourite doctor, and very specially, to Sayoko, who has given me the final push to complete this long journey, and waits with the greatest reward in the world.

Juan Parra Cancino , 2014

A note on the texts

Some texts included in this thesis are reworked versions of previously published articles. The reworking took place on the drafts, and not the final, published works, so at times the changes are quite fundamental. For the sake of clarity, I include here a list of the publications where different forms of these texts are available.

Parra Cancino, Juan (2009). “Historical Contextualisation in Live Electronic Music: Reconstructing *Aria/Fontana Mix* by John Cage.” In William Brooks and Heike Vermeire (eds.), *MetaCage: Essays on and around* Freeman Etudes*,* Fontana Mix*,* Aria (pp. 9 - 17). Orpheus Research Centre in Music Series vol. 2. Leuven: Leuven University Press.

Parra Cancino, Juan (2009). “*PLP I*: Redefining Musicianship in Computer Music.” In Paulo de Assis and Heike Vermeire (eds.), *Dynamics of Constraints: Essays on Notation, Editing and Performance* (pp. 35 - 42). Orpheus Research Centre in Music Series vol. 3. Leuven: Leuven University Press.

Parra Cancino, Juan (2013). “From Emulation to Instigation: Revising the Notion of the Etude as Compositional Form in Live Computer Music.” *Proceedings of the 2013 International Computer Music Conference* [Perth, Australia] (pp. 380 - 382). San Francisco: International Computer Music Association.

Parra Cancino, Juan (2013). “Timbre Networks: An Approach to Composition and Performance in Computer Music.” In Tony Veale, Kurt Feyaerts and Charles Forceville (eds.), *Creativity and the Agile Mind: A Multi-Disciplinary Study of a Multi-Faceted Phenomenon* (pp. 355 - 374). Berlin: De Gruyter Mouton

Introduction

This research project started from my need to understand what constitutes performance practice in computer music, how it differs from traditional instrumental practices, and how it can be further challenged and developed. The initial hypothesis for this research was developed during my years as a student at the Institute of Sonology at the Royal Conservatoire The Hague and, in particular, during my work as co-founder of the percussion and computer music trio The Electronic Hammer. This ensemble was active for eight years, in which time it created, promoted, and disseminated contemporary live computer music, focusing on the interaction of a traditional virtuoso instrumentalist and two computer performers.

The work methods developed within the ensemble, and later applied to other musical collaborations, helped define some of the main research questions for this project. Some of the tasks we dealt with within the ensemble included exploring instrument-independent musical notation, the disjointed relationship between physical action and sonic manifestation in electronic instruments, and the hierarchical dynamics between (traditional) instrumental and electronic components. The various strategies we developed to deal with these issues led towards a methodology for live performance of computer music.

In rigorously pursuing these methods, it became clear to me that it was necessary to investigate the extent to which composers approaching working with The Electronic Hammer were inspired by and tackled the notion of considering performers of computer music as equal to traditional instrumentalists, and how many of the performance decisions came through self-reflection on experiences garnered before the ensemble's founding. My introduction to the particular historic and aesthetic contexts of electroacoustic music offered by the Institute of Sonology deeply influenced this reflection on the role of the computer music practitioner in a live performance.

Thus, in order better to situate the starting point of this research journey through the questions and experiences raised by my musical practices and explorations, I will

spend some time presenting a few key elements of my personal trajectory as a music practitioner.

Guitarist by accident

My entry into the world of music practice was through the guitar. This was not due to any special talent or affinity with the instrument and its repertoire; rather, because of a wrist and thumb injury suffered while playing in goal for a youth division football club, I took the decision to learn to play the guitar after my kinesiologist suggested it might help recover mobility in my right hand.

At the time I was too old to start a traditional instrumental career, but I had the good fortune to cross paths with a private guitar instructor who had just experienced a major change in his practice. Since I had no previous serious experience in the instrument, I agreed to approach learning my instrument using the principles my teacher had acquired from Guitar Craft, a pedagogical system developed by Robert Fripp, with which I would later assist and continue to be involved in for several years.[1] The most striking, salient feature of this approach is that the discipline transmitted has as much to do with life-learning as it has with learning a musical instrument.

According to its founder, “Guitar Craft is three things” (Fripp 2004: n.p.):

> A way to develop a relationship with the guitar;
> A way to develop a relationship with music;
> A way to develop a relationship with oneself.

In his introduction to Guitar Craft, Fripp (Fripp 2004: n.p.) touches only briefly upon the musical skills required of beginners, instead focusing more intently on aspects such as discipline and commitment:

> The *Introduction To Guitar Craft* is open to all levels of experience, even none at all: the requirement is commitment. We ask that participants come with a clear aim, and the commitment to honor that aim. Emphasis is on how to play, rather than what to play. We

[1] Founded in 1985, the activities of Guitar Craft are continued worldwide through the extended work of its related guitar circles. More information is available at www.guitarcraft.com.

address the principles underlying our practice. These principles are applicable in other areas of our lives.

In addition to the musical activities, done primarily in a circular formation using a tuning system closer to that of traditional orchestral bowed string instruments than that of the guitar (tuning by fifths rather than by fourths), other aspects of the Guitar Craft discipline were slowly revealed during the years of my involvement. These tasks included both extremely concrete ones, such as cooking and cleaning for large groups of people, and a careful introduction to applied practices and techniques that would facilitate the sharing of creative, musical and, potentially, more spiritual experiences.[2]

Musically speaking, one of the main aspects of the ensemble work within Guitar Craft is that it allows for the creation of very transparent or, conversely, complex counterpoint structures. *Transparency* relates to the uniformity of timbre (akin to the work of a string orchestra or a choir) and *complexity* relates to the large number of players and different voices of the core repertoire. The learning process for the repertoire provided a fascinating work dynamic between several players: each member of the ensemble would learn every voice of a particular piece, to the point of being able to play the whole melodic line, or some notes of the melodic line, while allowing a second (or third, or fourth) performer to fill in the notes that the first performer omits. Combined with the uniform timbre of the group, this technique helped to organise the ensemble as a collective, thereby approaching playing as if sharing a single instrument played by multiple performers instead of structuring the ensemble in a traditional orchestral hierarchy.

Another aspect of the work of this school that would later come to define my personal musical interests was the delicate use of spatialisation in performance. The main musical setting in the work of Guitar Craft, in both practice and concert, is a circular formation, where the notion of becoming a single instrument divided between several bodies is used to establish uniformity and coordination in sound. To achieve this, strong emphasis is placed on “circulations”, where single notes are passed from

[2] Perhaps the most prominent is Alexander technique, developed by F. M. Alexander and simply described as a learning process that aims to undo the tension patterns accumulated in our bodies. For a complete resource on Alexander technique, visit www.alexandertechnique.com.

guitarist to guitarist, challenging the attention of the performing group and creating for the audience sitting within the circle a sensory experience very rarely reproduced in other music performance settings. This suggests a distancing from the traditional model both of venues and of ensembles: the recital platform model that, in the words of Edward Said, situates the performer in a place where he or she becomes something "to be looked at, admired, and marvelled at by a worshipful, sometimes incredulous crowd […] The idea of the performer as a specialized object of wonderment for a middle-class paying public." (Said 2006: 118)

While the practices and ideas within Guitar Craft left a very strong imprint on my early development as a musician, there were certain questions that remained unanswered. Being the performer of someone else's musical ideas, I can now articulate one of these questions as a limitation on creativity. I could never truly embrace the notion of creativity in the process of interpretation. In retrospect, this was perhaps a product of my lack of aesthetic affinity with not only the traditional classical guitar repertoire but also a large amount of the repertoire practiced within Guitar Craft. I perceived the timbral uniformity of the work when played by the ensemble, perhaps essential to reach the aural impression of communion and unity, as one of the biggest shortcomings on a purely artistic level. I soon realised, both as a listener and as a practitioner, that my main fascination with music was the *sound* itself; as a performer, I felt limited to the all-too-restrictive sonic palette of a single instrument.

These were some of the reasons that led me to continue seeking a development of music based in sound and a different approach to the guitar as a sound source.

<u>Composer on purpose</u>

I began studying composition initially to understand how I could apply the ideas about space organisation and polyphony that I had learned in Guitar Craft to sonic complexes richer than the guitar ensemble setting. I started to articulate certain concepts that helped focus my search for and fascination with musical practices in which timbre and its transformation over time were central to the creative process. I sought to find resonance in pre-existing repertoire that focused on the use and manipulation of the sound-print itself: timbre, the complexity (or lack of complexity) of an instrumental source and the *play* of voice densities in polyphonic vocal music.

The first result of this search manifested itself while listening to a recording of Anton Webern's orchestration of J. S. Bach's *Ricercare a 6* from *The Musical Offering*. The notion of *Klangfarbenmelodie* was introduced in 1911 by Arnold Schoenberg and is defined as "music in which consecutive tones differ timbrally." (Cramer 2002: 1) Webern used Schoenberg's notion to produce an orchestration that made me understand how, in the words of Theodor W. Adorno, a "normalised" (or dehierarchised) understanding of the musical structure suggested by the twelve-tone technique could be applied to the organisation of timbres: "The total construction of music permits constructive instrumentation to a surprising degree. The Bach arrangements by Schoenberg and Webern, which convert the most minute motivic relationships of the composition into relationships of colour – thus realising them for the first time – would not have been possible without twelve-tone technique."[3] (Adorno 2007: 63) I could hear the different timbres sharing melodic lines, which gave the piece a spatial dimension that for me transcended the spatial limitations of the recording through which I encountered this piece. It was in understanding this co-dependence between timbres and structures that I began to clarify how and why I appreciated music.

Around the same time, I had my first encounter with the aesthetics and techniques of *musique concrète* through listening to a piece by the Chilean composer Juan Amenábar. In *Los peces* (the fishes)[4] from 1957, Amenábar created a magnetic tape composition by extracting all the timbres from a single sound source: the piano. Exploring the disassociation of the timbre from its original source, Amenábar removed the attack component from the recorded samples, creating sonorities closer to modulated sine waves; in so doing, he successfully transformed the spectromorphology of the original source material to create a "new" instrument. This first experience of musique concrète was followed shortly after by my exposure to the work of Pierre Schaeffer, in particular his *Etude violette* (1948), which, like Amenábar's *Los peces*, was made solely from piano sounds.

[3] Although this is not the only way to structure music through timbre, perhaps it is the sense of familiarity of Bach's music, and what Webern does to it, that touched me in such a powerful way. In doing so, I cannot disagree with Adorno's statement.

[4] It can be heard at http://www.fondation-langlois.org/html/e/media.php?NumObjet=14575. I call it *fishes* to emphasize the plural nature of the original Spanish title.

Nevertheless, whereas Amenábar restricted himself to pitch-oriented material, Schaeffer's explorations went deeper, seeking to deconstruct the whole sonic identity of the instrument. To do so, he embraced and treated several sounds that pianists would not deem "musical", such as the squeaking of the pedals. This radical attitude towards music composition led Schaeffer to define, create and use *sound objects*. My experiences of both Schaeffer's and Amenábar's works redefined my perception of the sonic palette emanating from a single instrumental source, and opened a doorway to the timbral complexity I was still seeking in traditional ensemble and orchestral settings. I thus began refining my creative experimentation with the aim of reproducing these sonic constructs using the tools that were familiar to me: my guitar and guitar effects processors.

The search for expanded timbres on the guitar, which at the time still felt like a restrictive instrument, led me to develop a performative approach to the instrument focused chiefly on manipulating and masking its traditional timbral characteristics. I found a source of inspiration in the work of improvisers such as Derek Bailey and Fred Frith[5] – not only in their radical departure from traditional playing techniques but also in their incorporation of the full sonic potential of the guitar as a resonant object.

However, while Frith's and Bailey's approaches to the instrument inspired and refreshed my relationship with the guitar, there were certain boundaries, characteristic of traditional instruments, that I still wanted to cross.

<u>The transition to electronic media</u>

These experiences with improvisation on acoustic guitar allowed me to exercise in performance what I could point to as the most striking element from my experience of listening to the works of musique concrète: the recontextualisation of the sound material and the proposition of new meanings. Nevertheless, I was still missing my own "ricercare".

My somewhat traumatic relationship with instrumental composition was due to the frustrating notion that, given the reality of classical composition in a country such as

[5] I had the opportunity to participate in a workshop conducted by Fred Frith in 1997 in Chile; it was my introduction as a practitioner to graphic scores, free improvisation and a less traditional approach to the use of the instrument.

Chile, where the opportunities to have one's music performed are extremely rare, the act of writing music was focused more on the writing itself – the production of the score – than on the actual manifestation in sound of such scores. Having been primarily involved with performance, I felt the only way I would be able to relate to music creation and creativity was if I had the definite opportunity to listen to the results of my musical explorations. This led to two choices: (1) create music for guitar, so I could always play it, or (2) find a way of creating music for instruments (or tools) that I could always rely on.

Following the second option led to my first steps in the understanding and use of electronic media, and later to the computer, as my main source for sound creations and manipulations. Early explorations in the use of recorded materials as a primary source and their transformation through direct manipulation of recorded media (tape) gave way to a first approach to the use of computer-based music languages such as Csound[6] and several other computer-based signal-processing tools.

The results of these early works were confined to the final output of a recorded medium, and for this reason, I still did not have the opportunity for decision-making and creativity in front of an audience that working as a guitarist offered.

Thanks to the advice of Robert Fripp, who since the early 1970s has been experimenting in live performance settings with implementing certain techniques used in experimental recording studios, such as tape looping, first with his *Frippertronics*[7] and later with *Soundscapes*,[8] I began seeking inexpensive digital equivalents to realise my "one-man-orchestra" endeavours. Using a series of digital delays and effects processors, and an overly complicated signal-splitting and amplification

[6] Developed by Barry Vercoe in 1985, it was the first programming language based on C fully dedicated to the generation and processing of sound. Being free, multi-platform and available online, it was the sole resource for my early explorations into the world of computer music. For its current version, see http://www.csounds.com/.

[7] Labelled as *Frippertronics*, the initial system created by Robert Fripp in collaboration with Brian Eno included two reel-to-reel Revox tape machines, set to record and play back incoming guitar improvisations and cascade the recordings into each other.

[8] *Soundscapes* defines the continuation of Fripp's explorations of looping and sound transformations, this time using MIDI and other digital instruments, with a system that, at the time of writing, continues to evolve.

system, I began performing semi-structured improvisations, working with the guitar as the starting sound source.

Although there was nothing technically groundbreaking in my approach, the novelty of the system at the time was its musical intention. Whereas the nature of Fripp's improvisations had been described as "the first public performances of 'ambient' music," (LaFosse 2012: n.p.) my aesthetic goals were still closer to the more complex sound worlds of Pierre Schaeffer and Anton Webern – not so much because of a clear aesthetic affinity to these composers' works, but, rather, because of the potential artistic value of a presenting the deconstructive processes of musique concrète and the structural development of *Klangfarbenmelodie* through a solo performance.

The generation – in real time – of multiple evolving sound-objects with their own timbral characteristics, which would be spread around the performance space and surround the audience, was a task that soon came up against technical limitations. Nevertheless, these initial explorations were satisfying enough to encourage me to keep pursuing the development of this work methodology. This search for development is what eventually led me to leave the guitar behind altogether.

The Institute of Sonology and farewell to the guitar

During my first period at the Institute of Sonology at the Royal Conservatoire The Hague, it became clear that I had only scratched the surface of what electroacoustic and computer music offered – namely, through integrating the performative expression I was seeking to develop from electronic and concrete sounds.

In the beginning, my deepening understanding of the techniques used by the different "schools" of electronic music,[9] as well as of the historical repertoire attached to these techniques, led me to develop a strong affinity with the work of the complex analogue studio[10] at the Institute. For a long time, my performative endeavours (including my

[9] Lacking a better word, by the term *schools* I refer to musique concrète in France, *Elektronische Musik* in Germany (and to a certain extent, in Sonology) derived from the work of Koenig and Stockhausen and computer music in the United States, derived from the work of Bell Labs and at Stanford University.

[10] Codenamed "BEA 5" and ran by Kees Tazelaar, through use and manipulation it functions as the ultimate tool for understanding the techniques and tools used in the

participation in the 2000 - 2002 iterations of the SonoEnsemble)[11] relied on my existent set-up of (touch-style) guitar and effects processors. It was not until I began working regularly with the ensemble *[ie]*[12] that I started to develop a computer-based live processing system, the primary aim of which was to act as an extension of the acoustic instruments within the ensemble. Within that context, I began not only to define my role as a "sonic extender" of traditional instruments but also to find the limitations in the kind of interactions that as a performer I was able to create with my colleagues and the audience.

It was within the context of *[ie]* that I began working with percussionist Diego Espinosa, a great improviser and interpreter with a musical personality simultaneously refreshing, comforting and demanding. The subgroup that we formed within *[ie]* soon spun out of the large ensemble and started working on developing a more controlled and focused interaction between traditional instruments and electronic extensions than was possible within the large ensemble.

This focused laboratory work was soon enhanced by the presence of the composer and electronic performer Henry Vega, who had been working together with Espinosa in preparation for a performance of Cort Lippe's *Music for Hi-hat and Computer* (1998),[13] which is based on a Max/MSP[14] patch created by the composer. In the spring

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early electronic music of the 1950s and 60s – and is still evolving. The manual for the studio is available online at http://www.sonology.org/UK/STUDIO%20MANUAL%20BEA%205%202005-2.pdf.

[11] Founded by recorder player Michael Barker and led by composer Richard Barrett at the time of my participation, the SonoEnsemble was (and still is) a performance-lab environment where collective creations were developed by an eclectic group of performance-motivated Sonology students. Snippets of the 2000–2001 iteration of the ensemble at work can be seen in a TV series about the Royal Conservatoire The Hague, produced by the Dutch company AVRO and available at http://cultuurgids.avro.nl/front/detailklassiek.html?item=8179600. For this particular project, composer and then director of the Sonology department Konrad Boehmer acted, next to Barrett, as coordinator of the project.

[12] *[ie]* was a collective of improvisers based in Krakow and The Hague, founded by Keir Neuringer and formed mainly of composition and sonology students of the Royal Conservatoire The Hague.

[13] A recording is available at http://ehammer.bandcamp.com/track/music-for-hi-hat-and-computer.

[14] Created by Miller S. Puckette, and further developed by David Zicarelli, Max/MSP is one of the most popular flexible music programming environments to follow the

of 2003, the trio started working towards creating a fluid improvisational set, the goal of which was to present the system as a *meta-instrument* with three performers, as well as to look for (and compose) a repertoire to complete a full concert.

The Electronic Hammer

Performing first at the DAFX conference in London in September 2013, Espinosa, Vega and I started a collaboration that rapidly transcended the laboratory nature of student work to become the main vessel for my creativity. In the context of the trio, notions of creativity in interpretation, collective composition, composer-performer interaction, instrument building and free improvisation began gaining strength and came close to those I had experienced as a traditional instrumentalist. At the same time, the differences and potential weaknesses rapidly became apparent when compared with a more traditional instrumental setting. Perhaps the clearest issue was the lack of a repertoire for our chosen media. The vast majority of pieces for percussion and electronics were written for electronic fixed media (tape or CD recordings), which acted as a soundtrack to showcase the virtuosity of the solo performer (this was also the case for the format of other works for solo instrument and electronics, such as Jean Claude Risset's *Invisible* for soprano and tape (1996), Horacio Vaggione's *Taléas* for recorders and electroacoustics (2004), and Jonathan Harvey's *Other Presences* for trumpet and electronics (2006).

The task for the two electronic performers was to transform the way we presented the fixed media by adding slight filtering and spatialisation to both the soundtrack and the amplified percussion, as in pieces such as Javier Álvarez's *Temazcal* (1984) for maracas and soundtrack or Alejandra Hernández's *Pies, para qué los quiero* (2001) for multi-instrumental set and soundtrack. At the same time, we began an extensive collaboration process with several composers, commissioning new pieces. These collaborations revealed some of the interesting tensions and challenges of our novel format: composers were presented with the computer and its performer as an interpreter with whom to collaborate, raising a long list of questions that could only be answered through experimentation in an ensemble setting.

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modular paradigm of Max Matthews's Music-N programming system, only in a visual representation. For its current version, see http://cycling74.com/products/max/.

Another interesting point of creative tension for the trio was the desire to continue the improvisatory work side-by-side with the evolving repertoire. This led us to ask composers (and ourselves as part of the composer's force for the trio) to push as far as possible the notion of the trio as a non-improvisatory entity, encouraging the fixing of instrumentation, notation and all other elements common in traditional instrumental composition.

The variety of approaches each composer took towards the different functions of the two computers within the ensemble, the clear difference in familiarity and results for structuring the instrumental and electronic parts of the compositions and my own frustrations and unanswered questions regarding notation, instrumental virtuosity in the computer and the tension between the roles (composer, performer and instrument designer) that were natural to the computer performers, led to the formalisation of the initial questions of the present research project:

- What is the role of the performer in electronic music?
- What can he or she contribute to a music practice that can be infinitely precise?
- Can the computer become a musical instrument?
- What are its possibilities, and what are its limitations?

The research I have conducted as a doctoral candidate is focused on the development of a performance practice in computer music; as such, I was confronted with the need to bring to light the unique performative qualities of a computer music performer. Therefore, it became necessary to find a methodology that would enable the development of a set of musical elements inherent to electronic media as well as their presentation in performance.

Some of the activities I was able to identify at the beginning of my research trajectory were as follows:

- Dividing the roles of composer, instrument builder, and performer.
- Composing, focusing on the importance of the generation of timbre and its manipulation over time.
- Instrument building, mapping, parameterisation; design of possibilities and limitations.
- Performing and interpreting.

In my experience as a performer of music with live electronics, composers often understand that electronic media makes a rich timbral contribution to their creative palette. They also think of a traditional instrument and its performer as an indivisible entity. But to think of electronic media as a material to be enriched by the interpretative musicianship of a human performer, it is necessary to conceive a strategy from both ends.

During my research journey of the last six years, a key shift took place in the way I considered the indivisibility of the roles of composer, performer and instrument builder in computer music. Having previously considered such indivisibility to be one of the problems that needed to be overcome in the field of live electronic music, I came to accept that – in light of the outcomes of the different experiences conducted and the nature of the media itself – composer, performer and instrument builder not only are indivisible in electronic music but also demand a set of skills from practitioners that can be understood and presented as what in traditional instrumental performance is defined as *musicianship*.

The case studies I am presenting in this thesis expose the different topics that I believe to be most relevant in the search towards formalising a performance practice in computer music. They emphasise an understanding of the multi-threaded role of the practitioner as it is, presenting aspects of each one of these roles in light of the influence of the other two and in different contexts. In doing so, these case studies emphasise the following two topics:

Interpretation, understood from three different perspectives:

- Reconstruction, as proposed in the interpretation of Luigi Nono's *A Pierre. Dell'azzurro silenzio, inquietum* and *Post-prae-ludium nr. 1 per Donau*.
- Reinterpretation, as proposed in the interpretation of John Cage's *Aria/Fontana Mix*.
- Re-appropriation, as proposed in the interpretation of Morton Feldman's *The King of Denmark.*

Creation: five case studies focusing on different aspects of computer music practice:

- On *Accumulation of Hesitation: Timbre Networks* and mapping as compositional strategy.

- On *PLP*: the score as the condensation of improvisational processes.
- On KVSwalk: bringing sonification strategies onto the stage.
- On *Flux*|*Pattern*: the etude as a compositional form in live computer music.
- On Multiple Paths (omaggio a Nono): the transformation of physical space over time as a musical parameter

Given that computer music is frequently analysed, discussed and researched in relation to the technology involved – the ways of producing, transforming or transmitting sound – this research aims to contribute to shifting the focus of research and exploration in computer music towards an area that can benefit from other musical/philosophical and aesthetic discourses, such as historical context, the relationship between the performer and his or her instrument and the interdependence of composers and performers. Through this research process, I hope to be able to identify these relationships, use them to approach existing repertoire, and create new works informed by them.

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On Interpretation Paths

During my research trajectory towards a performance practice in computer music, as a composer and a performer I have constantly dealt with the problem of *roles*. By this I mean the understanding that computer music practice demands that practitioners merge or *blend* in one person the roles of composer, performer and instrument builder/technician. At present there is almost no tradition of computer music practitioners trained or focused on interpretation of live electronic repertoire. Composers often become the performers of their own works; therefore, they become logistically bound to the presentation of their own music in front of an audience.

In addition to this many of these composer/performers also became the designers and builders of the instruments they were playing. Facilitating the creation and performance of works dealing with electronic instruments from the position of the interpreter was my initial motivation to develop a performance practice, and consequently, an *interpretation* practice where I could put my technical and musical skills at the service of others.

The development of interpretative skills brings with it the inherent challenge of searching for suitable repertoire that either explicitly demands the expertise of a computer performer in charge of the electronic media component of the piece, or presents a potential for such a musician to contribute his or her skills to the performance of music not written for electronic instruments.

I will present three case studies serving different initial needs and skills, detailing occasions on which I became familiar with and helped develop performance tools and techniques. Each of these case studies responds to a different approach for understanding the notion of interpretation: I have called these three categories *reconstruction*, *reinterpretation* and *re-appropriation*, depending on the degree to which the traditional notion of music interpretation was challenged. These categories are connected to the three sets of skills inherent to my understanding of the figure of the electronic musician (composer, performer and instrument builder) and how these skills are initially better suited to address the performative task. The three case studies are:

- Luigi Nono's *A Pierre. Dell'azzurro silenzio, inquietum* and *Post-prae-ludium nr. 1 per Donau,* dealing with interpretation as *reconstruction*, starting from the skill set of the computer music performer as technician/instrument builder.
- John Cage's *Aria/Fontana Mix* dealing with interpretation as *reinterpretation*, starting from the skill set of the computer music performer as a performer, recovering a pre-existent performance practice.
- Morton Feldman's *The King of Denmark,* dealing with interpretation as *re-appropriation*, starting from the skill set of the computer music performer as composer, informing music interpretation.

These case studies served as antecedents to my own compositions developed within the framework of this research trajectory.

Reconstruction: On Luigi Nono's *A Pierre* and *Post-prae-ludium*

Introduction

One of the problems inherent in the preservation and dissemination of live electronic music is the dependence of many such works on a specific set of tools. The use of apparatus created primarily for the recording and reproduction of sound (microphones and tape recorders) or for the measurement and testing of signals in the studio environment (tone and noise generators) is intertwined with the beginning of electroacoustic music. The transition from adapting these machines for creative purposes during the 1950s towards the construction of dedicated tools for electronic music creation during the 60s and 70s, as well as the advent and democratisation of computer technology during the 80s and 90s into the present, has created a flow of technological development, and therefore, of technological obsolescence. This has contributed to a difficulty in preserving musical works created with a specific technology in their original format, posing serious problems for the sustainable reproducibility of compositions involving live electronics, and therefore, for establishing a core repertoire to relate to as practitioners.

There are two main approaches to tackling this issue. The first approach advocates fidelity to the original conditions under and in which the piece was created, and defends and promotes the use of the original tools and technical setups.[15] Although this would arguably be the ideal choice, particularly since the inherent limitations of certain tools are as obvious in the final result of a piece as are their declared features, the practicalities of such an approach negatively affect the potential of this music to be widely disseminated since it requires not only equipment that is difficult and costly to acquire and maintain but also a build-up of time and manpower that prohibits access to the setup for extended periods of time in contexts outside big, well-funded productions.

A second approach towards the preservation of live electronic music works is focused on dissemination and transferability. Starting with the acknowledgment that the

[15] Such is the case in several of Steve Reich's productions of pieces requiring AKAI samplers and their floppy-disk-loaded sound banks, and, more pertinently to this thesis, performances of music by Luigi Nono produced during his time at the Experimentalstudio der Heinrich-Strobel-Stiftung des Südwestfunks in Freiburg.

replacement of certain components or tools in the original setup of a piece will undoubtedly transform the final sonic result, this approach chooses to design digital models (mainly in software) of the entire system required for the reproduction of a piece. Although this reduces the costs while increasing the possibility of dissemination, it generates a new set of problems: first, the inherent limits of the tools are lost (along with their impact in the decision making process of the composer while making the piece); second, there is a lack of standardised computer tools.

The paradox of replacing potentially obsolete technologies with current ones is that the notion of currency has become increasingly ephemeral, particularly in digital media. Anyone familiar with current consumer-oriented computer technology has suffered the pressure to accept a schedule of obsolescence that gets shorter and shorter. This means that – even when the software tools created and used by computer musicians attempt to remain stable and backwards-compatible – the operating systems of the platforms used to run these tools might have a completely different agenda.[16]

Context

In the 1980s, the last decade of his musical career, Luigi Nono felt the positive impact of technology on culture and its contribution to social emancipation. At the same time, his output departed from the directly political topics he raised in his earlier works and began exploring the creation of music that proposed new ways of listening. These explorations culminated in *Prometeo* (1984), featuring texts by Hesiod, Friedrich Hölderlin and Walter Benjamin, which explores the origin and evolution of humanity. Nono's shift towards a timeless and visionary context, which questions and challenges the relationship of oneself with the environment through listening, is expressed in his beautiful 1983 text "L'errore come necessità" (Nono 2001: 522):

[16] The endless back-and-forth exchange between publishers and potential performers of pieces using digital live electronic elements has become an almost unavoidable part of the preparation process of a performance – a process that discourages many non-technically-oriented musicians from approaching this repertoire.

> Silence.
> Listening is very difficult.
> Very difficult to listen to others in the silence.
> Other thoughts, other noises, other sounds, other ideas. When one comes to listen, one often tries to rediscover oneself in others. To rediscover one's own mechanisms, system, rationalism in the others.
> And this is a violence of the utmost conservative nature.
> Instead of hearing the silence, instead of hearing the others, one often hopes to hear oneself once again. That is an academic, conservative, and reactionary repetition. It is a wall against ideas, against what is not yet possible to explain today.
> . . . To listen to music.
> That is very difficult.
> I think it is a rare phenomenon today.
> . . .
> Perhaps one can change the rituals; perhaps it is possible to try to wake up the ear. To wake up the ear, the eyes, human thinking, intelligence, the most exposed inwardness. This is now what is crucial.[17]

Pianist and musicologist Paulo de Assis (2014: n.p.) remarks that

> Nono's late works bring the inner musical structures and features to the foreground, focusing on small instrumental forces, on subtle harmonic fields and clearly differentiable vertical sound-aggregates, on extreme soft dynamics and fine articulation markings, on fragmented successions of sections, and on a highly elaborated dialogue with old historical forms. The act of *listening* to these works becomes a highly demanding process – the listener being confronted with his/her own capacity of listening.

Works from Nono's late period require a completely different attitude to the conception of the work as a whole: sound perception, flexibility in the notation, the behaviour of performers, and positioning musicians and audience in the concert space. Regarding this concert space, musicologist Angela De Benedictis remarks that it "was conceived as an environment in which spatial and temporal relationships could form part of a total dimension both in acoustic terms (with the multiplication and spatialization of the sound sources) and visually (by eliminating the separation of stage and auditorium)."

[17] Translation by Paulo de Assis.

(De Benedictis 2013: n.p.) The antecedents for this use of the space in Nono's work come from the polychoral practice of the composers of the San Marco Basilica in Venice, such as Andrea and Giovanni Gabrieli and Adrian Willaert. (Raposo Martín 2009: 281)

Nono's search for an ever-moving sound to activate the concrete and perceptual musical space he was proposing, what he calls the *suono mobile*, dates back to his *Epitaffio No. 2* from 1952 – in other words, before starting to work with live electronics.[18] "The execution of the same sound by different instruments situated on different points onstage, carries a stereophonic, spatial, group quality that conditions and modifies how the total sound effect that reaches the audience is heard."[19] (Raposo Martín 2009: 277)

In preparation for performances of his large later works involving electronics, such as *Prometeo* (1984), *Caminantes…..Ayacucho* (1986–1987) and *No hay caminos, hay que caminar.....Andrej Tarkowskij* (1989), the position of the performers was determined by a careful calculation of the resonance characteristics of the venue. As a result, the orchestral groups were placed in different parts of the performance space to achieve the desired spatial trajectories for the sound lines between instruments.

Since the function of the live electronics in these works was primarily to extend, expand and project the instrumental resonances onto the physical space, for every new performance a new adaptation of placement and programming of the electronics was required, and thus flexibility in musical notation was necessary, as well as a sensitive understanding of the performer who must react to the subtleties of micro-variations in pitch, dynamics and timbre. In relation to this, Claudio Abbado (1999: 4–5) remarks that

> While it is true that the acoustics of a hall will influence the sound of any music, the works of Nono have to be actually recreated in every new hall. It was a profoundly moving experience to bring Gigi's music to life together with young musicians [Gustav Mahler Youth Orchestra], to explore boundaries, to overcome limitations, to realise the

[18] Luigi Nono introduces the term *suono mobile* in his handwritten notes for *Guai ai gelidi mostri* (1983). (Nono 2001: 491–492)
[19] My translation.

> challenges of the score in ever changing circumstances: in other words to find new ways to new music.

In this last creative period, Nono also challenged the nature of the performative unit created by interpreters and their instruments – whether traditional or electronics. Highly accomplished performers were required to display a kind of "static" virtuosity: utmost concentration and control of the most subtle changes in sound, while retaining the ability to interact with the rest of the group. Nono's considerations of the potential of live electronics helped create a new "musical space" in order to challenge both audience perception and the spatial conventions of the concert situation, as well as the instigation towards performers to challenge their relationship with their instruments. These are elements that not only influenced my work as a composer – as I will explain in the case study "On *Multiple Paths*" – but also prompted me to reflect upon and make decisions about the demands towards the reconstruction of the technology and the performance practice of the electronic setups for his *A Pierre. Dell'azzurro silenzio, inquietum* and *Post-prae-ludium nr. 1 per Donau.*

Project

I have been fortunate to work on Luigi Nono's music in different capacities. My most striking experience was as a technical and artistic collaborator on the project "Seizing the Ephemeral", led by musicologist Friedemann Sallis of the University of Calgary and conducted at the Banff Centre for the Arts in February 2009. This musicological, technical, and artistic research project aimed to unravel the musical secrets of *A Pierre. Dell'azzurro silenzio, inquietum* (1985), for contrabass clarinet in B ♭ and contrabass flute in G, and *Post-prae-ludium nr. 1 per Donau* (1987), for tuba and live electronics, to "capture, for conservation, transmission and study, those aspects of Nono's late work that can not [*sic*] be notated conventionally." (Burleigh and Sallis 2008: 1)

From now on, when mentioning this works, I will use the abbreviations *A Pierre* and *Post-prae-ludium*, respectively.

According to Sallis (Burleigh and Sallis 2008: 1),

> *A Pierre* and *Post-prae-Ludium* involve real-time manipulation of sound, producing micro-tonal variation and spatial distribution of sounds and [...] these aspects have the

> effect of short-circuiting traditional musicological analysis. The musical scores provide reliable information for the preparation of a performance, however, as the editors admit "the acoustic and dynamic result [of a concert performance] will not correspond to the graphic notation."

Since the graphic notation used to represent the actions of the live electronic component did not correspond with the sound result of the piece, it was necessary to look into the actual sound results to understand better the musical structure.

The method of the "Seizing the Ephemeral" project was, first, to produce a recording of both pieces, and, at a later stage, to analyse, study and interpret the recording by incorporating sonograms and other computer-based analyses into the traditional study of the score. In addition to the recording, the research data included interviews with the performers at the different stages of the project (preparation, rehearsal, concert and recording).

Initially, my involvement in this project was purely technical. The task was to create computer models of the original live electronics setup, to allow the performers and researchers involved uninterrupted access to the whole musical system for an extended period.

One of the drawbacks with creating digital versions of early electronic music setups are the choices that occur in the mapping and design of the interface. Unless one is using commercial software and adapting the signal processing and routing to the features and limitations of that software, the decisions made in rendering the functionality and signal flow will almost inevitably make the designer the most suitable performer of the system.

For this reason I was invited to become more involved in the project as a performer, thus expanding my own artistic involvement with the pieces through searching for connections between the score and the intrinsic potential of the electronic components of the two pieces. What is presented as notation for the electronic performer in the scores is more a suggested guideline for actions based on previous performances, rather than the product of a preconceived musical idea devised by Nono. I considered that by unravelling the potential interpretative opportunities available in the relationship

between traditional instruments and electronic systems, I could both find my own artistic position and help to define what an electronic performer could contribute to these works.

I will now describe the electronic setups for both pieces, how I reconstructed them in the digital domain, what musical salients I identified in the reconstruction process and how they influenced my artistic choices.

A Pierre

The electronic setup consists of two delay lines set to no feedback, which results in a single repetition of any incoming signal. The delay times are twelve seconds for the first delay, and twenty-four for the second (which is effectively another twelve-second delay on top of the first). Anything played is thus repeated twice: first twelve and then twenty-four seconds later. The choice of these durations is far from arbitrary: they are the result of studio experiments conducted by Nono in collaboration with Hans Peter Haller at the Experimentalstudio der Heinrich-Strobel-Stiftung des Südwestfunks in Freiburg, whose goal was to find the threshold of short-term auditory memory. This twenty-four-second threshold emerged as the necessary time span to perceive a repeated sound event as new and thus no longer connected to its source. Further experiments targeted shortening this time span. Nono and Haller observed that if the repeated event was presented with an alteration in its timbre (filtered), the time span between original sound and repetition could be shortened by half: a filtered repeated event was perceived as new after only twelve seconds.[20]

This constitutes the entire electronic setup for *A Pierre*: an initial sound event is filtered and presented twelve seconds later, and presented again, unaltered, twenty-four seconds after its original exposition. The live electronic performer must make musical sense of this reality to help shape the structure of the piece.

[Media: How is *A Pierre* set up: Scheme, score and audio excerpt]

[20] This kind of experimental setup is very interesting since it merges a psychoacoustic enquiry with an artistic one. Most research done on auditory time spans focus on either echoic memory (short-term span) and its connection to memory development and speech. (Anderson 1939: 95) Connecting these lines of research directly into the creative experimental process is what makes Nono so fascinating.

If the electronic performer were to stop analysing the piece once the technical setup was successfully reproduced, there would be little else for him or her to do other than to control the potential feedback from the microphones once they start picking up repeated information coming from the loudspeakers, and to balance the overall dynamics of the amplified instruments and the delayed signals. Were this the only job at hand, it would be easy to feel disappointment that there was not more to access – and therefore, influence – in the musical development of the piece.

My personal approach to the role of the electronic performer in *A Pierre* was to study the instrumental score to understand the challenges Nono set for the instrumentalists, and from there to consider how I could relate the electronic system to those challenges. In doing so I found a performance strategy informed by the material itself and not only based on aesthetic choices made by previous performers.

What I discovered was a deceptive simplicity. The score of *A Pierre* is written in 4/4 and has a tempo marking of ♩= 30. At first glance, there are very few events per bar (if we want to use note density as a measure). But precisely herein lies the stimulating aspect of this piece: the apparently simple tasks required from the performers become extremely complicated because of two factors.

The first factor – what I referred to above as the challenge of the performative unit – is to place performers in conflict with their instruments by demanding actions and sounds that go against their nature. Nono's choice of dynamics and pitch make this true for both the flautist and the clarinettist. For most of the piece, the performers are asked to play at the top of their instrument's pitch range but with extremely soft dynamics (*pppp*), which requires a high level of tension and gives very little control over the result – they play on the verge of breakdown. What this creates is only the first layer of confusion in this piece. It is extremely difficult for anyone playing, once the instruments are amplified and the sounds are being repeated in the space, to connect with certainty any actions with the sounding results.

The use of fermatas creates a second level of confusion for the performers. Their durations are up to the discretion of each performer, with suggested durations of six to eight seconds. These successfully destroy any sense of temporal stability in the otherwise rigid grid of 4/4 at ♩= 30. So even if one performer wanted to stay in the grid, the other will have a six- to eight-second temporal suspension, which, added to the

kind of sound material being produced, breaks any hope of metric stability. This confusion is already present before adding the layers of delayed instrumental sounds.

During my collaboration with the “Seizing the Ephemeral” project, I had the opportunity to reflect upon how these elements of the instrumental part of *A Pierre* influenced the setup of the electronic system and how they could potentially be reinforced by the performance of the electronic part. Given that the goal of the project was to shed light on the musical and structural elements of the piece that are absent in the score, I felt encouraged to introduce my take on Nono’s technical and creative choices into the performance as much as possible.

Although using digital technology to reproduce analogue electronic equipment, I attempted to preserve the inherent limitations of the automation and routing of the original setup, considering them part of the identity of the electronic instrument. In the case of *A Pierre* and *Post-prae-ludium,* these limitations of the original material are, more than technical considerations, connected to cost, dimensions and availability. The use of dedicated hardware for each delay and filter necessitates a number of routing choices given the number of inputs and outputs and the processing power of the tools. The routing choices seem arbitrary when dealing with a computer-based version of the setup. It was, and still is, my opinion that these choices are not only an essential contributor to the sonic and structural identity of these pieces, but demand from the electronic performer decisions that lie between the technical and the artistic and, therefore, should be preserved when dealing with computer models.

I wanted to draw a connection between the apparent simplicity of the score and the unravelling complexity of the musical result. The challenge was to relate the task of keeping the balance between input and output levels for the electronic performer to the playing of very high pitches at very soft dynamics by the instrumentalists.

In the rehearsals conducted at the Banff Centre, with Marieke Franssen on contrabass flute and Carlos Noain Maura on contrabass clarinet, it became clearer that one of the biggest challenges was to control feedback in the system. This feedback was induced by two factors that were part of the original setup: The sound projection is done over four loudspeakers, two directly behind each performer and two at the back of the hall. Since two microphones capture the sound of each performer and they sit directly in

front of a loudspeaker, the amount of sound emanating from the loudspeaker that is recaptured by the microphone is quite substantial. To avoid immediate feedback, the electronic performer must constantly act as a real-time, human limiter-compressor who opens the microphones when the instruments are playing but reduces their sensitivity when the repetitions come back too loudly through the front speakers. Accepting this task plunges the electronic performer into the twelve-seconds/twenty-four-seconds cycle of the piece and leads to more calculated choices for the sound location of the repetitions within the performance space.

[Audio excerpt: Demo of the twelve- and twenty-four-second delay cycle, and the room feedback that needs to be controlled]

The second source of feedback – an additional challenge for the electronic performer – comes from the use of band-pass filters to modify the first wave of repetitions. The schematics for the piece indicate that the incoming direct signal of each instrument's microphone must be routed to the opposite speaker (so that the direct amplified sound of the flute comes from the speaker behind the clarinet and vice versa). In performance, this adds an extra layer of confusion, which makes controlling the feedback induced by the heavily filtered repetition entering the microphone (and going to the opposite front speaker) extremely difficult.

All these elements make the system very sensitive and fragile. The musical challenge that *A Pierre* poses to the electronic performer resides in controlling and balancing the overall sonic texture.[21]

[Media: sound excerpt of *A Pierre*]

[21] Although some computer-based performances of this work take advantage of the automatisation and dynamic limiting and compression possibilities of today's sound amplification technology, I strongly advocate preserving the risks of the original setup as the starting point for the creative contribution of the electronic performer in a concert situation.

Post-prae-ludium

The creative process for *Post-prae-ludium* was somewhat similar to the one of *A Pierre*. Intended as the first of a series of pieces for solo instruments and live electronics written by Nono for (and with) his close collaborators, it ended up being the only one of these works ever officially finished. Created in collaboration with tubist Giancarlo Schiaffini, the piece employed an experimentation process that started with the documentation of the extremes of the frequency and amplitude ranges of the tuba. Schiaffini remembers being asked to present his personal range extremes on the tuba, as well as his own approaches to timbre transformation. All these findings were then used as source material, organised on a score with a timeline, which provides a "traditional" linear progression to the time structure of the piece. Schiaffini recalls that "we experimented with different instrumental and live-electronics techniques. Sometimes it was a kind of improv to be recorded and studied." (Tignor 2009: 9) In addition, to adapt the sound to the musician, Nono was known to explore the instrumentalist's sound world within experimental sessions such as this. Schiaffini states that "the composition was tailored to my technical possibilities; he wanted to know different transformation of sound (1st page), then the highest and the deepest pitch, the most powerful (loudest) and on these extremes (as *fffff* and *ppppppp*) he built the composition." (Tignor 2009: 9)

Just like the apparent rigidity of the notation grid of *A Pierre, Post-prae-ludium* proposes a path to the performer where the first step of the journey seems to dissolve the apparent rigidity of the path itself. The piece is divided into five sections for the tubist and four programmes for the electronics, each of which are assigned to one of the sections of the piece. Extremes of pitch and the timbral limits of the tuba are explored in the instrumental part and are further shaped and expanded by a series of spatial and temporal displacements controlled by the electronic performer.

[Media: How is *Post-prae-ludium* set up: Scheme, score, and audio excerpt]

Originally, this piece required two technicians for the opening section. In this section the electronic setting consists of four delays of fixed duration (five, seven, ten and thirteen seconds of time difference) feeding into a double spatial rotation system developed by Hans-Peter Haller (and therefore named the *Halaphon*). The function of the first technician was actively to open and close the input of the tuba signal routed to the different delays, while the second one varied the speed of the Halaphons, which

rotated in opposite directions (clockwise and counterclockwise). This produced an unpredictable layer of delayed and chopped-up tuba sounds that appeared unexpectedly from the speakers located in each corner of the room.

[IMAGE: Score of *Post-prae-ludium*]

The score shows how the tuba player needs to switch from system to system, selecting the musical material offered, which depends on the path chosen. The score also presents a suggested dramaturgy for the opening and closing of the delay inputs that, given the different speeds of the halaphone and the choice of material produced by the tubist, inevitably creates different sound results from one performance to another.

[MEDIA: sound example]

Haller (Haller 1999: 13) mentions that

> Nono thought of the interpreter as an equal partner in his work. He considered the instrument and its player, a voice and the personality of the singer, as a unity. In his imagination an abstract sound could exist, but usually he connected it with the personality of an interpreter. [...] The flautist Roberto Fabbriciani played with his mouth and nose very close to the microphone; as a result of this experiment, the musician was able to additionally produce wind sounds with his breath directly in the microphone while he played a normal sound. [...] This playing technique represented one of the materials which Nono used for the flute part of *Das atmende Klarsein*, electronics sound extensions by means only of the microphone.

Although these timbral transformations might seem rudimentary compared to the possibilities of manipulation of timbre in electroacoustic music today, it is fair to say that no fundamental evolution has taken place in the world of signal processing in the digital domain since then.

Post-prae-ludium was studied, performed, and recorded during the “Seizing the Ephemeral” project, with tubist Tjeerd Oostendorp. In this piece, the main challenge for me was to adapt the original electronic setup, conceived for two electronic technicians, into a system controlled by one single performer, while preserving the limitations of

both the original system and the tasks assigned to each technician. Rather than using automatisation procedures in the digital domain, I opted for a simplified layout of the entire system interface where, emulating a rack of hardware equipment, I had all effects available and active at all times, and could activate any of the sections at all times, rather than shifting between each module or "programme". In doing so, I succeeded in preserving the challenge of gatekeeping the incoming signal of the tuba, while being able to follow the path delineated during the performance and activate/deactivate each section of the electronic setup accordingly.

Reflection

A close examination of the tools Nono used in his pieces with live electronics reveals how he was able to devise performative strategies that transcended the limitations and characteristics of the time and place in which these tools were created. His timeless, and therefore very current, musical notions are instrumental to my understanding of *musicianship* in live computer music. They can be distilled into two key concepts, which I will elaborate later: the transformation of the physical space over time and the challenge of the performative unit.

In addition, in the case of *A Pierre,* as in most of Nono's pieces for multiple instruments and live electronics, there is the goal of *con-fusion*, understood as "fuse-with". This is a task given to the traditional instruments, the aim being to create a common timbre by weakening the upper harmonics of the instrument (therefore generating a signal as close as possible to a sine-tone). The demand on the electronic performer is to deal with the delicate challenge of amplifying this con-fusion without adding any extra colour to the global spatial mix. For this reason, the use of compressors or limiters for the incoming signal is not recommended, since they might introduce a slight colouring that could potentially destroy the illusion of fusing the timbre of the two instruments.[22]

[22] These ideas about con-fusion, as well as the technical and aesthetic functions of using very weak instrumental sounds, come from my personal notes taken both during the course on interpreting Luigi Nono's, conducted by André Richard (et al.) at the Fondazione Giorgo Cini, Venice, Italy, 2–7 November 2007, and during the performance and recording sessions of *A Pierre. Dell'azzurro silenzio, inquietum* and *Post-prae-ludium nr. 1 per Donau*, organised by Friedemann Sallis at the Banff Centre for the Arts, 20–27 February 2009.

As a composer, I wanted to extract this information and reshape it in my own musical output using the experiences gained in the reconstruction of the tools and performance strategies of these two works by Nono. This was the initial impulse for the series of experiments leading to *Multiple Paths (omaggio a Nono)*. As a performer, in order to transition from technical translation into performative analysis and decision-making, I sought to find points of connection between the inherent qualities of the original electronic setup and the instrumental score. The multithreaded role of the computer music practitioner reveals itself in this project, unfolding the creative and performative demands of a task that was meant to be purely technical: to create a digital version of the original electronic setup. This is what I call interpretation as *reconstruction.*

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Reinterpretation: On John Cage's *Aria/Fontana Mix*

Introduction

This case study deals with the notion of *reinterpretation*, understood as the process of recovering not only a particular piece of music but also the circumstances of composition and original performance of the work in order to adapt them for a performance with electronic instruments. Although they are nowadays considered and performed as individual compositions, *Aria* and *Fontana Mix* were first performed together as a single work. This was the point of departure for me to (a) review the compositional procedures behind the creation of *Fontana Mix,* (b) apply them in the design of a musical instrument to be used in performance, as complement to *Aria*, and (c) propose a simultaneous performance of both works following the score of *Aria* as a structural guideline.

Context

One aspect of John Cage's compositional strategies was his concern with the role of the performer's contribution to the musical structure of a piece. His abandonment of harmony, and attempt to define structures based on rhythm, opened a creative path that can be illustrated with his early percussion works. The search for new sonorities to fill these structures moved him to extend Henry Cowell's experiments with preparing the piano and, at a structural level, to deal with the importance of silence as musical material (presented *in extremis* in his *4'33"*). But more important to Cage's output was his quest for a new philosophical approach to musical phenomena: "I was to move from structure to process, from music as an object having parts, to music without beginning, middle, or end; music as weather." (Cage 1993: 243–44)

This focus on *process* rather than on a predetermined structure led Cage to create pieces in which the musical result was entirely dependent on the performer's creative contribution. The performer's influence on Cage's musical output can be perceived through the work of, among others, David Tudor, one of Cage's closest collaborators. Tudor's approach to interpreting contemporary piano music was very meticulous; for each piece that was written with a certain degree of indeterminacy, Tudor would produce a detailed performance score with precise, fixed measurements.

Tudor's approach to *Variations II* (1961), a piece dedicated to him, was slightly

different and marked a departure from the strict notation of performance scores towards a more personal path, a quest that later would lead Tudor towards the creation of his own compositions for live electronics. For *Variations II*, instead of predetermining a time structure for the sound events, Tudor designed a binary process in which each sonic parameter could have one of two values: simple or complex. His performance notation consisted of fifty squares, one square per sound event, presented sequentially in rows on the front and back of three narrow pieces of thick paper. These square notations he called "nomographs." In addition to this non-traditional approach to notation, Tudor incorporated another level of innovation: the use of amplification as a creative resource. He used not just an amplified piano but a system "conceived as an electronic instrument, whose characteristics orient the interpretation of the six parameters to be read from the materials provided by the composer." (Pritchett 2004: 14)

The setup used by Tudor for *Variations II* included microphones placed above and below the piano, contact microphones attached both to the piano body and to a set of stiff springs that were used either to play on the strings of the piano or to serve as connectors between the strings and phonograph cartridges (with inserted objects) that could be used as amplifiers and as exciters for the strings of the piano. Pritchett (Pritchett 2004: 14) describes the setup as follows:

> This setup produces a number of feedback loops. Playing on the strings of the piano excites the various microphones in different ways depending on their placement and nature. When these signals are amplified and played back into the space, feedback is communicated directly through the microphones but also through the sympathetic vibration of the strings of the piano. The whole system presents a very complex interaction of its various parts. Adjusting the levels of the various microphone signals, the ways in which the cartridges are deployed in the piano, and the ways in which the piano is played will alter the behavior of the whole system.

Tudor's realisation of *Variations II* encouraged him as a performer to explore the possibilities of the whole system. The sounds, complex as they were, demanded from him the flexibility to drop ideas and change paths while trying to shape the musical result. His later work as a composer and performer of live electronic music would focus increasingly on the real-time manipulation of sound, reinterpreting Cage's departure from structure towards process and translating it into an even more radical idea: a

focus on performative gestures rather than sonic results. David Tudor's contribution to the fleshing out of Cage's works of this period was then to solidify these processes into sonic identities, reinforcing with each performance the structural salients of the work, acting as a composer from the perspective of performative practice, and, in doing so, mirroring Cage's performativity in his compositional process.

Project

My own interpretation of *Fontana Mix* aims to honour both Cage's and Tudor's legacies. To interpret such a piece today requires one not only to be aware of the different musical and social contexts (something applicable to any "historical performance" situation) but also to expose and revise the technical limitations of the original material, demonstrating how these limitations were, and still can be, used by the performer to present his or her musicianship. Pritchett (Pritchett 1993: 132) accounts the genesis of *Fontana Mix* and its relationship to *Aria*:

> Cage used *Fontana Mix* to compose several other works, beginning with *Aria* for solo voice. This work was composed for Cathy Berberian immediately after the *Fontana Mix* tapes were completed in 1958, and was premiered together with those tapes on January 5, 1959. [...] Here, *Fontana Mix* was used to determine the placement and durations of the events, along with the colors and languages to be used. *Aria* can be performed together with the *Fontana Mix* tapes and any part of the *Concert for Piano and Orchestra*, thus indicating the common ancestry of these three works.

The historical context made presenting *Fontana Mix* together with *Aria* a natural choice, not only to provide a clearer view of the historical circumstances but also as a performative strategy that would redirect the time/place structure of "my" *Aria/Fontana Mix* away from the fixed form of the original (the tape recording) and bring it closer to Cage's ideas of collaborating with performers. I mention this since other reinterpretations of *Fontana Mix,* such as Karlheinz Essl's *FontanaMixer* (2004–2012) and Max Neuhaus's *Fontana Mix-Feed* (1964–1968), have tended to focus on *conceptual* aspects of Cage's work (an approach common in modern interpretations of his work), missing the opportunity of (re)instating a dialogue with the *inceptual* Cage: that is, engaging with and learning from Cage the performer as well as Cage the composer.

Preparing a performance-oriented version of *Fontana Mix* required that the creative process be divided into three parts:

(a) Musical and technical analysis of the original work and its architecture.
(b) Design and creation of "Fontana-Mix: The Instrument".
(c) Elaboration of an event-oriented score, based on the pacing and events of *Aria*.

The sound materials for *Fontana Mix* are recordings divided into six categories that were defined by Cage for his 1952 piece *Williams Mix*. These are:

(a) City sounds
(b) Country sounds
(c) Electronic sounds
(d) Manually-produced sounds (including music)
(e) Wind-produced sounds (including songs)
(f) "Small" sounds (requiring amplification)

For each category I selected three different sounds having lengths varying between 3 and 30 seconds. No two of the eighteen sound-files have the same duration, and each category has a "short" sound (3-7 seconds), a "medium" sound (8-15 seconds), and a "long" sound (longer than 15 seconds). At this stage, my first creative decision was to use the "c" category (the electronic sounds) to invoke some historical sonic references. By doing so, I intended to make a performative repository out of my *Aria/Fontana Mix*. All three sounds belonging to the electronic category are strongly linked either to *Fontana Mix* itself or to other electronic music associated with Cage. The sounds chosen were excerpts from Max Neuhaus's *Fontana Mix-Feed*, a run from Karlheinz Essl's *Fontana Mix Feeder* generative patch, and live recordings of electronic music performances by David Tudor. The second and third steps – the development of the instrument (with an associated performance technique) and the elaboration of a performance score – were realised using the Max/MSP software environment and TouchOSC, a TCP-IP control client for the iPhone. In the instrument, a computer algorithm randomly selects as next-in-queue a sound event from the available sound material, obeying only one rule: never to choose two consecutive sounds from the same category. The reason for doing this was to aim for a continuous flow of contrasting sounds between categories, which I considered a possible point of connection with the way the sound material for the singer in *Aria* was organised.

In addition to the selection algorithm, a number of mild sound-manipulation algorithms were implemented as additional expression tools for the performer: a panning tool, a band-pass filter, and a reverberation algorithm in which length and resonance are fixed but feedback and early reflections are controlled by the performer.

[IMAGES: Snapshot of *Fontana Mix*: the instrument and the TouchOSC controller]

The rehearsal process soon revealed a need to divide the events into two global categories: structural and incidental. In order to create a repeatable structure, some sound events in my version of *Fontana Mix* would remain consistent, appearing after or together with specific events in *Aria*; these could then serve as structural reference points for both the electronic performer and the singer throughout the piece. This led to a slight modification of the instrument in order to allow the electronic performer to recall these specific structural sound events at any time. The sound events in the second, incidental set, remain a mystery to the performers until they appear. Only then can the limited set of sound manipulations (panning, filtering) be used to shape a new sound event into or away from the material that the performer of *Aria* is presenting.

Reflection

Where the interpretation project of Nono's *A Pierre* and *Post-prae-ludium* started from a technical challenge that later informed the composer and performer aspects of the multithreaded role of the computer music practitioner, my involvement with *Aria*/*Fontana Mix* started from a performance-oriented enquiry: to deal with interpretation in electronic music as a process of recovering both historical performance strategies and the material itself. In other words, looking to interpretation *through* performance (what I call *reinterpretation*), opens possibilities to the computer performer that go beyond the materials used, or even the work selected for interpretation. The combination of a traditional notion of interpretation and choice-making processes that traditionally lie in the hands of the composers has resulted in musical ideas that inform my personal practice in a broader performance context.

Aria/Fontana Mix has thus turned into an organic play with various elements of the Cagean conceptual palette: inflexibility of the material, extreme flexibility of the material, chance, the unexpected, control, discomfort, fragility and strength. This play reveals new directions for defining musicianship in live electronic music, invoking a

task that is commonplace for music practitioners but little explored by performers of electronic media: the development of tools and skills that will allow creative expression and decision-making while honouring the aesthetic and conceptual ideas of a different person.

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Re-appropriation: On Morton Feldman's *The King of Denmark*

Introduction

One of the greatest challenges in computer music practice today is the lack of a performance tradition for almost all its repertoire. The sole fact that we still define computer music and live electronic music by the media that are being used rather than by its aesthetic, historic or social relevance, shows a lack of maturity in these areas. Since we are approaching nearly the ninth decade in the production of electronic music, it seems odd that very few attempts have been made to define the positive aspects of developing a performance methodology around this practice. Additionally, little has been done with regard to experimenting with the collision between what it is possible to derive from traditional instrumental practices and what escapes the norm of a traditional instrumental discipline.

A personal method for exploring and challenging these potential points of connection (and collision), has been the definition of a historical and aesthetic context through the interpretation of music that, although not conceived to be performed live by electronic instruments, is suitable for it, given the relationship between its conceptual framework and its manifestation in sound. This is what I call interpretation as *re-appropriation*.

Looking for repertoire to be interpreted in this way, one of the main elements that I search for is feasibility. This requires an analysis of the musical challenges present in the score, as well as an evaluation of the features and constraints demanded from a specific traditional instrument, and how these could be translated into electronic media. The other important element when selecting potential repertoire is the mapping that the composer proposes between the musical identity of the composition and the performative challenge. This demands a specific way of interpretation. It is here that the element of "appropriation" takes place in interpretation. Once the challenges proposed to the traditional instrumentalist in the score are identified, it is necessary to seek a possible answer to the question of why the composer is posing this challenge, and from there restate the challenge, the question and a possible answer in relation to electronic media.

Context

In particular, solo percussion pieces lend themselves to in-depth exploration, as they tend to focus on using and combining diverse sound sources, thereby generating a rich timbral texture. This is something that is not only feasible for a live computer system but allows one of the unique qualities of electronic media to shine. On the other hand, the interpretative challenges presented to a percussionist can serve as an interesting point of departure for the computer performer, as the rather clean one-to-one relationship between physical action and sonic manifestation can be emulated, contrasted and commented on by a computer music practitioner. Finally, the solo percussion repertoire has a history that in many ways parallels the history of computer music in its ongoing evolution from effect – or novelty – towards maturity.

An example of such a solo percussion piece that lends itself to being *re-appropriated* by electronic instruments is Morton Feldman's *The King of Denmark* (1964).

[Sound excerpt: Max Neuhaus version]
Excerpt information: *The King of Denmark* by Morton Feldman. Max Neuhaus (percussion). *Fontana Mix-Feed*, 6 November 1967. John Cage. Realised by Max Neuhaus. Aspen, New York, NY, 1967.

The score consists of a grid of densities, timbres and registers, and although it has a set tempo, in the words of the American percussionist Steven Schick, "no rhythmic coherence emerges. Sounds simply float out, detached and weightless. One instrument has no more sonic gravity than another does. A small bell weighs the same – takes up the same acoustical space – as a large gong." (Schick 1998: n.p.)

[Image: Score of *The King of Denmark*]

In "American Sublime", the music critic Alex Ross reviews the genesis of and reasons behind the title of Feldman's composition:

> There is no mistaking the lonely, lamenting tone that runs through Feldman's music. From time to time, the composer hinted that the horrors of the twentieth century, and in particular the Holocaust, had made other, more ornate kinds of musical expression impossible for him. He explained that the title "The King of Denmark," which he bestowed on a graphic piece for percussion, was inspired by King Christian X, who was

> occupying the Danish throne when the Germans invaded his country in 1940. Feldman proceeded to tell the story, now considered apocryphal, of King Christian responding to German anti-Semitism by walking the streets with a yellow star pinned to his chest. It was a "silent protest," Feldman said. In a way, his music seemed to protest all of European civilization, which, in one way or another, had been complicit in Hitler's crimes.

Whether the original story is true (it has now been documented that the yellow Star of David badge was not introduced in Denmark during the Nazi occupation), Feldman's political view is apparent due to his focusing on this pacific protest, this silent resistance, as well as its human fragility. Feldman translates this silent resistance into performance by removing from the hands of the percussionist what had until then been his or her most important means of sound production – sticks and mallets – and instead has the percussionist produce the sounds with his or her fingers, hands or arms. The sounds produced by the percussionist's actions now become not only soft but also fragile, played with the dramatic intention of producing sounds, or rather, performing actions that lead to sounds, at the limit of audibility – something later explored, for example, in Luigi Nono's works with live electronics.

Flutist Eberhard Blum (Blum 2008: 1) recounts that Feldman's silent resistance not only corresponded to a very clear political statement in music, it also served as a direct answer to Stockhausen's *Zyklus*, composed five years earlier, which featured the expressivity of the solo percussionist in a completely different way:

> In 1956, John Cage had composed the first work ever of this kind, his "27´10.554´´ for a Percussionist." Stockhausen reacted to this pioneering work with his "Zyklus," The soloist places a great number of instruments in a circle enclosing him, according to a plan by Stockhausen. During the performance, the player slowly turns, clockwise or anticlockwise, as he chooses, and executes one of the possible cycles of the composition. It is a most impressive and virtuoso act, one could almost say "expressionistic". Feldman knew this work, as it was performed in New York by the percussionist Max Neuhaus shortly after its completion. He called his own new percussion work "the American answer to 'Zyklus.'"

In contrast to Stockhausen, Feldman's approach to the politics of the soloist led him to propose a performance where the fragility of the sounding results would suggest an equal fragility in the actions of the performer him- or herself.

It was this notion of performative fragility that I wanted to preserve when translating *The King of Denmark* into the electronic domain. The lack of a clear interdependency between physical action and sonic manifestation in electronic instruments led me to rethink how to expose this fragility.

Project

The King of Denmark presents its performer with the challenge of balancing controlled and decontrolled elements. Feldman divided the musical parameters at the disposal of the percussionist in these two categories, providing instructions to the interpretation of dynamics and articulation (always with the same extreme softness, on the verge of not producing a sound), tempo register and duration. Rhythm and pitch are left unspecified. Pitch becomes then a quality absorbed by the timbre of the instruments chosen by the interpreter for his or her setup. Rhythm is somewhat framed by the prescriptions of the other parameters, in as much as the natural resonances of the instruments – their constantly soft dynamics and the way they overlap – suggest the need for a sustained, stable unfolding of the piece. My solo computer version of *The King of Denmark* aims to transfer the notion of silent resistance into the world of computer music by creating an interface between performer and instrument that varies in responsiveness according to the instrumental densities defined in Feldman's score. In this way, the timbral palette remains consistent, as in the original, but the uniqueness of electronic media reveals itself through the emphasis on its disjointed nature, such as in the relationship between physical action and sonic manifestation and in the potential negation of the spatial cause/effect relationship between sonic impulses and resonances.

This approach allowed me to preserve the original challenges posed to the interpreters by the piece, while recovering the feeling of uncertainty towards the sonic manifestation of each sound. Whereas in the percussion a restrained physical effort might deem a particular action too "soft" to be heard, in the case of my version, the intensity and densities of gestures might deem a sound too "early" or too "late".

The software component of the instrument is developed in the Max/MSP environment and consists of two parts: an instance of "bamboo~", a physical model of a wooden percussion instrument developed by computer music researcher Perry Cook as part of

the PhISEM (Physically Informed Stochastic Event Modelling) Library for Csound, and a resonator bank composed of an array of twelve decaying sinusoids.

[Image: Max patch for *The King of Denmark*]

To recreate the uncertainty in audibility present in the original percussion piece, I decided to implement three elements that would help simulate a feeling of instability in the instrument. First, at each hit, the resonator bank would retune itself by rotating through a list of twelve preset pitch values.

[Audio: Resonator bank]

Second, the wooden physical model (bamboo~) was used to feed a granular synthesis engine that in turn was mapped to project the sound at random intervals between four sound outputs, two of which were not connected to any speaker.

[Audio: Bamboo physical model]

The aim of the third element of instability was to transfer the dynamic uncertainty of the original piece into the time domain; this was achieved by creating a non-linear mapping between the software instrument and the physical controller used to trigger it. This controller was a small pad array (Korg NanoPad[23]) that, rather than sending an on/off signal, sent continuous control MIDI values according to how hard the pads were hit.

[Image: Controller]

This controller allowed me to create a variable mapping calculation whereby the input sensitivity for the instrument could vary continuously on the basis of how many pads were hit simultaneously. In doing so, the instrument would change its responsiveness (the time difference between hitting a trigger and hearing a sound), creating a visual gap between action and sound that varied throughout the performance. I decided to

[23] More on the Korg NanoPad can be found at http://www.korg.com/us/products/controllers/nanopad2/.

preserve the original ending of the piece (a sustained G# on a vibraphone) – given that it is the only traditionally notated element – by simply triggering a sample.

Reflection

This case study aimed to capture a particular element of a piece written for a non-electronic instrument and re-appropriate it through electronic media by translating the element in question (dynamic fragility) into time displacement between physical action and sonic manifestation, in order to better illustrate the features of electronic instruments.

By focusing on the fragility of the audibility of *The King of Denmark* and shifting that fragility from dynamic to time displacement (or responsiveness), the piece maintained its nature while presenting a new challenge to its performer. In doing so, it was possible to emphasise a feature in electronic instruments (the nonlinearity between physical action and sonic manifestation), and present it as a tool for expressiveness and performative theatricality.

[Video: Performance of *The King of Denmark*]

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On Accumulation of Hesitation: Timbre Networks and mapping as a compositional strategy

Introduction

This case study presents the search for a creative procedure that would encompass the multithreaded role of the computer music practitioner, demonstrating how certain aspects of instrument design in electronic music can inform the organisation of musical structures and, in turn, the performance practice of the instrument itself.

Context

Timbre Networks: a definition

We can define a network for the present purpose as a system of asymmetric relations between discrete objects that allows an exchange of information between connected objects. Following the notion of connectionism in network theory, better known as *neural networks,* we can say that a model for such a network is "loosely defined around three aspects: computing nodes, communication links, and message types." (Judd 1990: 2) We could then describe *Timbre Networks* as a model for organising the threads connecting the different musical elements that play a role in live electronic music. In using this term I aim for a systematic organisation of the possible relationships between computer, musical instrument(s) and performer(s).

By focusing specifically on timbre and using it as the foundation of these relationships, I aspire to create a system in which the sound sources, on one hand, and their manipulation through performance, on the other, become part of a single entity, in a more concrete sense than would be provided by a mere conceptual definition. In other words, I seek to define a compositional strategy based on systematising the relationship between a determined number of sound elements and their potential interdependence, leaving in the performer's hands the responsibility for unfolding the musical structure over time.

The structure of a particular *Timbre Network* can be characterised as a complex of musical actors (both human and non-human), their interdependent relationships, and

the behavioural developments that can be induced through performance. As a compositional procedure, a *Timbre Network* has to define:

- The nodes (actors) of the network.
- The threads (relationships) between them.
- How those nodes and threads are malleable over time, either through real-time manipulation by a performer or through using predefined interdependent variables.

Once these initial states are defined, additional compositional procedures to develop the time structure of the musical piece may and should be used. The question then arises of whether it would be possible to derive the musical time structure from the timbre network structure itself.

Timbre Networks provides a compositional method for generating *outside-time* structures by focussing on the composition of predefined initial states of a musical system that can (and should) evolve in time through performance. The concept of outside-time structures was introduced by Iannis Xenakis, who made a distinction between structures such as scales or modes (outside-time) and the melodies constructed from them (in-time). Xenakis (Xenakis 1992: 207) points out that

> It is necessary to divide musical construction into two parts [...]: I. that which pertains to time, a mapping of entities or structures onto the ordered structure of time; and 2. that which is independent of temporal becomingness. There are, therefore, two categories: *in-time* and *outside-time.*
>
> Included in the category outside-time are the durations and constructions (relations and operations) that refer to elements (points, distances, functions) that belong to and that can be expressed on the time axis. The temporal is then reserved to the instantaneous creation.

The results of using *Timbre Networks* can be understood as hybrid musical entities with characteristics of both an instrument and a composition. *Timbre Networks* may be seen as a way of applying compositional thoughts to mapping procedures.

The idea of creating a system that generates both the sound and the time structure of a composition has been explored by composers other than myself, most notably by Gottfried Michael Koenig, who had “hoped for (and postulated programmatically) a seamless continuum of timbres; not only between all timbres, but between internally

static sound-colour and musical structure. The goal revealed itself to be the colour set in contours, the fluctuating sound-colour."[24] (Koenig 1992: 78)

This vision was successfully realised in his work *Terminus* (1962). On this composition, musicologist Elena Ungeheuer (Ungeheuer 1994: 32) states that

> a complex sound metamorphosis results from the superimposing of semi-automatic modulation processes, which are not object to further manipulations once the machine has started. The composer does not control the sound elements themselves, but the steps of sound-forming. The musical form – describing a path through the steps of sound modulation – guarantees that structures can be recognised and distinguished.

My departure from defining a "final" path through the steps, and, in consequence, fixing a final version of a piece, led me to the separation of the in-time structure of a composition from the outside-time structure of the timbre network. I did this to emphasise the importance of the performer actively contributing to the unfolding of a musical structure, leaving him or her with the responsibility for its manipulation and development. This is made possible by considering and implementing a compositional strategy which defines the identity of a piece of music principally in terms of initial states.

I would argue that for a musical system (the *Timbre Network* and its sound-interdependent variations) to comprise an interesting set of relationships, its development need not necessarily be governed by an intrinsic time-structure. Nevertheless, music is clearly a phenomenon which unfolds over time, which means that the timbre-network itself must be augmented by a set of in-time relationships contributed by the performer.

Composing the network

The elements of a network may be divided into nodes and threads. In the present case, the nodes are the instruments, which are responsive to the physical control of a

[24] "Man hoffte (und forderte programmatisch) ein lückenloses Kontinuum aller Klangfarben; nicht nur aller Klangfarben, sondern das Kontinuum zwischen der in sich stationären Farbe und der musikalischen Struktur. Als Ziel zeigte sich die in Konturen gesetzte, die bewegte Farbe". (Some specificity might have been lost in my English translation.)

human performer. These may be either traditional instruments or electronic sound sources (such as a computer or a part of the computer system). I describe threads here as the predefined interdependent connections between each instrument. They might be seen as the constraints of the system, but also as its intrinsic characteristics. What is important to acknowledge is that the sound transformations of the instruments are potentially considered both as nodes and as threads. This is to say that the nature and extent of the sound transformation can either change the inner characteristics of a source (creating a new node) or extend the natural character of an instrument (thus generating another thread between two nodes).

[Image: schemata of a Timbre Network]

I consider timbre to be a multidimensional music parameter. To allow the potential timbre complexity of an individual sound source to merge and interact with others in a *Timbre Network,* it is important as a first step in the composition of the network to define the behavioural limits of the sound sources (the initial nodes of our network) and, later, to focus on the inner complexities of these nodes and on how they can be connected within the complex of the network as either:

- Control information passing between two or more sound sources (a thread between nodes)
- Intrinsic richness of the node itself (which will still be subject to variations through performance)

A *Timbre Network* allows a number of computer systems to act in harmony with one another in a range of alternative configurations. Computers can be used as independent sound sources, with or without the ability to be influenced by a performer; thus, a computer system can be seen as both a static and an active node in the network. Computers can also serve as dedicated signal processors for other nodes, or as signal-to-control translators, working as threads between elements of the network. If more than one computer is used within a structure, one of them must assume the role of the core of the network. The core of a *Timbre Network* is the place where node characteristics are extracted and transformed into threads (control parameters) for other nodes, and where the initial settings of node/thread relationships can be stored, recalled and modified.

Project

An example of an actual implementation of the *Timbre Network* concept is *Accumulation of Hesitation* (*AoH*), a piece that I started to compose as a "*Timbre Network* in a box". In this setup, all nodes and threads are generated in a single system implemented in the Max/MSP environment and manipulated by a single performer. A later expansion to *AoH* is a no-input mixer, which serves as an extra source for the network, as both sound generator and control generator.

Architecture of the system

AoH consists of five basic sound sources (nodes) and four engines of sound manipulation (threads). Additionally, the output of each sound source or node is translated within the network into control information to trigger global changes in the calibration of the sound manipulation engines (threads). The pacing of these changes within the predefined boundaries of each calibration state is carried out by the performer.

Sound sources: Nodes

Two of the five sound sources in the *AoH* piece are pre-composed sound-sequences (labelled 1a and 1b) realised at the BEA5 analogue studio of the Institute of Sonology in The Hague, two are instances of "GENDYN" (a synthesis algorithm developed by Iannis Xenakis),[25] and one is a small analogue mixer modified to generate pulses and clean, almost sinusoidal tones.

The pre-composed sequences are two-minutes long and based on similar analogue patches to the ones used in my 2005 composition *Lonquimay.89*.[26] In that piece, fixed timbres were created to be further articulated by a series of behavioural control

[25] A note on GENDYN: created by Xenakis, the dynamic stochastic synthesis consists of waveforms that can vary continuously according to a pre-formalised stochastic function. "Instead of 'curving' the waveform, Xenakis interpolated the breakpoints (samples) in a linear way. The horizontal and vertical proceeding of the points in the successive cycles are calculated on the basis of a probability formula, causing a kind of stochastic amplitude modulation (vertically) and frequency modulation (horizontally). To control the timbres, Xenakis must determine the range of the variation of points of a cycle, so that the more radical the variation, the noisier the timbre, and vice versa." (Penov 2006: 2)

[26] More information on *Lonquimay.89*, including media samples is available at http://juanparrac.bandcamp.com/track/lonquimay-89.

patches generated in the ACToolbox[27] environment created by Sonology faculty member Paul Berg. The sequences used in *AoH* comprise four superimposed layers of sounds: tone changing to pulse, pulse to tone, static tones to silence and static pulses to silence, each with an independent rate.

The next two sound sources (labelled 2a and 2b) are produced by "gendy~," an abstraction of the dynamic stochastic synthesis algorithm developed by Iannis Xenakis and ported into the Max/MSP environment by Sonology faculty member Peter Pabon at the Institute of Sonology of the Royal Conservatoire of The Hague.[28]

The fifth sound source in *AoH* is a small analogue mixer, the audio outputs of which are connected to its inputs. This permits the generation of simple pulses and quasi-sinusoidal tones from internal feedback. Although audible throughout the piece, the main purpose of this last sound source is to provide continuous control-information threads for the manipulation engines affecting the other two sources.

Additionally, every node has its own set of parameters that are already defined and stored in presets. In the case of the pre-recorded sequences, these parameters are playback speed, playback direction and loop points. For the gendy~ engines, the parameters are:

- Frequency
- Distribution warping
- Jitter mask for period-to-period fundamental frequency variation
- Size of the random number tendency mask for Y-axis variation
- Number of break point samples in the buffer for Y-axis variation
- Time-warping factor
- Size of the random number tendency mask for time axis variation
- Number of break point samples in the buffer for time axis variation

[27] For more information on the ACToolbox, see http://kc.koncon.nl/downloads/ACToolbox/.

[28] The original work by Pabon on the porting of GENDYN onto the Max/MSP environment has been continued and further documented by Johan van Kreij. For more information, visit http://www.jvkr.nl/home/files/gendy-non-standard.html.

Sound manipulation engines: Threads

Each of the sound sources communicates with the others through a sound manipulation engine, which affects its sonic properties directly and provides control information for the sound manipulation of each of the other sources. An exception to this connection is the external analogue mixer, which only provides control information to the other sources and does not receive control information from anyone other than the performer. The engines of sound manipulation are:

- Sound spatialisation
- Reverb/freezing
- Pitch shifting
- Granular synthesis

The changes from one preset to another for every node are triggered during performance in two ways: (1) when any of the sound manipulation engines crosses a predetermined threshold value, or (2) when signals produced by the analogue mixer induce a sudden shift in those values.

Connecting the network

Each sound source in *AoH* is connected to two different sound manipulation engines, but only one of the connections is made audible. The non-audible result is transformed into control information, which continuously modifies one parameter of the three remaining engines. For example, sequence 1a is sent through both granular synthesis and pitch shifting. While the granulated output is audible, the pitch-shifted sequence is converted into a numeric value to control:

- Reverb size value (audibly affecting gendy~ 2).
- Sound spatialisation, randomly chosen from a list of start and end points and time durations of the spatial trajectory (audible in sequence 2b).
- A tendency mask[29] for grain density (audible on sequence 1a itself).

[29] Developed as an electronic music concept by Gottfried Michael Koenig, and implemented in algorithmic composition by Paul Berg, a tendency mask is a set of dynamic boundary points between which elements will be selected at random or according to various other kinds of statistical distribution.

Performance control

AoH is intended to have a performance-driven compositional structure; therefore, in addition to the internal changes of the system due to the network connections, a performer is required to control the pacing of the overall result and to refine the variations in every sound transformation parameter. Additionally, the performer has complete control over the main parameters of a granular synthesis engine (grain pitch, size and density) which are mapped to an external hardware controller.

The unfolding of the piece, rather than being based on a linear time structure, proposes an evolutionary approach, based on the performer's manipulation of predefined initial settings stored for each of the sound sources. This means that, rather than following a predetermined sequence of events, the structure of the piece becomes manifest only through the decisions of the performer, who chooses when and how these elements appear, interact and transform one another. The decision to approach time-structure in this way, rather than in a more traditional timeline fashion, can be justified under the following headings:

- The character of the sound sources: The common denominator between the compositional method behind the pre-recorded sequences, Xenakis's GENDYN and the nature of the no-input mixer sounds is that they are all sources with a rich inner complexity, yet which exhibit rather static behaviour on the macro-level, so that any real-time manipulation is strongly perceptible as a musical contribution by the performer.
- The character of a network: For similar systems, but where more than one performer is involved, a preconceived time structure might be preferred. The intrinsic nature of a timbre network is rather static; that is, it is not as concerned with time evolution as it is with material interconnectivity.
- The character of a performer: This approach emphasises the importance of the performer as a contributor not only of musical expression but also of musical structure.

On a performance level, the goals of a timbre network as a structure are:

- To define the initial sonic limitations and their interconnecting expressive constraints.
- To preserve the identity of the original network during a performance.

- To leave the performer(s) responsible for expanding, pacing and controlling the dynamics of the musical result.

Reflection

Accumulation of Hesitation demonstrated how the concept of *Timbre Networks*, based on mapping procedures, can be used to create an environment that shifts between an instrument and an articulated piece. The articulator in this case is the performer, who is responsible for unfolding over time the inner structure of the piece, connecting through the act of performance Xenakis's notions of *outside-time* and *in-time* in music structure. How to articulate these ideas in relation to traditional instruments will be one of the motivations behind *PLP I* and *KVSwalk.*

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On PLP I

Introduction

The creative premise behind *PLP I*, for electric violin and computer, began as a way to explore the grey area in computer music between the roles of composer, performer and instrument builder. In particular, it explored how the *devenir*[30] between these roles could, first, be understood as the unique quality that a computer performer should acknowledge and develop, and, second, be transferred to traditional instrumentalists as a way of creating a convergence – conceptually and logistically – between the approaches to sound production and performance of both traditional and electronic musicians.

Context

PLP I presents itself as a practical implementation of both the technical and the conceptual principles proposed by *Timbre Networks* (see case study *Accumulation of Hesitation*). It addresses, and demands from its performers, not only a flexible approach to creating and interpreting live computer music but also an understanding of the final set of parameters and interrelations that form a new score, which turns into a reference point to return to, revise and improve the outcome of the piece.

To start the process of fixing the backbone of *PLP I*, the behavioural limits of the sound sources (the initial nodes of the network) were defined. Later, the focus concentrated on the inner complexities of these nodes and on how they could be streamed within the complex of the network, as either control information for another fixed node (a thread between two sources) or an intrinsic richness of the node in itself (still subject to variations through performance).

[30] Used in a Deleuzian fashion, usually translated as *becoming*. I considered that to use "becoming" could have led to a false sense of single directionality. I prefer to understand *devenir* (or *becoming)* as a generative process rather than as a one directional effect: "In a way, we must start at the end: all becomings are already molecular. […] Starting from the forms one has, the subject one is, the organs one has, or the functions one fulfils, becoming is to extract particles between which one establishes the relations of movement and rest, speed and slowness that are closest to what one is becoming, and through which one becomes. This is the sense in which becoming is the process of desire." (Deleuze and Guattari 1987: 272–277)

Project

PLP I uses two computer systems that can (and do) act in several different roles: they are independent sound sources, with or without the ability to be influenced by a performer, turning into a static or active node, but also serve as dedicated signal processors for other nodes, or as signal-to-control translators, working as threads between elements of the network. The use of an electric violin allowed me to define parameters that were common to both the violinist and the electronic performer, given the relative independence between sound production and perception. The definition of these parameters constituted the first step in the creative process. The next step was to create consistent identities for both instruments as sound sources and as generators of control information, and, later, to define and refine the possible transitional paths between these identities.

[Image: *PLP I* score]

To articulate these three network relationships for *PLP I* (definition of sources, identities and relationships), I focused my attention on the score – or rather, on departing from the score to dive into a collaborative process which both adopted and rejected elements rooted in the conventional uses of a score in composition. Traditional music notation was replaced by a defined number of determined events, represented by graphic symbols on paper, distributed over time. Unlike in traditional notation, the graphic score used in *PLP I* demands that each symbol, timeframe and suggested gesture is determined anew on every reading of the initial sketches: every time I approach the score, I must assign actions (and their sounding results) to each one of the sketched symbols.

[Media example: Interpretations of the symbols, by Sayoko Mundy, violin]

In doing so, I deprive the score of its grounding role in composition, encouraging the performer to use her or his interpretative skills in a way that a traditional setup would not encourage. This makes it possible to reach a mind-set where the exploration of very well-known sets of tools (such as the mechanical skills required to play an instrument) could be reassessed repeatedly, thus influencing and advancing the skills of the computer performer, who is subjected to the same set of symbols, and therefore

to an analogous interpretative challenge.

Reflection

Although *PLP I* was conceived as a process piece, in which the departure points were defined but not the destination, this conceptual ideal was rapidly challenged by traditional music conventions when dealing with the perception of time for the composer, the performer and the listener.

The interpretative freedom that a piece such as *PLP I* claims to offer creates a new challenge when dealing with these different sets of time. The challenge is to define a structural constraint that, while being consistent enough to allow the piece to be called "a composition", nonetheless will not jeopardise the results achieved through the exploratory process that initially signified the primary driving force of the piece.

[Media example: Video excerpt. Performance of *PLP I*, with Mieko Kanno, violin]

Originally developed in close collaboration with violinist Mieko Kanno, it was only after going through the same process with different musicians[31] that this never-defined, always-mutating, grey-area-centred piece acquired its backbone. This was achieved through limiting the actions anew during each performance to a determined interpretation of the symbols for both the traditional instrumentalist as well as for the sets of transformations and actions in charge of the computer performer. Each version let those determined sounding actions articulate the vertical axis of the musical structure (the polyphonic relationship between sound layers), while performers dealt with a flexible understanding of the horizontal axis of the structure (the unfolding over time).

[Media example: Rehearsal and performance of *PLP II*, with Santiago Lascurain, guitar]

PLP I is the result of several interpretations of parameter interdependencies, from straightforward frequency-based (range) distributions and multi-parametric articulation gestures to more precisely defined musical units and durations. Although each performance helps stabilise the expansive nature of the piece, it seems clear both to

[31] One of these musicians was Mexican guitarist Santiago Lascurain. More information about Santiago can be found at http://santiagolascurain.com/.

performers and to audiences listening to *PLP I* that the final version is an entity that might not (and should not) ever manifest itself.

[Media example: Audio recording performance of *PLP I*, with Mieko Kanno, violin]

Although the use of a graphic score proved an interesting way of generating a common ground for electronic and traditional instruments, I started to elaborate different strategies to tackle from different perspectives the challenge proposed with *PLP,* raising questions about how to recover, for composers and audiences alike, the fragility, surprise and unexpectedness that presenting music on stage is all about.

The continuing quest for possible answers to these questions led to the elaboration of new case studies, such as *KVSwalk* and *Flux|Pattern,* by proposing methods to bring the timbre palettes and the musical challenges of traditional and electronic instruments closer together.

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On KVSwalk

Introduction

KVSwalk is an exercise in finding an identity for the computer performer in an ensemble context situation. While selecting a number of personal artistic projects dealing with notions of the body in computer music performance, and specifically with the idea of the disassociation of physical action and sonic manifestation, I realised that I had been trying to approach this problem from a research perspective, and failed to communicate it to other musicians. I sought a definition of a computer performer and asked how such an individual could be shaped – how skills might be identified and learned from traditional instrumentalists and applied to computer music practice.

Initially, the idea of studying the role of the computer music performer was approached by dividing the roles demanded by computer music practice. First, there is the compositional aspect: He or she should be informed by composing electroacoustic music with special focus on the interaction between electronic and traditional instruments. In addition, the creation of textures and timbres is part of the composer's tasks, as is the generation of structures and the creative conceptualisation of dependence and interdependence between electronic and traditional instruments. Eventually, the development of notational systems pertinent to the computer-based instrument and its performer might also become part of the task.

Second, there is the role of the instrument designer and the technical skills required to develop the instruments and controlling devices, which are necessary to unfold compositional structures in front of an audience and in collaboration with other musicians. Decisions taken at a design level influence and determine the roles of the performer of such instruments by establishing the potentials and constraints of the computer system, as well as the gestures and actions to be used.

The third role, that of the performer, condenses both the compositional and instrument design decision making when determining the relationships between materials and actions, and activates them in the concert situation.

The study of these roles was approached pragmatically, with the aim of being informed as much as possible by traditional musical practices (instrumental composition, instrument building and performance). The clash between this initial, idealistic approach to connect traditional instrumental repertoire and practices with the experiences of performing repertoire conceived, or adapted, for live electronics, led me to the project I present here.

In the context of composing, I started investigating three different ways of defining musical structure by regarding composition as the creation of a structure or grid, or a time-length to be filled in by sound events and interactions between them. First, I looked into different music traditions and their approaches to combining musical structure and improvisation (e.g., the *Real Book*[32]) and, second, into the fixing of improvisation as composition, a frequently met practice in electronic music creation: going into the studio, starting sound generation and manipulation processes, recording these results and later establishing architectonic and time organisation schemas. The third approach, the one I discuss in this chapter, is the notion of the *sonification* of non-musical information. Sonification, as understood by the scientific community, can be defined as "the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation." (Hermann 2010: n.p.) *KVSwalk* is presented as a way of using sonification procedures to structure composition and, in turn, apply these procedures in a live performance situation.

Context

Some antecedents of data sonification

Without claiming it is a real sonification example, Iannis Xenakis's early orchestral works might illustrate the intention to derive musical structure from extra-musical material. For example, in *Pithoprakta* (1956), he aimed to construct a musical analogue for the motion and collision of gas molecules, on the basis of the idea that, although it is not possible to determine the motion of an individual particle, it is possible to find the average for the change of position of a cluster of particles over a discrete period of time, and, therefore, to measure an average speed behaviour, which is a mathematical description of the temperature of the gas. Xenakis mapped data of

[32] A collection of lead sheets of jazz standards started by Berklee college students during the late 1970s.

this kind onto a graph of pitch versus time, which was applied to the fingerboard and bow positions for an ensemble of string instruments.

[Audio: *Pithoprakta* excerpt]

I consider this piece to be a direct antecedent of what in electronic music was later termed sonification. Xenakis himself used similar procedures to translate data into sound in composing *Concret PH* (1958), a work that could be considered as something between a musical composition and a sound installation, and which was created to be played as an interlude between performances of *Poème électronique* (1958) (an audiovisual work by Edgard Varèse and Le Corbusier) inside the Philips Pavilion at the 1958 Expo in Brussels.[33] I mention Xenakis and *Concret PH* in order to frame each of my projects in relation to a particular aesthetic context. In other words, the music and procedures for music creation that I want to present operate either as influenced by or in resistance to a particular work or artist.

In electroacoustic music, sonification is often used to describe musical structure on the basis of non-musical data. Composers such as Ed Childs presented sonification as the scientific representation of data into sound. Possible distinctions between kinds of sonification can be seen in the following categorisation (Burk, Polansky, Repetto, Roberts and Rockmore 2011: n.p.):

- *audification:* the direct rendering of digital data in (usually) sub-audio frequencies to the audible range, using resampling. Example: speeding up an hour of seismological data to play in a second.
- *sonification:* mapping data with some other meaning into sound.
- *auditory icons/earcons:* using sound in computer GUIs (graphical user interfaces) and other technological interfaces to orient users to menu depth, error conditions, and so on. For example, a cell phone company could design an *AUI* (auditory user interface) for its cell phones so that users do not have to look at the little LCD display while driving to select the desired function.

[33] Xenakis mentions *Concret PH* as part of a series of works where he used stochastic principles to define musical structures: “Stochastics is valuable not only in instrumental music, but also in electromagnetic music. We have demonstrated this with several works: *Diamorphoses* 1957–58 (B.A.M. Paris), *Concret PH* (in the Philips Pavilion at the Brussels Exhibition, 1958); and *Orient-Occident,* music for the film of the same name by E. Fulchignoni, produced by UNESCO III 1960.”(Xenakis 1992: 43)

Larry Polansky introduces the term *manifestation* to try to differentiate sonification with scientific and illustrative purposes from those endeavours with artistic pretensions. For Polansky, the deviation from a purely functional manifestation of data into sound is essential for the understanding of the artistic nature of a sonification procedure (or in his words, a manifestation). He elaborates: "There is no canon of art which necessitates 'efficiency,' 'economy,' or even, to play devil's advocate, 'clarity.' While a great many artists would agree that these are desirable qualities, art in general has no such rules, requirements. While these notions might be (and are) useful starting points for many beginning artists, and pedagogically productive, once established as principles they must of necessity be confounded or least manipulated by most working artists". (Polansky 2002: n.p.)

Particular takes on the notion of sonification can be found in the work of artists such as Gerhard Eckel, who understand creative sonification as the articulator for mapping strategies between physical movement and sound[34] and that of Andrea Polli, who works in collaboration with atmospheric scientists to develop systems for understanding storm and climate through sound using sonification procedures.[35]

In a simplified fashion, sonification procedures have the following steps:

- Selection of input data
- Definition of parameters
- Mapping (and scaling)
- Realisation

As an example of my own attempts at data sonification, *Tellura* (2003–2004) uses data from seismographic stations – telluric activity detected in five different submarine and terrestrial locations around the world. My main interest in developing this piece using sonification procedures was to be able to create a result that would resonate with the original source of the data. Thus, in choosing data connected to earthquakes, I intended that the final sound world and structure of the piece would reflect this by

[34] Eckel and his collaborators have developed the notion of using physical movement as auditory feedback, and applied it for both artistic and medical purposes. For more information visit http://iem.at/~eckel/science/science.html.
[35] For more on Andrea Polli and her projects, visit http://www.andreapolli.com/.

resembling the imaginary sound world of an earthquake. As a composer, I found it important to take this approach, given that the risk of disconnection between the source of the data used and the final sound result was one of my main criticisms of sonification as a compositional procedure. I sought to find a middle ground between the notion of conveying information about the origins of the data and the creation of a musical structure.

[AUDIO: *Tellura* (finale)]

The main limitation I found with this method of working was that I consistently failed when trying to merge the aesthetic and structural results from my sonification work together with writing for traditional instruments. My transition towards an understanding of how I could manipulate traditional instruments into coming closer to the sound world I was creating with sonification procedures began when I focused on the performative aspect of the material I was working with. This entailed analysing and stretching myself as if I were a traditional instrumentalist, while still being able to produce similar sounds to those generated electronically by sonification procedures.

The status quo of performance in live electronic music

In order to apply sonification procedures in a live performance context, I first had to revise the demands of the electronic performer in the existing repertoire for ensemble and live electronics.

I started investigating repertoire in which an electronic performer was deemed part of an ensemble. I realised that, in most cases I encountered as a performer, the contribution demanded from an electronic practitioner in the existing repertoire was often limited to live-triggering pre-recorded sound files, acting as a human score-follower to cue the starting and stopping of live processing of traditional instruments, and being a mixing technician who controls the balance between the instrumental and electronic sound sources. I am pointing at works by, for example, Kaija Saariaho (*Six Japanese Gardens,* 1994; *Vent Nocturne,* 2006), Philippe Manoury (*Partita I,* 2006), Cort Lippe (*Music for Cajon and Computer*, 2011) and Richard Karpen (*Strand Lines,* 2007), to name a few.

At the beginning of my research, these limited tasks allowed me to work towards the development of a performance practice, mainly through reinforcing the interactive

nature of the actions demanded in relation to other performers in a concert situation: executing these actions onstage and seeing how my presence affected the other performers' and the audience's perception of the musical event.

I tried to understand what kinds of action such a rudimentary computer performer needed to be concerned with. Focusing on the existing repertoire up to the beginning of the twenty-first century, the demands on the computer performer could be listed as follows:

- Triggering a synthetic layer.
- Dealing with onsets and offsets of the different sections in a piece (involving many physical actions with no direct sonic consequence).
- Controlling and moving sound events in the physical space (also demanding physical actions with no linear sound result).

In this threefold scenario, it is the traditional instrumentalist who provides the control information to the synthetic layer through harmonic and amplitude content. It also feeds the Digital Signal Processing (DSP) component of a piece.

This is the way most repertoire for traditional instruments and live-electronics still operates; however, by performing these pieces, one can be confronted with certain technical issues and limitations. First, there is the logistical difficulty of signal extraction in a live performance situation. This is normally overcome by using a pickup or a microphone, where very small placement differences significantly influence the overall behaviour of the instrument-computer system; however, such differences are to be expected in a real-life scenario, such as at a festival, where the setup needs to be changed rapidly between performances. Second, there is the confusion of signal analysis (i.e., the extraction of pitch and amplitude information in real time from a performer) with musical analysis (which would suggest the ability of the system to understand and judge the musical nuances produced by the decision-making of a performer). This misconception effectively demotes the traditional performer, however virtuosic, to the role of generating pitch and amplitude events over time.

This kind of musical setup risks reducing the traditional performer's potential for expression, while also underusing the potential of another musical decision-maker, the electronic performer. Music technologist Miller Puckette and composer Cort Lippe

were already concerned with the idea that, for these pieces to be genuinely responsive and to be appreciated by audiences as being generated by the decision-making of the musicians involved, they were forced to reduce the instrumentalists' input only to pitch and dynamic: "We can now provide an instrumentalist with a high degree of timing control, and a certain level of expressive control over an electronic score. [...] A dynamic relationship between performer, musical material, and the computer can become an important aspect of the man/machine interface for the composer, performer, and listener, in an environment where musical expression is used to control an electronic score." (Lippe and Puckette 1994: 64)

I proposed to help contribute to what this "musical expression" might mean by enhancing the decision-making potential of the electronic part, even in pieces where the electronic part was designed to be autonomous by responding to the signal of the traditional performer. I returned to the ideas I used when creating a method for my sonification pieces, and defined a very simple and systematic procedure:

- Design of the instrument
- Selection of the repertoire
- Definition of the instrumentation
- Realisation

Following Marcelo Wanderley's model for digital instrument design, which focuses on describing the performer's "expert interaction by means of the use of input devices to control real-time sound synthesis software" (Wanderley 2001: 3), one can split the task of creating the instrument into two components: software and hardware. The software side includes composing or programming the software environment, defining the tasks and limitations of the instrument and the parametrisation of the instrument. The hardware side includes the design of the gesture acquisition interface (for example, hand motions, hitting keys), the design of the gesture-acquisition platform (sensors, cameras, trigger interfaces) and analogue-to-digital conversion for the gestures.

[Fig. 1. Digital instrument design schemata by Marcelo Wanderley]
[Fig. 2. Extended digital instrument design schemata by Juan Parra]

I have been working towards adapting both Wanderley's and my own models of instrument design into musical composition and performance, presenting them as the definition of musicianship in live computer music with the primary intention of collaborating with traditional instrumentalists, both in the interpretation of pre-existing repertoire, as in the performance of new compositions. To do so, I extended Wanderley's model by adding live-input, both sound and gesture. This is to say, a traditional instrumentalist (e.g., a violinist) *interferes* in the model of the digital instrument, rather than the other way around.

I developed the notion of *Timbre Networks* in an attempt to systematise these procedures, moving away from this metaphor of interference when dealing with existing repertoire for traditional instruments and electronic media and towards an integral model of creation and performance of live computer music. In other words, I aimed to create an instrument which itself was a composition, and which demanded a performance practice that would allow it to be included in different performative contexts.

The concept of *Timbre Networks* was a way to describe interactions between a number of (musical) nodes in a musical structure. By finding correlations between several definitions of timbre, texture and network, the goal was to present possible relationships between the computer as a tool and other musical instruments: as a self-contained instrument, as a signal processor, and as a tool for the analysis and scaling of incoming data. It also aimed to incorporate the decision-making tasks of the composer into the performative arena, both for the electronic performer and the traditional instrumentalists involved in the network. Together, each performer's part of the network would contribute by exploring and playing with:

- Texture composition
- Texture manipulation
- Timbre flexibility
- Interdependence of musical and physical gestures

An example of a self-contained timbre network is my *Accumulation of Hesitation* (*AoH*) from 2008, where I used a Max/MSP port of GENDY, a digital implementation of the dynamic stochastic synthesis algorithm conceived by Iannis Xenakis and described in his book *Formalized Music* (1992), to generate both the initial sound materials and the

control streams for their signal processing. Additional sound material and control information for *AoH* was generated by a feedback circuit, using a *no-input mixer* as a live instrument.[36]

[Audio: *Accumulation of Hesitation* excerpt]

After my experience with developing the concept of *Timbre Networks,* I realised that I was aiming to present the potential of the computer as a musical instrument while also finding a common ground with which to interact with traditional instrumentalists. This second aspect began to take more concrete shape through collaborative work with Mieko Kanno, Catherine Laws and Stefan Östersjö which led to the creation of *KVSwalk*.

Project

To integrate the compositional ideas defined in *Timbre Networks* with the interest of applying sonification procedures in live performance, I sought a unifying concept that could encompass dealing with the relationship between instrument and performer, the translation of data from one media into another and the use of mapping strategies as a unifier of both.

The notion I used to articulate this project was that of *embodiment*, defined as "how the body and its interactive processes, such as perception or cultural acquisition through the senses, aid, enhance or interfere with the development of the human condition" (Farr, Price and Jewitt 2012: 6); therefore, I understood the body as a possible agent when dealing with the assimilation and translation of concepts. I propose then to consider procedures of sonification and/or visualisation as valid processes of embodiment as understood by Farr, Price and Jewitt. When translating data into sonic or visual streams of information, the interaction between the data and the translating agents will produce the same interferences as when the human body is the agent of assimilation.

[36] A musical instrument first made popular by Japanese sound artist Toshimaru Nakamura, a *no-input mixer* is made by connecting the outputs of a sound mixing board into their inputs, generating a series of feedback loops in the mixer's circuit, which in turn can be used as a somewhat crude and unpredictable electronic instrument, when compared to pitch-graded electronic instruments.

My interest in understanding possible interpretations of the notion of embodiment, and how these could be articulated in sound turned into the starting point for the collaboration process leading to *KVSwalk*. To structure the piece, I considered embodiment as physicality, as assimilation and as transformation, and sought to create different sound layers connected to these notions. Simultaneously, I wanted to articulate how these layers interacted with one another using an external shape. I chose to implement the *Kármán vortex street* formula (Kármán 1954: 76), used in fluid dynamics, as an algorithm for spatialisation and dynamic control because of its actual shape and motion. I chose it also for its metaphorical potential and for the sonic derivatives that it suggested, given its manifestation in nature both physically (in cloud formations) and aurally (in the fluctuating pitch of electricity power lines).

[Video: Kármán Vortex Street formula and shape]

Incorporating the concept of the Kármán vortex street in the structuring of my collaborative work with Kanno, Laws and Östersjö was a response to the challenge of relating to sonification as a compositional tradition in electronic music. It allowed me to understand sonification in relation to the idea of embodiment as transformation and assimilation, and to explore how I could bring this primarily studio-based compositional practice into a live performance dimension. In short, I asked myself how a sonification piece could be presented in performance, with all the procedures, data capturing, scaling and mapping exposed in a concert situation.

Procedure

I designed a spatialisation and dynamic control algorithm based on the formula of the Kármán vortex street phenomenon. This phenomenon occurs when the flow of a fluid is interrupted by a cylinder-like object, which generates a train of vortices in a zigzag pattern, rotating in opposite directions. In nature this phenomenon may be seen in water flow where streams are interrupted by a mountain. There are numerous examples of audible manifestations of the phenomenon: the singing of telephone lines, or the ascending high-frequency noise audible during a plane landing in which high and low pressures interact with each other in nature, which in this case creates a particular shape – a train of vortices. While performing *KVSwalk,* I manually trigger a new start of the Kármán vortex street with each new instrument incorporated in the

piece, which initiates the incoming instrument signal moving in the physical space at a rate determined by the harmonic spectrum of the instruments used.

The manipulation of sound in space

On the basis of the work of mechanical engineers Lionel Espeyrac and Stéphane Pascaud (2001), who designed a digital model of the traditional method used in physics to create the Kármán vortex street, I developed a spatialisation system to distribute streams of processed sound material over a virtual auditory plane following the motion and energy loss of the vortex model. The sound streams were created by analysing incoming (instrumental) sound and freezing its spectral component to simulate a continuous sonic flow. For each flow, the direction of the vortex (clockwise or counterclockwise) was left open to the decision of the electronic performer. The duration of each process was dependent on the initial energy (average amplitude and attacks over the duration of a specific time window). An additional aspect of the algorithm left to the control of the electronic performer was the determining of the initial location of each stream. By default, each instrumentalist would feed a vortex that would start in a loudspeaker located opposite his or her position on stage, but its routing could be interfered with by the electronic performer at any time.

The final control parameter of the spatialisation system was the dynamic scaling of the frozen sound streams. Before the triggering of a new stream, the performer selected whether the centre frequency of the incoming instrument would remain unaltered or would be scaled to either 0.5 or 4 times its value, a decision that affected the timbral qualities of the electronic sound streams (by transposing them an octave lower or four octaves higher), while the duration of the processes and its energy fluctuations remained unchanged.

The instrumental sounds

To create the initial sound objects for *KVSwalk*, I followed a similar path to the one used in *Tellura*. The main difference was that the generation of sound material, created using only synthetic algorithms in *Tellura*, was conceived in *KVSwalk* as a task for a traditional instrumental ensemble.

Following the notion of *embodied know-how,* where the “inherently synesthetic as well as multi-modal nature of the human being, by patiently integrating sensorimotor,

intellectual and embodied capacities toward expert artistic skill in a specific domain, emerges" (Coessens 2009: 272), I attempted to create for the performers a conceptual distance from their embodied instrumental knowledge and replaced it with more abstract, gestural and motion-oriented tasks, creating a set of initial materials that I could treat as sound-objects with an unspecified duration.

At the same time, this artificial distance between the requested actions and the resulting sounds allowed me to reorganise the collection of materials according to timbral and harmonic similarity, regardless of the instrument. The process of exploration focused on the physical motions of the performers on their instruments, levelling the pitch material (by using a single pitch as the central tone, as well as for departure and arrival of pitch-lines) and testing different ways of creating bridges between the timbres of the different instruments, either through performance (extended techniques) or artefacts (such as tin foil) added to the instruments like prepared piano accessories.

After a period of experimentation, the selection of material was made by grouping sound events according to the similarity or difference between the physical action performed to excite the instrument and the sonic result. In doing this, some events that sounded alike required very different actions to be produced. On the other hand, imitating physical actions on different instrument would lead to sound results with varying similarity among them.

I distributed the selected material in a time line for each instrument, following these two axes:

1. (Physical) gesture similarity < > (sonic) gesture difference
2. (Sonic) gesture similarity < > (physical) gesture difference

This experimentation and selection process was carried out with the invaluable collaboration of Mieko Kanno (violin), Catherine Laws (piano) and Stefan Östersjö (guitar), in a series of meetings over a period of four months. A parallel process was conducted online with Chris Chafe, composer, cellist and designer of the *celleto*, a hybrid electronic instrument derived from the cello, which he used for his collaboration in this project. The resulting material was then arranged in a score in which each instrumental action and each gesture would be sonically different from its predecessor,

and at any given moment during the piece the physicality involved would be as (metaphorically) connected as possible with the other ongoing (physical) gestures. Alongside this, a first (instrumental-only) structure for the piece was completed, in which every meta-gesture (that is to say, a gesture in both physical and sonic senses of the word) was assigned a symbol and a guideline description for its performance.

Gesture groups:

I > 

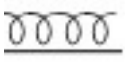
Violin: Brushing of the bow over strings, without producing a clear pitch.
Piano: Brushing of the strings in the soundboard, without producing a clear pitch.
Guitar: Performed muted attacks progressively increasing speed, moving towards a fast tremolo.
Celleto: Brushing of the bow over strings, without producing a clear pitch.

II > 

Violin: Pizzicato on G (any octave).
Piano: Play high G on any octave over a pedal on the lowest G.
Guitar: Simulate a continuous glissando, starting and finishing in G.
Celleto: Pizzicato on G (any octave).

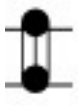
III > 

Violin: Undetermined pitch. Continuous, yet irregular bow weight.
Piano: Random “walk” of hands over keys.
Guitar: Irregular excitation of strings, from upper to lower register. End with a slowdown on the lower octave.
Celleto: Undetermined pitch. Continuous, yet irregular bow weight.

IV > 

Violin: Ricochet, use aluminium foil on fingerboard.
Piano: Scattered notes with aluminium foil on soundboard.
Guitar: Transition from pitch-less tremolo to natural harmonics with G as the fundamental frequency.

Celleto: Ricochet, use aluminium foil on fingerboard.

V > 

Violin: Searching for “unattainable” harmonics (undetermined pitch).

Piano: Play weak-action clusters around G (any octave).

Guitar: Transition from tapped tremolo around G (higher registers) towards low-registered phrases using aluminium foil on fretboard.

Celleto: Searching for “unattainable” harmonics (undetermined pitch).

Structure

Once the initial instrumental skeleton of the piece and of the sound processing and spatialisation algorithms had been completed, the next task was to define structural pivot-points for interaction between the instruments and the electronic components of the piece. To reinforce the metaphoric gesture of the Kármán vortex street as a series of energy impulses that should propagate in a somewhat cyclical motion, I had the idea to extend the exploratory nature of the piece by revisiting the concept of embodiment as a new source to inform different materials and layers. As I stated before, two possible interpretations of the notion of embodiment could work simultaneously on different levels – the physical relationship between the performer and his or her instrument or the assimilation and transformation of non-musical ideas into sonic and visual manifestations. *KVSwalk* attempted to shed light on how the multiple meanings of the concept of embodiment in electronic music could be interpreted, and how these could be used to create different musical materials and help structure a composition. It was at this point that I incorporated new layers of material (video, additional electronics) in order to sonify and visualise these different processes.

A map of the piece: multiple meanings for multiple layers

After having described the five gesture groups that constitute the basic instrumental material for *KVSwalk,* I will now present the five layers that together formed the structure of the piece. The final version of *KVSwalk* contains five layers of musical information, each of which responds to a different approach/experiment/exploration of a particular notion of embodiment.

- (1) Instrumental layer (gesture groups)

This layer consists of the physical gestures required to produce sound on a particular instrument, and experiments with finding points of connection between the physicality required to produce sound by each instrument and the timbral similarity of the resulting sounds.

- (2) (Networked) instrumental layer

This layer is concerned with the same interpretation of embodiment, but sheds light on the (potential) change in perception when the visual and auditive elements are disengaged. It is presented here as the first networked element of the piece: Chris Chafe (celleto) was faced with the same challenges as the other instrumentalists, but his contribution differs from the other players due to his physical absence on stage. Dealing with only the sonic result of the physical gesture aims to raise new challenges and questions when setting up a collective performance situation, and intends to explore the limits and possibilities of disembodied chamber music interaction.

- (3) Computer signal processing layer

This layer focuses on bridging two different embodiments: the manifestation (in sound) of a concept (the Kármán vortex street phenomena) and the relationship of the performer's body to an instrument (the computer).

- (4) Video layer

This layer deals with embodiment as translation from a form or concept into another medium (visualisation as embodiment). This process was done by analysing certain parameters of the live performance (amplitude thresholds and deviation from the centre tone), and mapping the outgoing values in a two-dimensional space.

- (5) (Networked) computer synthesis layer

This layer is an experiment in transliteration (a sonification of the visualisation process). The resulting images and motions of the video layer were translated into linear data streams and translated into sound by a computer synthesis engine programmed by Henry Vega in the SuperCollider environment.

While the initial instrumental material and its processing and spatialisation form the structural backbone of the piece, the intention with the additional layers was to manifest in sound (or image) a complementary (while somewhat different) notion of embodiment which would preserve the overall metaphorical identity of the Kármán vortex street: an expansive, cyclic energy-losing motion.

[Video: Michael Schwab's video]

Solo versions

The next stage in the composition process was to create a test-version of the piece. This solo performance version, using recorded fragments of the instrumental material and the signal processing and spatialisation computer system, was presented in performance as a way of both refining the proportions of each section of the time structure of the piece and developing different performance strategies for the electronic part.

To compensate for the lack of interpretative nuances in the pre-recorded instrumental fragments, I designed a collection of timbre and articulation gestures for the computer processing part relative to the instrumental collection, which could give a dedicated performer three key controls over the processing behaviour, while preserving a close dependence upon the interpretative nuances of the instrumental recording:

- Initialisation/interruption of overall gestures.
- Dynamic control over the speed and direction of predefined spatialisation trajectories.
- Dynamic control over the deviation in pitch of the processed sound in relation to the incoming instrumental gesture, producing the illusion of perspectival depth.

During the preliminary tests, it became clear that the inflexibility of recorded fragments of the instrumental sounds caused a somewhat predictable performance, so I replaced the initial sound material (the recorded instruments) with electronic sounds.

A first implementation of the solo computer version of *KVSwalk* was tested using a very rudimentary synthesis setup as its input instrument: a no-input mixer, capable of generating three distinct sets of controlled feedback, a resonator bank on a fixed-frequency setting, and a noise generator. At this point two additional symbols were added to the working score.

Computer symbols:

Manually triggered synthesizer engine (a low G1 sine-tone tuned at 48.9 Hertz)

Manually triggered “grains” (activation of a granular reverb engine, with two different transposition presets: one at 2, 4 and 6 octaves above and 2 octaves below the fundamental frequency, and one at 3, 9 and 12 octaves above).

KVSwalkSOLO entailed the specific design and construction of a physical controller for the computer part. One of the two elements of this controller requires physical actions, which are comparable to those used in various forms of traditional instrumental playing, while the other, which is used for controlling the spatialisation algorithm, is manipulated using more theatrical hand gestures. This portion of the project was a collaboration with Lex van den Broek,[37] head of the technical department of the Royal Conservatoire of The Hague. The intention here was to create a closer relationship between physical actions and sonic results, considering that this relationship has not always been considered while designing computer music interfaces in the past.

KVSwalkSOLO features a mixed setup consisting of an analogue and digital sound-generation engine and a custom controller capable of capturing at least four continuous-control signals, coupled to four synthesis engines and four discrete audio outputs. Ideally, the time and voice structure calls for five high resolution physical sensors (one ultrasound, three pressure and one heat sensor), five synthesis engines routed to five filtering engines, a circular-motion spatial distribution system, and a 5.1 audio output setup.

[Photo: *KVSwalkSOLO i*nstrument]

KVSwalkSOLO was premiered during the Raflost 2010 festival in Reykjavik, Iceland, and subsequently performed in Florence, Padova, Narbonne, Santiago de Chile, Sao Paulo and Tallinn. After these experiences, I had the opportunity to focus again on the relationship between these new sound materials, the instrumental material (still as sound recordings) and the processing and spatialisation system. This second period of experimentation took place at the Pompeu Fabra University in Barcelona, using the Reactable system, an electronic music instrument and environment developed since

[37] For more on Lex van den Broek’s work, see www.ipson.nl.

2003 by a group of researchers at that university.[38] The Reactable version of *KVSwalk* included recordings of the instrumental layers and an adaptation of the control and sound manipulations of the spatialisation algorithm designed for both the ensemble and solo versions. *KVSwalkReactable* was presented during the SMC 2010 conference in Barcelona, on 23 July 2010.

[Video: *KVSReactable*]

The ensemble version

Parallel to the work on the solo versions, additional layers for the ensemble version of the piece were in the process of being created. The next two layers of the piece were creative collaborations with visual artist Michael Schwab and composer and computer performer Henry Vega. For the video layer, Michael Schwab (with the programming assistance of David Pirró) created a visual interpretation of the data generated from the sound processing layer of the piece. Combining the concept of the Kármán vortex street and the sound parameter information, Schwab's layer brings together and blurs the distinction between the available conceptual and inceptual information in the process of translating them into the visual domain.

The purpose of the (networked) computer synthesis layer, generated and controlled through a dedicated computer network by Henry Vega, is to translate the above-described process back into sound. This was achieved by transforming data generated by the visual materials of Schwab – specifically pixel position and trajectories – into OSC[39] streams of numbers, sent through a dedicated web server to Vega's computer, in which these flows of data were sonified using a synthesis engine developed in the SuperCollider programming environment.

Once all the components (or layers) of the piece were in place, we rehearsed and prepared the final performance version. This process served to define the framework for a piece whose fragile nature slowly manifested itself: a somewhat fragmented set

[38] For more information on the Reactable and its current, multiple iterations, visit http://www.reactable.com.
[39] OSC stands for Open Sound Control. It is a protocol for networking computers and other multimedia digital devices. For more information visit http://opensoundcontrol.org/.

of processes of collaborative interaction, connected to one another by an implicit concept as well as by one another's technical co-dependence. The technical issues met in setting up this final system created the opportunity for a different way of rehearsing: it was only at the final sound check that performers in all three locations were audible in the concert hall, in which situation the visual and auditory feedback for the musicians was challenged by the needs of the visual layer of the piece. As a way of solving some of these issues, the computer performer on stage took on the responsibility of dynamically adapting the balance between the sounding layers to highlight the structure of the piece through what can be considered subtle conducting, thereby preserving control over amplification, spatial distribution, and the cueing of global sections. *KVSwalk* was premiered by the ORCiM ensemble (Mieko Kanno, Catherine Laws, Stefan Östersjö, and Michael Schwab), Henry Vega and Chris Chafe, during the ORCiM Festival in Ghent, Belgium, on 16 September 2010.

[Video: Video of the performance]

Reflection

The collaboration process and creation of *KVSwalk* aimed to bring sonification procedures into a live performance situation, by rereading sonification as a possible interpretation of the concept of embodiment in order to integrate the sound worlds of electronic and traditional instruments. The experience of conducting such a process left me with a number of issues that have informed my subsequent work. The use of both physically present and networked performers, following the same musical guidelines, helped me reflect upon how much of the semantic value given to the relationship between body-action and sounding-output is a cultural construction rather than an intrinsic aspect of music performance. I became aware that this issue in effect undermines the initial motivation for bringing the electronic performer back on stage, a strategy I relied upon in much of my early case studies. Other aspects, such as the timbral relationship between the instruments and the electronic processes, seemed to be more important. I am happy to accept that this aspect remains as one of the unsolved motivations to keep producing and researching live computer music. How to present the participation of networked performers to the audience is an aspect to evaluate. Since there was no visual representation of these networked performers, the audience was not aware of their presence. Although this cannot be considered

unsuccessful in itself, their contribution on a conceptual level – commenting on embodiment as physicality when no physicality was present – was lost.

Another aspect to reconsider in this project arose from the desire to incorporate too many simultaneous layers of interpretation of the notion of embodiment, which rendered any one of them practically ungraspable. Perhaps the most confusing element was the notion of embodiment as assimilation and transformation, and its connection not to sonification but to the translation of the sonified material into the visual domain. The visualisation of the procedure by which the spatial trajectories of the sound material was generated, using a design by Michael Schwab, and generated in real time using software programmed by David Pirró, ended up absorbing most of the attention of the audience (which is a frequently met problem in interactive pieces with video), covering the presence of multiple layers of interaction between electronics, performers (on stage and through a network environment) and the space.

Removing the video layer in later performances has helped to focus attention on the interaction between the performers and on the fragile nature of the musical texture being generated as the core of the piece. Thanks to the experience gained during the collaborative processes spawned by this project, I have developed a number of strategies to tackle similar collaborative settings where the long periods of exchanging ideas and materials have been replaced by a set of initial structural, conceptual and material pivotal points.

An example of such condensed collaborative work was the reworking of *KVSwalk* for an ensemble of wind instruments conformed by Terri Hron (recorder), Solomiya Moroz (flute), and Krista Martynes (clarinet). A two-day workshop, conducted at the Matralab studio of the Concordia University in Montreal, was dedicated to this version, and through a number of very simple tests it was possible to create the initial sound materials while simultaneously developing versions of the time structure. The performance took place at La Elástica, Montreal, Canada, on 16 March 2011.
I believe that the rapidity and success of this performance only became possible as a result of the long and complex collaborative setting leading to the initial ensemble version, as described above. It is the knowledge accumulated in the course of those initial collective sessions that now allows me to select and propose this piece to other ensembles with less luxurious time schedules than my original one.

[Video: Video of Montreal performance]

Evaluating this project in the light of adapting sonification strategies for a live performance situation, one can in retrospect focus on understanding embodiment as a concept with multiple meanings – as agent and as an inherent quality of the body – thus helping to articulate these meanings in music in relation to the procedures of sonification. In doing so, the separate layers of the piece, articulated by the different steps to sonification, in turn help illustrate certain aspects connected to embodiment in music – such as the relationship between physical action and sonic manifestation, and the idea of mapping as the strategy for acquisition, assimilation and transformation of data from one dimension into another. These elements will be explored further in other projects, such as *Flux|Pattern* and *Multiple Paths*.

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On *Flux*|*Pattern*: The etude as compositional form in live computer music

Introduction

The research process leading to *Flux*|*Pattern* sought to relate live computer music practices with technical challenges borrowed from traditional instrumental practices. I studied the etude as compositional form in the repertoire for piano, and identified aspects of different interpretations of the notions of the etude throughout history, specifically how it has been used to create and propose different challenges for performers to solve on stage. This helped me shape a framework where the artistic work conducted within the percussion and computer trio The Electronic Hammer[40] could be critically reflected upon and used to create new musical outputs. During the eight years of activity of the trio, the role of the computer and its performer was challenged, explored and developed to achieve the same level of musical nuance, expressiveness, and range of musical functions as those performed by traditional instrumentalists in a chamber music setting. Seeking to push this emulation role for the electronic instruments in new directions, *Flux*|*Pattern* was a series of etudes created for both traditional and electronic instruments using the challenges posed to the electronic performers rather than those presented to traditional instrumentalists. Considerations about features of computer music practice such as timbre flexibility, mapping, the use of the concert space as a dynamic parameter and the disassociation between physical action and sonic manifestation helped formulate the following research questions:

- What are the possible musical relationships between traditional instruments and live electronic set-ups?
- In computer music practice, how do the interrelated roles of composer, performer and instrument builder work together in collaboration with traditional performers and composers?

[40] For more information on The Electronic Hammer, visit http://www.electronichammer.com.

- How can we move from an emulation model (the imitation of traditional instrumental features and actions) to a differentiation of skills in computer music instruments?
- How can the non-sounding aspects of music performance help enhance the malleability and richness of the electronic media in a concert situation?

During the eight years of development of The Electronic Hammer (Diego Espinosa, percussion, and Henry Vega and myself, computers), we attempted to tackle the problem of improving performance in computer music practice by considering and challenging computer performers as traditional instrumentalists.
The tasks posed to the composers working with the trio were not to focus primarily on issues inherent in the electronic material. Rather, the main challenges were related to successfully emulating traditional instrumental behaviour in electronic media: how to create not one, but two electronic parts in a piece where the language and potentials are designed for the possibilities (and limitations) of traditional instruments.

The Electronic Hammer's working method produced a number of interesting results, creating technical and artistic solutions to the problems presented in the compositions. Some of these solutions, such as the use of network technology to continuously change tempo markings, or the development of "meta-instruments" that would receive gesture input from all three performers, dealt with finding ways of differentiating in a concert situation fixed and real-time generated electronic layers, developing cue-systems that could derive their tempo indications from the performance of each musician, and notation strategies that went from traditional scores to computer cue systems and to graphs mapping the computer keyboard as a trigger instrument. Although working as a traditional chamber music trio helped develop a rich body of musical pieces and advanced various aspects of artistic output in live computer media, in general the musical elements that could be considered unique to the electronic domain were always developed implicitly; the driving force for the music being created was primarily the onstage presence of the electronic performers and the virtuosity of the traditional performer. The technical and artistic work being done by the electronic performers was never approached as the starting point to build musical questions, and therefore it was never pushed to the point of becoming the most important aspect of the ensemble's output.

Context

Owing to my work at the Orpheus Research Centre in Music (ORCiM), I had the opportunity to develop collaborative settings to explore the relationship between live computer music and other musical traditions and practices. It was within this context that I started looking at the notion of the etude as a compositional form and how it could be used to create small musical problems derived from features unique to electronic instruments, which could be transferred to traditional instruments as well.

One of the general notions of etudes is that they are compositions "designed to improve technique of an instrumental performer by isolating specific difficulties and concentrating his or her efforts on their mastery." (Randel 2003: 301) I wanted to depart from the idea of the etude only as a set of tools for acquiring what could be called "athleticism" and expand my attention towards a definition in which the etudes would also pose aesthetic and compositional problems to performers, challenging them to present possible solutions in performance. In this search for a contextualisation of the etude from a compositional perspective, I identified the works of certain composers in relation to a single instrument (the piano), and worked out a development line between different etudes, their composers and the framework I wanted to use to create the *Flux*|*Pattern* series.

Starting from the athletic acquisition aspect of the etudes by, for example, Carl Czerny, I looked into the etudes of Franz Liszt, specifically the *Etudes d'exécution transcendante*, in particular number four, *Mazeppa* (1852), because of the unusual technical demands posed to the performer. Czerny's and Liszt's works helped me understand how athletic acquisition can be used as the core element of a musical piece. Next, I looked into the etudes of Claude Debussy, which provided a shift towards the notion of etude I was looking for. Debussy's etude no. 10, *Pour les sonorités opposées* (1915), for example, problematises for the performer musical aspects beyond the athletic dimension, such as colour, harmony and texture.

It was in the work of Olivier Messiaen that I found a clear notion of the etude as a didactic tool from a compositional perspective. His *Quatre études de rythme* (1949–1950) could be seen as practical examples of specific compositional ideas presented in his *Traité de rythme, de couleur, et d'ornithologie* (1949). I gave special consideration to *Mode de valeurs et d'intensités* (1950), the second of the series, since

it is usually quoted as “the first work by a European composer to apply numerical organisation to pitch, duration, dynamics, and mode of attack (timbre).” (Toop 1974: 142) Messiaen’s proto-serialism helped organise the initial materials used in the development of *Flux|Pattern.*

Boulez points out that the late 1940s and early 1950s “was, without a doubt, the most experimental period in Messiaen’s music. His rhythmic research in particular, which became more and more audacious, and his polyphony (*Epode* from *Chronochromie*) became adventurous and extreme.” (Boulez 2002: 5) In his *Treatise*, Messiaen explains how the structure of *Mode de valeurs et d’intensités* was conceived:

> The durations, intensities and attacks operate on the same plane as the pitches; the combination of modes reveals colors of durations and intensity; each pitch of the same name has a different duration, attack and intensity for each register in which it appears; the influence of register upon the quantitative, phonetic, and dynamic soundscape, and the division into three temporal regions imbues the passage with the spirit of the sounds that traverse them, creating the potential for new variations of colors.

While the work of Messiaen provided me with a clear compositional context for the use of etude, and the views of Debussy, Liszt, and even Czerny gave me enough nuances to approach the task of creating etudes from an athletic perspective, it was Pierre Schaeffer’s use of etudes as compositional devices that contributed to add a connection between traditional instrumental practices and the sonic and creative tools I was aiming to use, those of electronic music. Schaeffer’s *Traité des objects musicaux* (1966) is the culmination of a work aimed to “define a ‘solfège’ (i.e. define the ‘elements’) of the sound universe based on the perception of sound and to question what were clearly false notions about music, listening, timbre, sound, etc.” (Chion 2002: n.p.)

Schaeffer defines his notion of *mass* as the correlation between spectrum and pitch in a given sound-object: “whether it is a tonal or complex, concise or diffuse, related to a harmonic or non-harmonic spectrum, whether it consists of a single or an unlimited number of frequencies, mass is a musical perception that accounts for the harmonic structure of a sound.” (Schaeffer 1966: 517) The importance of the concept of mass lies in liberating a sound from its preconceived source, and turning into perception of the sound itself as the articulator for organisation and musical structure. This was

important for the development of a common challenge for both traditional and electronic instrumentalists in *Flux*|*Pattern,* since it gave me a basis to focus on listening while producing the work.

Created in 1948, Schaeffer's *Etudes de bruits* served as illustrations of his ideas on musique concrète. In his *Etude violette* (1948), the sole sound source is the noises that can be derived from a piano. The etude "consists of isolating sound fragments or rhythmic figures in different tempos and at different pitches, to be used structurally with different techniques: reverberation, reverse playback, etc." (Chion 2002: n.p.) The importance of *Etude violette* for the development of *Flux*|*Pattern* is that this particular musique concrète etude deals with sounds derived from a traditional instrument. Since the series *Flux*|*Pattern* was conceived as etudes for a combination of traditional and electronic instruments, it was very important to study and experiment with the possibilities of disassociating the instrument as identifiable object (i.e., the piano) from the sounds it produces as proposed by Schaeffer, seeking to mask, blur and combine the spectral characteristics of all instruments involved in my works.
It was this limitation to a single sound source, and Schaeffer's compositional goal to transcend the spectro-morphologic nature of the original source that motivated the creative choices behind *Flux*|*Pattern*.[41]

Project

The development of the *Flux*|*Pattern* series of etudes, in collaboration with Henry Vega (programming and computer performance), the ORCiM researchers Catherine Laws (piano) and Stefan Östersjö (guitar), and the flutist Richard Craig, dealt with creating an experimental setting to come up with possible answers to the questions presented in the introduction – experimenting with the possible musical relationships between traditional instruments and live electronic set-ups, with the interrelation of the roles of composer, performer and instrument builder in computer music, with evaluating the models of emulation and skill differentiation in computer music

[41] According to Denis Smalley, spectro-morphology "refers to the descriptive analysis of perceived morphological developments in sound spectra over time." (Smalley 1986: 61) What I consider important as a follow up to the definitions of sound morphology by Schaeffer, is the incorporation of the time variable, the perceptible change of the morphological structure of a sound while being listened to.

instruments, and with the influence of non-sounding aspects of music performance in a concert situation.

The goal was to recover the artistic and technical achievements produced during the previous work of The Electronic Hammer. The project started from the premise that looking into the interdependence of the roles of composer, performer, and instrument builder in computer music could lead to a re-evaluation of how traditional instrumentalists understand learning, practicing, technical improvement and performing.

Through the work conducted within that experimental setting, it became possible to define two clear goals that relate to the relationship between traditional and electronic instruments.
The first goal deals with the selection of a specific musical aspect common to both traditional and electronic instruments (and performers), the problematisation of this musical aspect, and its possible solutions through performance. The musical aspect selected for *Flux|Pattern* was *performative listening*, which was defined as the auditory feedback that allows the evaluation of one's own performance. The problematisation of performative listening started from the evaluation of its role with regard to electronic media and their possible transference to traditional instruments. The formulation of the musical problem dealt with the absence of primary (tactile) feedback in electronic instruments and the understanding of secondary (auditive) feedback as the only point of reference in playing an electronic instrument.[42] Thus, the goal was to focus on the act of listening as the evaluation tool of one's own performance as if it were the "primary feedback" for both electronic and traditional instruments. Eventually, the intention to exercise the listening flow between the performers by responding to a predetermined framework, led to the design of a dynamic cue system, programmed in SuperCollider, that would generate patterns of onsets and pauses for each performer on the basis of both individual and collective density of playing.

[42] An exception to this lack of tactile feedback is the "crackle box", an electronic instrument developed by Michael Waisvisz in the 1970s which provides small electric shocks to the performer interacting with the circuit. STEIM, the Dutch Studio for Electro-Instrumental Music still offers a version of the circuit. More information is available at
http://steim.org/product/cracklebox/.

[Image: Video of the dynamic cue system developed by Henry Vega in SuperCollider 3]

The second goal highlighted an interdependent relationship between traditional and electronic instruments. This was achieved by designing the musical materials of both on the basis of blurring the spectro-morphological identity of each instrument through (live) sampling and filtering. It was necessary to emphasise those elements of Schaeffer's use of the etude as illustration for the ideas of musique concrète. That is where the focus centred on showing the multithreaded role of the electronic music practitioner: selecting the sounds, manipulating them with (re)created tools, and capturing the result (or performance) on fixed media.

The first versions of the piece consisted of three simultaneous fluxes – that is, three continuous musical gestures that operated as semi-independent units, following predetermined multi-parameter directions (from high to low pitch, increase of density and decrease of amplitude). The three gestures shared several timbre commonalities and were cued by the computer system, which then determined when and for how long a particular flux would be allowed or whether it needed to be interrupted. The cue to resume playing ("the green light") was given by the same computer system, inviting the performer to choose how and when to continue, on the basis of both the current sound activity and the position within his or her own flux at the moment of interruption ("the red light").

[Video: Video of the rehearsal, with the cue system visible]

To merge all these considerations, the second stage of the research led towards the production of the musical score or structural diagram. It was created to serve as documentation of the sedimented processes of generating, testing and refining the materials generated by the performers, as well as the different patterns given by the computer cue-system. It became obvious at this point that to develop the project further, particularly with new potential performers, it would be convenient to present this documentation as a jump-start for producing new versions.

[Image: Structural diagram for *Flux|Pattern II*, for flute]

The first performances of *Flux*|*Pattern* (I to III) took place during the fourth ORCiM Research Festival at the Orpheus Institute, Ghent, 2–4 October 2013.[43]

Reflection

The production of *Flux*|*Pattern* aimed to determine what had been achieved by the two computer performers of The Electronic Hammer with regard to the development of musical and technical performance skills during the eight years of activity of the trio. It allowed them to explore what salient elements of the particular setting proposed to composers could be developed further, both as a duo and in combination with selected instrumental performers. By reflecting upon the different notions of etude in traditional instrumental composition, it was possible to create a framework in which aspects of traditional instrumentality and composition as problematisation of a musical aspect were used to find a common challenge in performance for both traditional instrumentalists and electronic performers. The understanding of Messiaen's and Schaeffer's compositional ideas, articulated in their etudes, helped to give shape to the material and sonic identity of *Flux*|*Pattern*.

The original questions that served as motivation for the development of the series of etudes dealt with the relationship between instruments (electronic and traditional), with the relationship between performer and instrument, and with the interaction between the roles of composer, performer, and instrument builder in the persona of the electronic practitioner, as well as its potential influence on traditional instrumentalists. Furthermore, the goal was to turn the tables in the creation of a piece for traditional instruments and live electronics that, rather than following a model of emulation from the electronic practitioner towards the traditional instrumentalist, would propose features belonging to electronic music as the starting point. I believe that by identifying a common challenge for both kinds of performer (performative listening), by focusing on the generation of common sound-objects among all instruments and deriving musical structure from computer based performance analysis, we generated several avenues for reflecting upon these issues.

After the first performances, one of the aspects that became necessary to address was the sensorial discrepancy between the musical challenge (performative listening)

[43] To watch the recording of Flux|Pattern_II go to http://www.youtube.com/watch?v=DeUlxc380SM.

and the way it was being controlled in the piece (the visual cue system). More recent versions of *Flux*|*Pattern* have addressed this issue by taking away the visual cues for the performers and replacing it with a pre-recorded soundtrack, which in turn is being triggered or paused according to the cue system. This has helped to reinforce the performative challenge of listening: evaluating and matching (or contrasting) each member of the ensemble's performing activity in relation to the soundtrack has become the new challenge, as well as the structural backbone of *Flux*|*Pattern*.

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On Multiple Paths

Introduction

The project *Multiple Paths* engages with two main issues: the search for a historical and aesthetic context for the creation of computer music today, and the extraction of musical elements from references to pre-existent music in order to feed them back into new compositions.

My encounter with the sound world of Luigi Nono's music provided me with a starting point to explore my own musical path. I retained several elements of this encounter as particularly relevant to my own questions regarding instrumental identity and practices. Furthermore I perceived that various implications of Nono's work go beyond the specific materials and performers featuring in either his music or my own, and beyond his or my specific historical moments, in constituting a fundamental challenge to traditional definitions of interpretation and composition.

Context

In the quest to define my artistic practice from a technology-independent, aesthetic perspective, I focus on and am fascinated by the possibilities technology provides for manifesting different interpretations of the notion of expansion in sound.

According to my personal experience as both practitioner and recipient, the context for computer music continues to be misrepresented. An underlying assumption is that work involving technology should always start from scratch: technology's potential for musical expressivity, which encourages the construction of personal tools or methods and their problematisation, carries the latent danger that the wheel will be constantly reinvented. Such hyper-personalisation is one of the biggest unresolved obstacles in the development of a shared computer-music practice, mainly because there is little interaction between practitioners other than in sharing technical information.

Performance practice on traditional instruments is very rich; aesthetic developments are informed not only by style but also by how performers gradually outgrew the existent instruments and encouraged constructors to rethink and evolve them. This is not evident for electronic media. An overwhelming focus on the tools employed, such

as the software used or the computer itself, often impedes the development of performative elements. The connection between tools and practices should ideally spawn technological development.

One of my goals here is to disregard technology and shift my attention towards underlying issues. For example, I focus on ideas of historical context or aesthetic affinity as the driving force for the development of computer music practice. I inform my personal practice in electronic media with traditional notions of musical interpretation. I challenge – even force myself – to create repertoire that inspires my musical creativity within the artistic framework of another's practice, thereby (re)introducing collaboration between performer and composer in computer music. Seeking out existing repertoire written for electronic media or pieces that could be adapted for it is at the centre of my musical fascination. In hindsight, such interpretative elements have greatly influenced my compositional endeavours.

A close examination of the tools used by Nono in his pieces with live electronics reveals how he was able to devise performative strategies that helped transcend the limitations and features of the time and place in which these tools were created. These timeless – and therefore very current – musical notions are instrumental to my understanding of musicianship in live computer music, and can be distilled into two categories.

First, the transformation of the physical space over time. This creates a Deleuzian *devenir* for the sounds of others.[44] The electronic instrument, then, plays with the act of becoming an independent musical voice by transforming the other voices. It attempts *being* something through something else. This is one of my main interests as a practitioner today: pushing the limits of musical expression by means of a "silent" instrument, an instrument that does not produce any sound and that only manifests itself when another instrument activates the physical space. Therefore, it allows the actions and decisions of its performer, or of someone (or something) else, to enter. This leads to communication with other performers that is no longer a linear dialogue

[44] I explain my choice of *devenir* over *becoming* in the *PLP I* case study.

or exchange of musical material. Rather, this silent instrument creates spaces that can be reshaped, influenced and transformed.[45]

Second, the challenge of the *performative unit*. By *performative unit* I mean the instrumentalist and her or his instrument. In the case of Nono, the challenge is manifested, for example, in *A Pierre* (1985), in the choice of instruments (extremely low register) and of actions for those instruments (extremely soft dynamics at the top of the range of the register).

My initial motivation to create *Multiple Paths (omaggio a Nono)* was to integrate these two musical notions in a new composition. To do this, I took as a starting point the revision and adaptation of the original electronic setups created for *A Pierre* and *Post-prae-ludium* into a single integrated virtual instrument. The process of collaboration with a dedicated group of performers, a recurrent strategy in my previous projects, led to the creation of the initial material, as well as the refining and expansion of the electronic setup.

Project

The point of departure for *Multiple Paths (omaggio a Nono)* was a collaboration between free improviser and double bassist Brice Soniano, composer and cellist Chris Chafe and myself.[46]

My initial aim was to capture those elements in the music of Luigi Nono that I was able to identify during my work on the preparation, performance and recording of *A Pierre* and *Post-prae-ludium* – the merging of the poetic and sounding notions of space transformation over time, and Nono's notion of the *suono mobile* – while searching for my own ways of exposing the potential of controlling this musical space as an instrument through the active manipulation of this space in performance; this is to say, to situate myself on stage, as part of an ensemble, using the resonances and traces of the other instrumental actions as the voice of my instrument. By *resonances* I mean

[45] The notion of an "independent" silent instrument might lead to confusion due to its sonic dependence on other instruments or sound sources. The "independence" is in the actions and intentions, rather than in the sounds.

[46] Chris Chafe is the director of Centre for Computer Research in Music and Acoustics (CCRMA) at Stanford University (https://ccrma.stanford.edu/~cc/shtml/index.shtml); Brice Soniano is a free jazz improviser from France (http://bricesoniano.com).

the trail left by the instrumentalist's musical action; by *traces*, I point to those sounds produced that are not necessarily part of the intended musical discourse.

I developed a set of strategies and tools to overemphasise, freeze and transform the original instrumental sounds while preserving their original timbre as a clear point of departure.
There are three different levels in the relationship between *Multiple Paths* and the music of Nono. The first concerns the approach to instrumental material. I started by asking performers to play their instruments unconventionally. I conducted a series of sessions with different musicians attempting, at first, to come up with small musical units that could be reinterpreted by different instruments. These were initially developed for double bass, bassoon, saxophone and daxophone.[47]

Aiming for a disassociation between physical action and sonic manifestation, I chose to present the daxophone in contrast with the double bass. Both share the same excitation mechanism (bow), but in the case of the daxophone the sound results are somewhat unpredictable. I set up tests where the physical actions could be shared by daxophonist and double-bassist, with (a partial) disregard to their sound results.

Extending this exploratory process, we reached a point where matching actions created sonic similarities between the two instruments. These were later refined into the musical cells to be used in the piece. This refinement translated into a specific action with a consistent sonic consequence: When keeping the bowing at a steady, soft level, the daxophone created a series of upper harmonics that did not sustain for very long. To imitate this, the double bassist tried to excite unattainable harmonics (such as those resulting from a minor seventh interval with an open string) while keeping his bowing as steady as possible.

[Sound example: Double bass]

[47] Invented by Hans Reichel, the daxophone is part of the idiophone family of instruments (excited by friction) and can be described as a stylised version of a "ruler-at-the-end-of-a-table" sonic experiment. More on the daxophone can be found at Hans Reichel's website: http://daxo.de/pages/page10.html.

I conducted a similar exploratory process with a bassoon player.[48] The initial premise was to grade how many different sounds could be generated from a single fingering. For the tests, we used only the lowest B♭ (all keys closed) and focused on the variations produced exclusively by changes in reed pressure – how accuracy in controlling the increase and decrease of pressure determined the resolution of our new instrument.

The next step was to develop a single musical gesture that could later be reproduced by other instruments. We chose to create a (mechanical) instrumental reproduction of what could be described as one of the most famous clichés of early *Elektronische Musik*: a gradual, accelerating transition from pulse into timbre.[49]

[Sound example: *Kontakte* and bassoon imitation of pulse-to-texture]

These two initial musical gestures (the pulse-to-timbre and the search for an unattainable harmonic) were then used to create the score for the first version of *Multiple Paths*. The score itself represents a second point of connection to Nono, specifically with *Post-prae-ludium*, where the tubist must choose points at which to detour from a delineated path in the score, which in turn affects the material that is received by the live electronics setup, thereby transforming the way this material is redistributed in the physical space.

Multiple Paths is built on these first collaborative sessions, which included a first performance that took place on 20 February 2013 in Ghent, Belgium, with Brice Soniano on double bass and Chris Chafe on networked daxophone, the latter playing from California using the jamLink[50] technology developed at the Center for Computer Research in Music and Acoustics (CCRMA), Stanford University.

[Video excerpt available at http://www.youtube.com/watch?v=kq0sK6HMYuw]

[48] Dana Jessen, from the US. More information on her can be found at www.danajessen.com.
[49] Perhaps the better known musical example of this musical gestures comes from Karlheinz Stockhausen's *Kontakte* (1958–1960).
[50] More information on the jamLink device and technology can be found at https://www.musicianlink.com/.

This first version of *Multiple Paths*, given its networked component, served to connect with Nono's ideas about creating unstable musical material by challenging the performative unit, as presented in the analysis of *A Pierre*: the use of networked performance technology (jamLink) in the earlier versions of *Multiple Paths* made it possible to add a dimension of spatial displacement to the piece. The instability of network performance systems (such as jamLink) undoubtedly colours the result; even in their most successful implementations, there are small ongoing discrepancies between sound (in time) and image (slightly delayed).

Multiple Paths expanded in instrumentation into its final version through a process of transcoding the initial musical gestures onto different instruments, always aiming to preserve relationships between the physical actions of the various performers and the sounding results of their actions.
Starting with the initial material generated in the sessions with bassoon and double bass, and the later parallel between physical actions of double bass and daxophone, the process of expansion of the instrumentation followed a sequence of two-by two; each pair of instruments would share a relative similarity in their physical actions for one of two available musical elements, and one sounding similarity for the other element.

Each instrument, then, ended up having two interventions throughout the piece. The pairs for the final expanded version for eight instruments were:

Flute – clarinet
Violin – piano
Trumpet – guitar
Cello – double bass

Although *Multiple Paths* differs in its result from the music of Nono, mainly in terms of density and the use of silence, I aimed to preserve his strategies for changing the relationship between performer and instrument, as well as his strategies for sound transformation. In that respect, Hans-Peter Haller (Haller 1999: 11) comments that:

> Nono was not merely a technical composer, he considered all acoustic phenomena according to musical criteria. He wanted to transform, extend, the natural parameters of

sound such as pitch, intensity, duration, dynamic envelope, and especially that of timbre.

The textural density of the piece was an element I tried to keep constant, irrespective of the number of performers in each version. Each new test iteration allowed the addition of more musicians, but to preserve the essence of the piece, each new instrument was instructed to play in an exponentially fragmentary fashion, so each instrumental line became more and more scattered in the course of the piece. Because of the increasing number of sources that the electronic system needed to analyse and process, it was necessary to elaborate a more discrete score for both the ensemble and the computer performer. With this score as point of reference, it was the task of the conductor to cue each instrument to start a new event, and to cue the electronic performer to start the transformation of that event by the electronic system.

[Image: *Multiple Paths* score]

The final version of *Multiple Paths*, for eight instruments and quadraphonic sound system, was completed in collaboration with and premiered by the Ensemble Modelo62[51] during the ORCiM Research Festival at the Orpheus Institute, Ghent, Belgium, on 4 October 2013.

[Video excerpt available at http://www.youtube.com/watch?v=HWp6PjaX78c]

After the manipulation of the physical space over time, and the challenging of the performative unit, the electronic setup constitutes the third connection to the work of Luigi Nono. Developed in the Max/MSP environment, it involves two distinct kinds of processes: first, an array of filters and short delays that create a trail of rhythmic patterns behind each action of the sustained musical gesture; second, a more static environment, similar to the one devised by Nono and Haller for *A Pierre*, consisting of a twelve- and twenty-four-second delay and a filtering system.[52] Additionally, multiple internal routing choices are available for the electronic musician to modify during the

[51] Under the direction of Ezequiel Menalled, Holland-based Ensemble Modelo62 has championed new music in the Netherlands for over a decade. For more information visit http://www.modelo62.com/.
[52] See the *Reconstruction* case study for the examples of Nono's *A Pierre* and *Post-prae-ludium.*

performance, as in the setup for *Post-prae-ludium*.[53] The system was developed during the initial experimentation sessions with the instrumentalists, and tested further in improvisatory sessions with improvisers Keir Neuringer and Rafal Mazur.[54] The electronic system was controlled by a dedicated interface nicknamed *Phoenix Egg*, an array of distance, ultrasound and gyroscope sensors, developed in collaboration with Lex van den Broek, head of the technical department at the Royal Conservatoire of The Hague.

Reflection

There are two fundamental aspects in my research trajectory that I wished to highlight with this composition. The first is the need for historical/aesthetic context. The connection with Luigi Nono's understanding of the role of live electronic media (and its performers) in composition resonates with my personal understanding of performance practice in computer music today as the fusion of the roles of composer, performer and instrument builder (or, in this particular case, technician). Nono states clearly that the electronic material, even in repertoire earlier than *A Pierre*, and even when it was in fixed form, needed to be played by a performer with artistic skills and curiosity, and that mere technical know-how was inadequate to present the material in a concert situation. Ogborn points out that "throughout the 1980s, in close collaboration with Hans Peter Haller and later André Richard at the Experimentalstudio Freiburg, Nono's compositional activity was centred on a process of interaction with particular, virtuosic performers on the one hand, and with the spaces of performance on the other." (Ogborn 2005: 2)

The second aspect is the material itself. I consider that one of the most salient features of Nono's works with live electronics is the successful manifestation in sound of an aesthetic or, rather, poetic element. An example of this is his *Prometeo*. Fundamentally, the use of real time spatialisation, reverb, filters and delays, which might seem rather simplistic and underdeveloped compared with today's signal processing possibilities, carries an aesthetic and poetic quality, and its careful

[53] See footnote 52.

[54] Keir Neuringer, saxophonist from the United States, and Rafal Mazur, bassist from Poland, are the founder members of the improvising ensemble *[ie]*. They have managed to sustain a transatlantic collaboration for over fifteen years. For more information on Neuringer visit http://keirneuringer.com/ and on Mazur see http://www.rafalmazur.eu/.

marriage to an equally fragile instrumental sound material, makes Nono's music transcend its apparent simplicity.

The act of paying tribute to someone's work starts with the recognition of personal affinities with the subject. In the case of my view of Luigi Nono, it would have been sufficient to focus on my affinities with his creative musical ideas. However, his deep political views, as reflected in his late musical output, were no longer expressed in explicit themes, but, rather, in the search for a profound change in the way people listened and communicated with each other through music. de Assis points that Nono's music of this period presents "an aesthetic and a politics of the smallest differences, of the finest details, of the barely audible. An invitation to question one's identity and courage for a change". (Assis 2014: n.p.)

Nono's political views are further explored when dealing with the notion of the musical work as a final object. He (Nono 2001: 273-75) stipulates that

> [T]oday more than ever the artist has the responsibility to avoid conclusive, finalized results. They must understand that (as Musil says) "it isn't important what *is*, but rather what *could have been.*" This does away with all Manicheism, all sectarianism and intellectual rigidity. Right up to the last moment, my new work is open to all possible transformations.

It is the reluctance to escape this questioning, and his willingness and ability to express these views through his musical work – while also succeeding to evade the aesthetic clichés of politically engaged music – which sits in the core of my admiration for him, at times providing comfort in my choice of electroacoustic music practice as a profession.

Appendix

The road towards the full ensemble version of *Multiple Paths* led to an accumulation of encounters with different musicians. Here is a brief account of them:

First encounter: with Dana Jensen (bassoon)

A session exploring the extended use of the reed, which was later presented against the static version of the electronic instrument. The first gesture of the piece grew from

this session. This initial gesture is a comment on one of the earliest musical gestures explored in *Elektronische Musik*: the transition from pulse to timbre.
Date: 12 November 2012.

Second encounter: with Keir Neuringer (saxophone) and Rafal Mazur (acoustic bass)
A free improvisation session, aimed at testing the basic trajectory gestures of the spatialisation controller in conjunction with the selection of the sources (sax, acoustic bass or electric guitar).
Date: 28 November 2012.

Third encounter: with Brice Soniano (double bass)
Development of the second core gesture of the piece: sustained pitches meant to target “unattainable” sounds; in the case of the double bass, trying to sustain and modify the articulation of the seventh harmonic over open strings.
Date: 11–12 December 2012.

Fourth encounter (and first version): with Chris Chafe (networked daxophone) and Brice Soniano (double bass)
The first version of the piece, combining a first transcription of material derived from encounters one and three, and incorporating the network performance element, as well as the spatialisation element developed in encounter two. Given the unpredictability of its sounding outcome, the use of the daxophone helps to highlight the physicality of the gesture, pushing its sound result to a secondary plane. The goal was to stretch the rudimentary articulation abilities of the daxophone towards imitating actions in the double bass, regardless of the pitches resulting from these actions.
Date: 20 February 2013.

Fifth encounter (the full ensemble version): with Ensemble Modelo62
For eight instruments and quadraphonic sound system. Premiered during the ORCiM Research Festival at the Orpheus Institute, Ghent, Belgium, on 4 October 2013.

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Conclusion

The initial premise for this research trajectory – to understand what constitutes performance practice in computer music, how it differs from traditional instrumental practices, and how it can be further challenged and developed – informed the development of a series of case studies where the notion of the computer music practitioner as a multithreaded role of composer, performer and instrument builder was, first, challenged by attempting to focus on one of these three roles, and, second, accepted and reinforced by allowing the influence of the composer's and performer's mindsets into the technical decision-making of instrument design, applying compositional and instrument building skills to inform interpretative choices of pre-existing repertoires, and, finally, developing compositional systems derived from instrument design, mapping, and performance traditions.

During this research trajectory I have looked at the performance practice of computer music through the mirror of traditional instrumental interpretation. In doing this, a misconception kept reappearing: the pairing of "interpretation" with "performance". I didn't want to present traditional music interpretation as a "higher" form of performance, or make a defense of the notion of *Werktreue*. The sets of skills required to decode and present in front of an audience someone else's musical ideas, and furthermore, to add an interpretation to a body of renderings of a determined musical work, presents a potential for creative and technical development that most trained traditional instrumentalist know very well, but that electronic musicians are rarely if ever exposed to.

In the current discourse on interpretation in computer music, one often assumes that the focus of our attention is the interpreter of traditional instruments and his or her interaction with the electronic system; most historical approaches to human–electronic interaction in contemporary music take this as a basic truth. After all, many pieces for instruments and fixed media (such as Karlheinz Stockhausen's *Kontakte*, 1958–1960, for piano, percussion and electronic sounds, or Luigi Nono's *La fabbrica illuminata*, 1964, for soprano and tape) have been created since the beginning of the era of electronic music composition, and this compositional format remains among the most commonly used. Recent examples include works by composers such as João Pedro Oliveira (*Lâminas líquidas*, for marimba and tape, 2002), Ton Bruynèl (*Brouillard*, for

piano and two soundtracks, 1994) and Mario Davidovsky (*Synchronisms,* a series of pieces for solo instruments and electronic sounds, the latest, for clarinet, composed in 2006).

While the new possibilities for digital sound synthesis and transformation have been thoroughly explored, the reliability of fixed media has never been abandoned. The development of technology and the possibility for real-time processing, analysis and synthesis of sounds have opened a window for the realisation of a new kind of music production, where both the traditional and the electronic sound elements of a piece can be controlled on stage by a human performer.

Early works exploring the use of live electronics to enhance the timbral qualities of music include Stockhausen's *Mikrophonie* (1964–1965) for large tam-tam, two sound-exciters, two microphonists and two filter control operators, and Nono's body of works in collaboration with the Experimentalstudio of Freiburg (e.g., *Das atmende Klarsein*, 1980, and *Prometeo*, completed in 1985). While bringing to the musical world new sonorities in real time (e.g., ring modulation and filtering, or extensions in time and space by means of reverberation and spatialisation), these approaches are limited by being dependent on the original sounds of the traditional instruments involved in the piece, leaving the impression that in order to gain real-time generation qualities the role of the electronics must compromise its potential for timbral complexity.

For the last twenty-five years, one of the main interests of IRCAM has been to develop innovative ways of using technology to achieve real-time interaction between the instrumental and the electronic elements of a musical system. A primary goal was to liberate performers from the rigidity of pre-recorded electronic material, and to provide them with the means to control more complex and timbre-independent electronic material. Examples of this approach are Pierre Boulez's *Répons* (1981–1985), for ensemble and computer system, John Chowning's *Voices* (2005–2009) for soprano and computer and Cort Lippe's *Music for Septet and Computer* (2013).

Although achieving considerable flexibility and timbral complexity, this approach still maintains a kind of master–slave relationship between instrumentalist and electronics, making the musical gestures and nuances of the electronic material independent from the articulations of the instrumental part.

Leaving this approach behind would involve a dedicated performer for the electronic elements of a piece, someone with the freedom to articulate the predefined parameters of the synthetic sounds and/or of the instrumental sound manipulation.

Towards a definition of the computer music performer

To this day, the role of the electronic performer is sometimes confused with that of the sound technician behind the mixing desk who maintains the balance between the electronics and the traditional instrument levels. However, that role requires the technician to be in an ideal audience location, far from the stage and far from the performers. A technician may thus require additional cues to follow a specific passage in the electronic part (if it is pre-recorded). In the case of a live processing system, where accurate notation for the traditional performer is less relevant than the exploration of the gestures that the computer system is able to identify and react to, the musicians on stage may need to be cued when a particular kind of playing is required. For example, to react as expected, the computer system may require the incoming signal for a time to be without vibrato.

These quasi conductor-like gestures, as well as other actions more closely related to those of a traditional instrumentalist, make up the role of what could be called *the computer performer*. Some of the characteristics of this new performer would be: the capability to resolve a number of technical challenges during a performance, dividing the logistical responsibilities between the performer and a sound engineer and, in particular, the ability to contribute to the performance like an instrumentalist, with his or her own sound-print and articulations, so as to be able to interact with other performers in a piece both at the timbral (sound) and at the gestural (control) level.

We can already find some examples of music creators who might serve as a model for such a computer performer. These individual developments have been greatly enhanced thanks to a broadening of access to computer technology in recent years, which has spawned a whole generation of laptop artists and other more complex human-gesture-controlled systems. Examples of the latter include Michel Waisvisz's *hands* and the LiSa system, both developed at the STEIM institute in Amsterdam, and Atau Tanaka's BioSensors system.

The undeniable contribution of these new artists/creators, who are immersed in finding new ways of controlling complex electronic music systems in a performance situation, begs one final question: Is it possible to divide the role of the composer and the performer when creating and using these complex systems?

The quest for “beauty” in electronic music forces composers first to generate an imaginary cosmogony of sound elements before justifying – through creative structuring – how this cosmogony works, mutates and exposes a musical meaning. The computer performer faces similar challenges. In a way, the alchemical role often connected to the work of composers or to innovative improvisers must be adopted by this new interpreter, not only to create the instrument on which he or she will perform – with its possibilities and limitations – but also to generate a consistent set of performance skills that will allow a creative interaction with composers and fellow music interpreters.

Having succeeded, the next step is to collaborate with composers on the design of software and hardware (musical instruments) that would potentially help to define a musical identity in a different form than that of a traditional score – for example, by promoting the dissemination of these new works by encouraging other computer practitioners to perform them.
This in turn necessitates accurate research into the status quo, to avoid reinventing already efficient tools that can be reutilised. It also demands a renewed focus on the development of new general-purpose tools in less explored areas, such as real time convolution. At the same time, researchers should be encouraged to produce dedicated practical implementations, in the form of software instruments and physical controllers for particular projects.

The nature of these musical systems leans towards an electronic equivalent of traditional instrument building, rather than the development of interactive systems, such as those developed in the 1970s by, among others, Joel Chadabe, who defines (Chadabe 1984: 23) his interactive computer systems as follows:

> An interactive composing system operates as an intelligent instrument – intelligent in the sense that it responds to a performer in a complex, not entirely predictable way, adding information to what a performer specifies and providing cues to the performer for further

> actions. The performer, in other words, shares control of the music with information that is automatically generated by the computer, and that information contains unpredictable elements to which the performer reacts while performing. The computer responds to the performer and the performer reacts to the computer, and the music takes its form through that mutually influential, interactive relationship.

My argument, as well as my whole thesis, aims towards a methodology where traditional and computer musicians would share a comparable set of skills, challenges and creative responsibilities. In this scenario (pace Chadabe's), the computer is a tool for expression, not an autonomous expressive component of the musical system.

From these considerations I develop strategies for production and performance with new electronic voices, such as *Timbre Networks*, where musical aspects such as material exchange, gestures, interlocking, and control of layer-density challenge and give the interpretative freedom that this new performer should demand: a kind of music in which the electronic media is a musical source capable of standing on its own.
We need to find a set of organisational rules that determine the intention and the extent of the interpretative influence on the material and discover efficient and artistically meaningful ways of delivering this control in a performance situation. This does not mean that composers should think of the electronic media (synthetically produced sounds or systems for real time processing) as traditional instruments. Similarly, an electronic performer should not aim to emulate gestures and performance conventions that are a product of hundreds of years of tradition. By revising some of the positive constraints of traditional instruments and performance, it is possible to aim for a successful interaction between the composers and interpreters of this electronic media.

One possibility is simply to divide the roles of composer and interpreter. Currently, composers perform the electronic parts for their own pieces for a variety of reasons. The main reason, however, is that they are the ones most familiar with the piece and, since we are far from reaching a consensual standard on electronics (not only regarding the tools used but also regarding parameter descriptions), the effort of defining a meaningful notation that will deliver enough information to the potential interpreter can be bypassed. The cost, of course, is that these pieces can only be performed by their composers, limiting the dissemination of their music. Some

composers have adopted the approach of creating event-based scores and self-contained computer applications that could be performed by a technician.

While this approach solves the dissemination issue, in a concert this kind of contribution of the electronic part to the overall piece is not that far removed from that of a traditional pre-recorded tape. Yet perhaps the greatest benefit of being able to divide these roles is to regain the collaborative potential of music. After all, it is through this interaction between composer and performers that music has continuously evolved throughout history, by expanding the sound palette of instruments through the development and formalisation of extended techniques, and by combining the personal backgrounds of particular performers with the structural ideas of composers. Skill development and focused understanding is only reached if we are able to reintegrate these separate roles. As it has been pointed out elsewhere, “Creative duality is *concise* duality, in which a plurality of meanings or functions is achieved not by simple addition, but by fusion and compression.” (Veale, Feyaerts and Forceville 2013: 55)

Once we succeed in dividing and fully developing these roles, we can move forward to our final goal: to recombine the roles of composer, performer and instrument maker in a productive blend with new, emergent properties. In effect, I aim to create a new, multi-threaded role in the guise of the computer musician, in whom the creative singularities of different aspects of musical practice will intertwine and fuse together. The limits of individual roles as we understand them today will be thoroughly blurred, allowing us to discover new and emergent pathways to creative musical performance.

By using computers, and timbre networks in particular, to dis-integrate and creatively re-integrate our conception of what it is to be a musical performer, I aim to recover, for practitioners and audiences alike, the fragility, surprise, and unexpectedness that presenting music on stage is all about.

References

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Summary

This research project proposes multiple paths towards the development of a performance practice in computer music. It starts with the author's transition from traditional instrumentalist to electronic musician, assessing the roles of composer, performer and instrument builder as integrated in computer music practice. Three of the case studies presented in this thesis suggest approaches to understand the notion of interpretation with electronic instruments, introducing the methods of *reconstruction*, *reinterpretation* and *re-appropriation* as applied to the performance of music by Cage, Feldman and Nono. The remaining five case studies deal with the author's own creations, developed on the basis of concepts such as *mapping*, *sonification*, *historical contextualisation* and *spatialisation*, and informed by the multithreaded role of the computer music practitioner. The situation of the performer of electronic instruments in relation to traditional instrumentalists is a topic of consideration throughout this thesis, informing the final conclusions as well as refuelling the questioning for future work.

Samenvatting

Deze thesis reikt meervoudige paden aan naar de ontwikkeling van een uitvoeringspraktijk voor computermuziek. Het startpunt is mijn overgang van traditionele instrumentalist naar elektronisch musicus, waarbij de functies van componist, uitvoerder en instrumentenbouwer beurtelings worden beschouwd als geïntegreerd in de praktijk van de computermuziek. Drie case studies presenteren manieren om de idee van “interpretatie” met elektronische instrumenten te begrijpen. Hiervoor worden drie methodes geïntroduceerd (reconstructie, herinterpretatie, en toeëigening), zoals deze werden toegepast in mijn uitvoeringen van, respectievelijk, de muziek van Cage, Feldman en Nono. De overige vijf case studies zijn toegespitst op een aantal eigen composities, ontwikkeld op basis van concepten als “mapping”, “sonificatie”, “historische contextualisatie” en “spatialisatie”, en geïnformeerd door de veelzijdige rol van de componist-uitvoerder. De plaats van de bespeler van elektronische instrumenten in verhouding tot die van traditionele instrumentalisten wordt doorheen de thesis geëvalueerd en motiveert niet alleen de uiteindelijke bevindingen maar werpt ook nieuwe vragen op voor toekomstig onderzoek.

Curriculum Vitae

Juan Parra Cancino (b. Chile, 1979) studied Composition at the Catholic University of Chile and Sonology at The Royal Conservatoire The Hague (NL) , where he obtained his Masters degree with focus on composition and performance of electronic music.

As a guitar player he has participated in several courses of Guitar Craft, a school founded

by Robert Fripp, becoming part of various related guitar ensembles such as the Berlin Guitar Ensemble, the Buenos Aires Guitar Ensemble, and until 2003, The League of Crafty Guitarists.

His compositions, that include pure electronic and electroacoustic mixed media with solo

instruments and ensembles have been performed in Europe, Japan, North and South America in festivals such as the International Computer Music Conference (2006, New Orleans, 2008, Belfast, 2009, Montreal), Sound and Music in Computing (2009, Porto, 2010, Barcelona), “Primavera en La Habana” (Cuba) “Sonorities” (Belfast, UK), "Synthese" (Bourges), "Visiones Sonoras" (Mexico),"Sonoimagenes" (Buenos Aires), November Music (’s-Hertogenbosch), "Montevideo Percussion Festival", "NWEAMO" (USA), "Rumor" (Utrecht), Musica Electronica Nova (Wroclaw), Aimaako (Santiago de Chile), among many others.

His acousmatic piece Serenata a Bruno obtained a special mention at the Bourges electroacoustic music competition of 2003 and in 2004, his piece Tellura was awarded with the residence prize of the same competition. It was recently edited in the album “50 years of Electroacoustic Music in Chile”, a release that obtained the 2008 Quartz prize for best compilation.

His is a founder and active member of The Electronic Hammer, a computer and percussion music ensemble devoted to the promotion, creation and diffusion of the music of the XXI century, whose debut album was edited by the EMF label; he also performs in WireGriot, a duo of voice and electronics that seeks to (re)construct the repertoire for the media.

His work in the field of live electronic music has made him recipient of numerous grants from the Dutch government, through the NFPK and Prins Bernhard Cultuurfonds.

The recognition for his work has given him the chance to participate in projects and give lectures in centers such as CCRMA (Stanford University, USA), Oberlin College (USA) Banff Center for the Arts (CA), Tokyo University of the Arts (JP), Republic University (Uruguay), Leuenburg Studios (Germany), Walter Maas Huis (NL), and to be composer in residence at the Centre for Composers (Gotland, Sweden) and University of North Texas (Denton, USA), among others.

Since 2009 Juan has also been appointed as a joint researcher of the Orpheus Institute Research Centre in Music (ORCiM) to work on the topics of Notation and Creativity.