Towards Hypertextual Music:
Digital Audio, Deconstruction and Computer Music Creation.

A thesis submitted for the degree of Doctor of Philosophy

by

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June 7, 2017

Abstract

This is a study of the way in which digital audio and a number of key associated technologies that rely on it as a framework have changed the creation, production and dissemination of music, as witnessed by my own creative practice.

The study is built on my own work as an electronic musician and composer and draws from numerous collaborations with not only other musicians but also researchers and artists, as documented through commissions, performances, academic papers and commercial releases over an 9 year period from 2007 to 2016.

I begin by contextualising my own musical practice and outlining some prominent themes associated with the democratisation of computing that the work of this thesis interrogates as a critical framework for the production of musical works.

I go on to assess how works using various techniques afforded by digital audio may be interpreted as progressively instantiating a digital ontology of music. In the context of this digital ontology of music I propose a method of analysis and criticism of works explicitly concerned with audio analysis and algorithmic processes based on my interpretation of the concept of 'hypertext', wherein the ability for computers to analyse, index and create multi-dimensional, non-linear links between segments of digital audio is best described as *hypertextual*.

In light of this, I contextualise the merits of this reading of music created using these affordances of digital audio through a reading of several key works of 20th century music from a *hypertextual* perspective, emphasising the role information theory and semiotics have to play in analyses of these works. I proffer this as the beginnings of a useful model for musical composition in the domain of digital audio which I seek to explore through my own practice.

I then describe and analyse, both individually and in parallel numerous works I have undertaken that seek to interrogate the intricacies of what it means to work in the domain of digital audio with audio analysis, machine listening, algorithmic and generative computational processes and consider the ways in which aspects of this work might be seen as contributing useful and novel insights into music creation by harnessing properties intrinsic to digital audio as a medium.

Finally, I emphasise, based on the music and research presented in the thesis, the extent to which digital audio and the harnessing of increasingly complex computational systems for the production and dissemination of music has changed the ontology of music production, a situation which I interpret as creating both substantial challenges, but also great possibilities for the future of music.

To Alice, Kip and Naomi with all my love.

Acknowledgements

Firstly, I am sincerely grateful to both Professor Richard Barrett (for not only encouraging me to embark on this PhD some nine years ago, but also overseeing the initial years of its development) and Professors Peter Wiegold and Christopher Fox for their patience, motivation, guidance, immense knowledge and conviction. I could not have hoped for better mentors or a more supportive and stimulating academic environment in which to shape this research.

I also owe and immense debt of gratitude to the numerous collaborators with whom I have had the fortune to work with during the course of this PhD, in particular, Oliver Bown, Lothar Ohlmeier, Maurizio Ravalico, Tom Arthurs, Philippe Pannier, Tolga Tüzün, Gareth Humphreys, Oliver Duckert, Rudi Fischerlehner, Alex Bonney, Will Worsley and also all those who have been involved or associated with the Not Applicable collective throughout this period. Their great insight, encouragement, unparalleled musicianship and critical ears have not only helped catalyse this research but also been a font of inspiration in general.

My sincere thanks also goes to Diemo Schwarz, Norbert Schnell, Emmanuel Jourdan and Arshia Cont, whose software, intricate research and formidable theories my own research draws on and continues to be inspired by.

Finally, I would also like to thank the whole music faculty at Brunel University and specifically Dr. John Croft and Dr. Sarah Nicolls for the many enlightening seminars and conversations that have helped shape this work.

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Chapter 1

Introduction

1.1 Point of Departure

This thesis encapsulates, investigates and elucidates the principle themes that have informed my practice as an electronic musician since 2007. Whilst the research and music discussed in this thesis are original to it, the practice it emanates from nevertheless draws upon my previous experience of realising electronic and electro-acoustic music collaboratively with other musicians, artists and researchers and my experience creating electro-acoustic music at IRCAM[1].

As these experiences serve as foundations for the point of departure of this thesis, I will discuss briefly two principle fore bearers for this investigation whose influence is catalytic to the hypothesis I explore. The first of these is my collaboration with Oliver Bown[2], through which we have published numerous musical works under the collective moniker 'Icarus' and the second is my composition 'Junkspace' for banjo and electronics, realised at IRCAM.

My collaboration with Oliver Bown spans almost two decades of published work[3], including 7 full length albums, 5 'extended play' releases and 17 remixes of other artists work. We have performed extensively together over the years and have also conducted research together, notably in residence at STEIM[4] in 2011.

[1] The 'Institut de Recherche et Coordination Acoustique/Musique', known primarily through its acronym IRCAM is an institute dedicated to musical research in Paris. Founded by Pierre Boulez in 1970 it commissions musical works, publishes research and develops software that explores the domain of electro-acoustic music creation

[2] "Oliver Bown is a researcher and maker working with creative technologies. He comes from a highly diverse academic background spanning social anthropology, evolutionary and adaptive systems, music informatics and interaction design, with a parallel career in electronic music and digital art (...) He is a senior lecturer at the Faculty of Art and Design, University of New South Wales." Profile on Oliver Bown at The Conversation

[3] Our first publicly released record was entitled 'Moth' and released as an EP in 1997 on the independent record label 'Recordings of Substance'.

[4] STEIM (STudio for Electro Instrumental Music) is a centre for research and development of new musical instruments in the electronic performing arts, located in Amsterdam, Netherlands.

> "Through 'Icarus', we have explored various forms of electronic music production, creating music with elements of electronica, breakbeats, free improvisation and electro-acoustic composition. Beginning in the late 1990s, we produced a series of studio based albums in which the musical material was created from scratch through detailed editing on a time-line - either a MIDI pianoroll controlling multiple synthesizers and samplers, or a multitrack DAW, the traditional "project studio" or "bedroom studio". From around 2002, real-time algorithmic processes entered our repertoire through patches made in MaxMSP, and we became involved in improvising with computers, leading to a number of recorded works based on live material. During this time our creative process evolved towards the production of electronic music through a combination of algorithmic generative processes and collectively improvised long-term structures. In this respect we were part of a wider movement, initially inspired by the futurism of electronic dance music, which -somewhat intuitively-explored the methodologies pioneered in 20th century avant-garde music through creative programming." Oliver Bown and Sam Britton, *An Album in 1,000 Variations: Notes on the Composition and Distribution of a Parametric Musical Work*, Leonardo, Vol. 47, No. 5, pp. 437-441.

This nascent investigation of 'music as research', which we stumbled into as 'Icarus' through experimenting in MaxMSP with algorithmic processes as an element of our own music production took centre stage in my own musical investigations when, from 2005 - 2006 I was a student on the 'Cursus' masters course in electronic music and composition at IRCAM[5]. My experience composing at IRCAM, which involved detailed work with software developed at IRCAM and the production of written scores to be interpreted by classically trained musicians is encapsulated by the piece I produced there; a 10 minute work for banjo and electronics entitled 'Junkspace'. 'Junkspace' is at once a product of the pedagogical environment fostered at IRCAM, but equally an attempt to see beyond it, something that is alluded to in the title of the piece, itself taken from a quote by the architect Rem Koolhaas:

> "If space-junk is the human debris that litters the universe, junkspace is the residue mankind leaves on the planet. Junkspace is what remains after modernisation has run its course or, more precisely, what coagulates while modernisation is in progress, its fallout. Modernisation had a rational program: to share the blessings of science, universally. Junkspace is its apotheosis, or meltdown... Although its individual parts are the outcome of brilliant inventions,

[5] "Each year IRCAMs Cursus training program, an integral part of the Institutes musical and intellectual life, welcomes ten young composers from diverse cultural and aesthetic backgrounds. After an initial phase of teaching dedicated to both composition and computer music, students go on to develop a project focusing on new methods of computer-aided composition." From the IRCAM website: www.ircam.fr.

> lucidly planned by human intelligence, boosted by infinite computation, their sum spells the end of Enlightenment, its resurrection as farce, a low-grade purgatory..." Rem Koolhaas, *Junkspace*, October Magazine, Spring 2002, No. 100, Pages: 175-190, MIT Press.

My experience at IRCAM and the process of composing 'Junkspace' combined with the contrast of producing work independently as 'Icarus' in effect set in motion a series of questions for me concerning not only the problems associated with musical research conducted in institutions such as IRCAM, but also the possibilities for a culture of musical research as proposed by a networked environment of software development on the internet, the exponential increase in the processing power of personal computers[6] and and the rising quality of commercially available electronic instruments and interfaces. Whilst there was a perception (echoed by Koolhaas in his description of 'Junkspace' above) that the type of ad hoc network environment fostered by the internet lacked rigour, it nevertheless seemed to benefit from a congruity with these networks and the associated possibilities for personal computing by functioning through them.

1.2 The Dynamic of 'Hacking'

Through the digitisation of many of the principle processes associated with music research, the increasing availability of associated hardware systems for personal computers and the distribution of research and software via the internet, my perception of music research was changing from one where institutions such as IRCAM occupied a dominant role to one where the principle dynamic was that of 'hacking'; whereby the expertise of such a domain as encapsulated by the tools it develops and mobilises to further knowledge is called into question by the democratisation of those tools:

> "expert systems technology involves the transference of know-how from particular human experts to machines. To the extent that the expertise thus acquired is "hoarded" by a few people, this technology may be seen as a way of centralising control. But if the computer interface of the expert system is made interactive enough, allowing human experts to conduct conversations with these "machine consultants," an expert system may become part of the scientific process of diffusion of knowledge. It could, for example, help human experts reach agreements and produce knowledge. But it could also

[6] This phenomenon, called 'Moore's Law' saw the power of commercially available personal computers expand to the point that by the early 2000s, these machines were starting to allow functionality through dedicated software for tasks such as audio and video editing that had previously required specialist hardware. From this point onwards, the democratisation[7] of digital processes engendered by personal computing has catalysed a trajectory whereby, currently, many of the specialist services once performed by dedicated professionals in dedicated facilities have now been emancipated through the home electronics market and software available to personal computers. One such example is the demise of commercial recording studios for music production.

> allow non-experts to share in some of the benefits of that knowledge. Thus, whether an expert system becomes (...) an aid in the diffusion of expertise among humans, depends on whether knowledge banks are hoarded or shared. And this in turn depends not so much on human intentions as on the design of the computer interface that decides whether a few privileged people or a whole community has access to those banks of expertise." Manuel De Landa, *War in the Age of Intelligent Machines*, p.224 - 225, Zone Books, 1991.

Before to the advent of personal computers, the domain of computing had been the exclusive purview of precisely such experts. In this reality, computers were in the possession of companies such as IBM who controlled access to them and who specified the dominant form of interaction people could have with them, that of batch-processing:

> "In a batch-processing system programs are developed by hand and then coded into punched paper cards. The cards are handed over to a special caste of technicians who are the only ones authorised to physically handle the machine. These operators feed the contents of the paper cards into the computer and, after a long wait, return the results to the programmer in the form of a printout. Any mistake in the original program has to be corrected and the whole tedious process started over again. The only tasks that could be accomplished in this way were payrolls, mathematical calculations and the statistical analysis of census data, and these activities were what most people pictured when they thought of computers." Manuel De Landa, *War in the Age of Intelligent Machines*, p.219, Zone Books, 1991.

During my time at IRCAM, I was struck by the similarities between the IBM paradigm and that of IRCAM, whose proprietary mechanics as an institution framed both access to the tools developed there *and* the type of musical knowledge that was considered appropriate to pursue with them. This dogma of institutional control is quintessentially evidenced by the history of the primary software used to realise this thesis: MaxMSP. Max was written by Miller Puckette in the 1980s at IRCAM and as such, was the intellectual property of IRCAM, a situation that eventually led to a divergence between the objectives of the institution and Puckette's perspectives on the development of the software:

> "Max was not created under an open source license, and Puckette discovered he could not always make the modifications he wanted. "As a minion, all the code I wrote belonged to IRCAM," he says. So sometime around 1996, he started over with Pd." Ryan F. Mandelbaum, *Miller Puckette: The Man Behind the Max and Pd Languages*, IEEE Spectrum website

For Puckette, Pd[8], an open source sister of MaxMSP was the solution, a situation that allowed a community of users to democratically develop the software without recourse to an institutional hierarchy such as IRCAMs. This democratisation of software tools via open source frameworks made accessible through the internet was a popular theme of the late 1990s and early 2000s, one that in part traces its roots in both the technological utopianism of early internet evangelists such as John Perry Barlow[9] but perhaps more significantly in the 'hacker' ethos fostered by scientific researchers such as Marvin Minsky:

> "From the early 1960s, Artificial Intelligence researchers like Marvin Minsky and John MacCarthy had developed a symbiotic relationship with young, obsessed programmers. The scientist would think of interesting projects to test their theories (like a chess-playing machine, for instance), and then let hackers implement those projects on the computer. In this process the hackers developed an unwritten ethical code which would become one of the driving forces behind the interactive movement, and the force that would eventually bring the personal computer to the marketplace. This ethical code was never encoded in a manifesto, but was embodied instead in the hackers' practices. It involved the idea that information should flow freely without bureaucratic controls and that computers should be used to build better, more interactive computers (that is, to advance the bootstrapping process). Typically, a hacker would write a piece of software, maximising interactivity, and then place it in a "toolbox," where it was available to anyone who wanted to use it or improve on it. Programs were not the private property of their creators, but tools to be distributed as widely as possible in a community." Manuel De Landa, *War in the Age of Intelligent Machines*, p.225, Zone Books, 1991.

The advent of the internet and its utilisation by technological democrats such as Puckette proposed an alternative method of evolving a distributed network of software tools and knowledge that effectively sought to bypass the exclusive, hierarchical nature of institutions such as IRCAM, with a view to developing an alternative culture through a community who were empowered to explore similar themes via open source software.

The fact that by the early 2000s, open source software tools for realising interactive music and such as Pd and SuperCollider[10] and research into its trajec-

[8] "Pure Data (Pd) is a visual programming language developed by Miller Puckette in the 1990s for creating interactive computer music and multimedia works. While Puckette is the main author of the program, Pd is an open source project with a large developer base working on new extensions." From the Wikipedia entry on Pure Data.

[9] See: John Perry Barlow, *A Declaration of the Independence of Cyberspace*, published online via the Electronic Frontier Foundation.

[10] "SuperCollider is an environment and programming language originally released in 1996 by James McCartney for real-time audio synthesis and algorithmic composition. Released under the terms of the GPLv2 in 2002, SuperCollider is free and open-source software." From the Wikipedia entry on SuperCollider.

tories were being developed and contributed to by a generation of protagonists under the burgeoning banner of 'creative computing' (both independently of previously dominant music research centres and practices and often in radically different contexts to that of the concert hall) began to increasingly persuade me that the most pertinent developments in electro-acoustic music might ultimately arise through precisely such channels[11].

1.3 The Memex and Bootstrapping

I left IRCAM with the desire to investigate from the ground up the types of interactivity that might effectively be 'hacked' together for musical ends without being prejudiced by their validity or otherwise for institutionalised music culture. In doing so, the question of how to instantiate an ad hoc network architecture that dealt specifically with sound (in the sense that it was amenable to both expert musical knowledge and open source experimentation) seemed to underpin the notion of how such an investigation might logically proceed. It was this objective led me to hypertext theory and its origins in the concept of the Memex as described by Vannevar Bush in his essay "As We May Think" in 1945:

> "It affords an immediate step, (...) to associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of the Memex. The process of tying two items together is the important thing. (...) Before him are the two items to be joined, (...) The user taps a single key, and the items are permanently joined. (...) Thereafter, at any time, when one of these items is in view, the other can be instantly recalled merely by tapping a button below the corresponding code space. Moreover, when numerous items have been thus joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any item can be joined into numerous trails." Vannevar Bush, *As We May Think*, Atlantic Monthly 176 (July 1945), pp. 101-108.

Bush's vision inspired Ted Nelson's 'Evolutionary File Structure' (ELF), a network architecture of entries, lists, links and sequences (the structure of which anyone who has used the internet is familiar with) and his coining of the term 'Hypertext' to describe the type of knowledge ELF aimed to catalogue:

> "Let me introduce the word "hypertext" to mean a body of written or pictorial material interconnected in such a complex way that it

[11]This subject is dealt with further in Chapter 4.2

> could not conveniently be presented or represented on paper. It may contain summaries, or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it. Let me suggest that such an object and system, properly designed and administered, could have great potential for education, increasing the student's range of choices, his sense of freedom, his motivation, and his intellectual grasp. Such a system could grow indefinitely, gradually including more and more of the world's written knowledge. However, its internal file structure would have to be built to accept growth, change and complex informational arrangements. The ELF is such a file structure." Theodor Nelson, *Complex information processing: a file structure for the complex, the changing and the indeterminate.* Proceedings of the 1965 20th national conference. ACM, 1965.

Latterly, the term 'Hypermedia' was coined to describe content other than text (such as images, sound and video) which could also be linked to using this architecture. This said, 'Hypermedia' is not strictly speaking an analogous extension of 'Hypertext' in that the media itself is not the possible subject of non-linear linking, it is merely presented via a hypertext link.

To clarify this point, let us consider a separate term 'Hyperfilm' that deals only with moving images as presented through film and video. 'Hyperfilm' as conceived in the manner of 'Hypertext' would mean that one would have the ability to create links from inside the media of the video itself to other videos:

> "Films, sound recordings, and video recordings are also linear strings, basically for mechanical reasons. But these, too, can now be arranged as non-linear systems -for instance, lattices- for editing purposes, or for display with different emphasis. (This would naturally require computer control, using the ELF or a related system, and various cartridge or re-recording devices.) The hyperfilm -a browsable or vari-sequenced movie- is only one of the possible hypermedia that require our attention." Theodor Nelson, *Complex information processing: a file structure for the complex, the changing and the indeterminate.* Proceedings of the 1965 20th national conference. ACM, 1965.

'Hyperfilm' as envisaged by Nelson would therefore allow a user to, for example, highlight a particular actor or actress in a film at a particular moment and create a link to the same actor or actress in another film where he/she might be performing a similar action, such as driving. This linking would happen from within the media itself and be analogous to the concept of 'Hypertext' in that 'Hypertext' is a interactive extension of plain text. Thus 'Hyperfilm' is an interactive extension of normal video. In a similar manner one might conceive of 'Hyperaudio', wherein it is possible to make links directly between sounds themselves, thereby highlighting the presence of comparable sonorities, musical phrases or types of instrumentation in other recorded works. Thus we might conceive of a network architecture for sound manifested through the medium of sound that is ontologically analogous to 'Hypertext'.

This speculation concerning the possibility of a 'Hypertext' for sound and the question as to what kind of links this might enable between sounds themselves, how they might be constructed into musical narratives and furthermore, whether such an interactivity might 'bootstrap'[12] a form of human machine interaction that instrumental musicians were willing to both perform publicly with and publish recordings of is the principle investigation of this thesis.

1.4 Attribution and Identity

I have chosen to publish the majority of the music of this thesis under the moniker Isambard Khroustaliov, a decision that in part reflects the sense in which this 'music as research' is speculative. Thus, the adoption of a moniker, whose identity was also to some degree speculative served for me as a method of reinforcing the research aspect of the music in a practical way.

> "... identity is *mobile*, a process not a thing, a becoming not a being; (...) our experience of music - of music making and music listening - is best understood as an experience of this *self-in-process*." Simon Frith, *Music and identity* in *Questions of cultural identity*, 1996, p110.

Whilst the broader questions concerning identity this introduces are many and beyond the remit of this thesis, as Simon Frith examines in *Music and Identity* the sense in which identity may be regarded as a construct determined by sonic attributes and processes is seen as a useful dimension in light of the experimental nature of the music being produced, or to use his words "we are only where the music takes us".

[12] "Bootstrapping has several meanings in the world of computers. In one sense it refers to the "magic act" through which a computer "lifts itself up by its own bootstraps" whenever it is turned on. (...) By extension, the term "bootstrapping" is also used to refer to the minimum amount of technology that needs to be developed in order to create the next generation of technology." Manuel De Landa, *War in the Age of Intelligent Machines*, p.222, Zone Books, 1991.

Chapter 2

Orientation

At this stage, as the both the research and the music of this thesis will draw extensively on it, it would seem necessary to give a brief historical overview of both the technical frameworks and philosophical perspectives that the music of this thesis embarks from. I will therefore detail two principle technologies (Digital Audio and the Fast Fourier Transform) and three philosophical perspectives (Glitching, The Digital Ontology of Music and Non-linearity and Hypertext) which are central to the articulations bought to bear in the thesis.

2.1 Digital Audio

Digital audio is a process of encoding and decoding an electrical signal over time into a succession of discreet frames, each of which transcribes the level of the electrical signal in volts into a corresponding binary number. The frequency at which the incoming electrical signal is transcribed is called the sample rate and is given in cycles per second or Hertz[1]. The resolution of the transcription is measured by the maximum length of the binary string used to encode the incoming voltage; an encoder whose maximum string of binary 1's and 0's (or bits) is 16 is therefore referred to as having a resolution of 16bits (corresponding to 2^{16} or 65536 discrete values). Compact Disc digital audio, which was developed and marketed by Phillips in the early 1980s[2] introduced what is still largely regarded as the benchmark for 'high fidelity' digital audio, specifying a sample rate of 44100Hz at a resolution of 16bits.

The development of digital audio for the reproduction of sound has arguably initiated the greatest paradigm shift in the history of recorded music. As a process of encoding and decoding electrical signals over time, digital audio opens up an enormous space of potentialities, including that the composition of a digital

[1] Named after the German Physicist Heinrich Rudolf Hertz and generally abbreviated to Hz.

[2] Compact Disc Digital Audio (CDDA or CD-DA) is the standard format for audio compact discs. The standard is defined in the Red Book, one of a series of "Rainbow Books" (named for their binding colours) that contain the technical specifications for all CD formats.

audio signal need not originate from direct encoding, but may be composed and subsequently output from a decoder directly, something generally referred to as digital synthesis. Thus any stream of data can effectively be rendered as sound.

> "With the aid of suitable output equipment, the numbers which a modern digital computer generates can be directly converted to sound waves. The process is completely general, and any perceivable sound can be so produced." Max V. Mathews, *The Digital Computer as a Musical Instrument*, Science, New Series, Vol. 142, No. 3592 Nov. 1, 1963, p.553-557.

Here, we open our first perspective on how the medium of digital audio engages with the concept of composition at its most basic and fundamental level; where notation as data produces the sound directly. In and of itself there are a number of analogue forebears to this phenomenon, where sound is not only reproduced by mechanical means but is also able to be composed directly using the medium of reproduction. The punched music rolls used in pianolas and fairground organs are one such example, where the realm of mechanical musical reproduction can also become a medium for composition, opening up possibilities for the composer that would be impossible to achieve otherwise. The music of Conlon Nancarrow addresses precisely this dimensionality, being characterised by an overt desire to interrogate the sonic possibilities of mathematical sequences and extreme poly-rhythms with an almost programmatic/algorithmic sensibility[3]. This said, the analogy of punched music rolls to digital audio only goes a small way to elucidating the possibilities of the latter as it does not take into account the fact that punched music rolls rely on a predefined instrument to 'sound' the compositions. This is equally true of analogue synthesisers, which may be controlled by a variant of punched music rolls called a sequencer. In these two examples, the notation is automated (in the case of piano rolls mechanically and in the case of sequencers electrically) to control the instrument, where the instrument defines the type of sound produced independently of the notation. The composer is therefore required to understand the sonic constraints and possibilities of the instrument in much the same way as they would in writing for a human musician. In this schema, part of the success or otherwise of any piece of composed music is attributable to exactly this kind of specialist musical knowledge, generally referred to as the study of orchestration.

The advent of digital synthesis and in particular digital sampling synthesizers (or *samplers* for short) effectively allowed music creators to circumnavigate this type of expert knowledge by building their own 'virtual instruments' using concrete sound[4]. In this sense, the sampler proved an extremely versatile instrument that helped define new perspectives on how concrete sound might inform

[3]This subject is dealt with extensively in Kyle Gann's authoritative book *The Music of Conlon Nancarrow*, Cambridge University Press, 2006.

[4]In principle the sampler functions as follows; sound is recorded digitally onto RAM (Random Access Memory) and is then triggered to play back either at the push of a button or via the MIDI (Musical Instrument Digital Interface) protocol The recorded sound is generally referred to as a 'sample' and might have any length in and of itself up to the maximum available memory built into the sampler. By 1988 samplers had become standard commercial

and augment the paradigm of composition, a fact that has been noted by both commentators and practitioners alike and is supported by a wealth of music that in its various forms and instances informs our current musical paradigm[5].

Nevertheless, at this point it is worthwhile to pause and reflect that the sampler, whilst capitalising on a wealth of new technology, did not effect a seismic shift in the basic language of musical composition. Techniques for composing with and manipulating recorded sound, whilst novel to those uninitiated in the world of Musique Concréte had nevertheless been a part of musical practice at least since the establishment of the numerous European 'Radio Studios' whose function had been to explore the possible musical worlds these emerging electric technologies might engender.[6] There exist numerous anthologies and studies that document the rise of these techniques[7], techniques that for the most part anyone with a sampler or Digital Audio Workstation (DAW) on their computer can now access and familiarise themselves with.

Thus, the phenomenon we have described here is not specifically one of the sampler engendering new musical techniques per se, but moreover, enabling the democratisation of the existing techniques of Musique concréte into a practical framework that could in the first instance be sold as a commercial instrument and in the second instance be sold as software that could be run on a personal computer. In effect, digital audio enabled the process of 'hacking' Musique Concréte by both providing a technical framework for instruments such as the sampler and subsequently allowing for the creation of ever more powerful DAWs on personal computers. This relative democratisation of the techniques of Musique concréte by the sampler and DAWs has become the dominant musicological story of what is variously described as 'Remix Culture'[8], a paradigm

electronic instruments, with the Akai S1000 digital sampler offering 2Mb of 16bit, 44.1Khz digital audio recording (equating to 12 seconds of stereo audio recording) as standard. The sample of recorded sound held within the sampler could then be played back and manipulated in various ways. At its most basic level the sound could simply be played back and pitched relative to the equal tempered scale by specifying different MIDI note values. An ADSR (Attack, Decay, Sustain, Release) envelope and various types of filter as implemented in conventional analogue synthesis could also be applied to the sound. In addition to this, various different sample looping functions were also supported including the ability to set a hold loop, a release loop and also perform palindromic loops.

[5]For an historical time-line documenting the influence of sampling in popular music culture see Kembrew McLeod's *An Oral History Of Sampling: From Turntables To Mashups*, in The Routledge Companion To Remix Studies, Routledge.

[6]The evolution of 'Musique concréte' by Pierre Schaeffer in the early 1940s is taken for the purposes of this study as the origins of an enquiry into the composition of music based on the technical possibilities afforded by devices able to record and reproduce sound. Schaeffer's development of the theory of 'Musique concréte' is evidenced by a number of early works that manipulated and juxtaposed recorded sounds from phonographs and magnetic tape and led to the establishment of the 'Groupe de Recherches Musicales' (GRM) in Paris in 1951.

[7]For an encyclopedic overview see Terence Dwyer's *Composing with Tape Recorders: Musique Concréte for Beginners*, Oxford University Press, 1971.

[8]"Remix culture is a society that allows and encourages derivative works by combining or editing existing materials to produce a new product." Ben Murray, *Remixing Culture And Why The Art Of The Mash-Up Matters*, TechCrunch Network, March 22nd 2015 and "The fundamental concept of remix culture is based on the act of using pre-existing materials to create something new as desired by any creator - from amateurs to professionals." from the

which I became familiar with and have to a certain extent operated in since 1997 as 'Icarus' with Oliver Bown.

2.2 Glitching

A key factor in the advance of digital audio has been the increasing power of digital computers and development of corresponding technologies for cheap storage of larger and larger amounts of digital data. As with early computers, the first commercially available systems for recording and reproducing digital audio made use of magnetic tape to store the data they recorded. Whilst magnetic tape made for an effective linear storage medium that enabled early pioneers of digital audio to demonstrate its fidelity it nevertheless effectively constituted a step backwards with regard to being able to edit recorded material. Magnetic tape with digital audio information recorded onto it could not be physically edited in the same way as corresponding analogue recordings could without creating a digital 'glitch' at the point of the edit.

'Glitching' as a technical problem to be overcome in the sense that it created undesirable 'artefacts' was a persistent threat across all digital media owing to the frame based nature of digital audio. In particular, the lack of buffering and error correction on most early Compact Disc players meant that they were particularly susceptible to 'glitching' as a result of scratches or dust accumulating on the surface of the CD.

As a result, the phenomenon of 'glitching' became commonplace such that artists sought deliberately to invoke it as a way of drawing attention to the otherwise superior fidelity of digital audio. Yasanao Tone's 1997 album 'Solo For Wounded CD' consolidates his earlier performance work 'Techno-Eden' from 1985 and operates through a methodology whereby;

> "(...) he prepared music CDs by slicing them with razor blades or attaching scotch tape filled with pinholes. The result was unpredictable chunks of sound as the CDs glitched and skipped - fragments of the original music (classical works by Beethoven and Tchaikovsky) combined with noises from the CD players trying in vain to read the digital information on the damaged discs." Maiken Derno, *Bad Music: The Music We Love to Hate*, Routledge, 2013, p.261.

Tone's work highlights very early on the potential of digital audio artefacts, not only in terms of ways in which it might be harnessed to create a intriguing and novel sound world, but also, perhaps equally significantly, the potential in digital audio systems of error or failure as a source of structural interest in and of itself. Whilst there is a general view that Tone's work with CDs has antecedents in the likes of Christian Marclay (whose use of cutup and mutilated vinyl records is similar in principle) and artists such as Throbbing Gristle who used malfunctioning tape recorders as part of the sonic palette of their work, it is

Introduction to *The Routledge Companion To Remix Studies*, Routledge, 2014 nevertheless distinct in that the actor/performer in Tone's pieces; the CD player itself is not under any threat of physical malfunction, but moreover induced into a process to failure. It is also significant that this process of failure is both perpetual, non-deterministic and algorithmic; three defining properties of computation. As such, Tone's work with 'wounded' CDs affirms a reading of the system that is producing the sound as not only as a naive autonomous actor in the life of the piece itself but also reveals that the underlying architecture of digital audio is inevitably part of a bigger computational paradigm. Tone's work effectively strips away the stage set of reproducing recorded music from digital audio to reveal its foundations as binary information, fragments of which we are able to hear in the fractures between skips across the surface of the CD.

As Kim Cascone elaborates in his article 'The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music', Tone's harnessing of glitching as a foundation for prototyping new forms of artistic expression runs almost parallel to similar lines of enquiry amongst a new avant-garde of electronic musicians who emerged out of the shadows of commercial dance musics such as Techno and House. In particular, the German group Oval's 1994 album 'Systemisch' explores the same technique pioneered by Tone of inducing CD players to skip by disfiguring the CDs themselves using felt-tip markers. While it employs the process to different aesthetic ends, framing it through this context of 'post-dance music', critically, it helped propagate the sense that the artefacts of digital processes could frame a legitimate domain for musical enquiry:

> "Over the past decade, the Internet has helped spawn a new movement in digital music. It is not academically based, and for the most part the composers involved are self-taught. Music journalists occupy themselves inventing names for it, and some have already taken root: glitch, microwave, DSP, sinecore, and microscopic music. These names evolved through a collection of deconstructive audio and visual techniques that allow artists to work beneath the previously impenetrable veil of digital media. (...) From the mid-1990s forward, the glitch aesthetic appeared in various sub-genres, including drum'n'bass, drill'n'bass, and trip-hop. Artists such as Aphex Twin, LTJ Bukem, Omni Trio, Wagon Christ, and Goldie were experimenting with all sorts of manipulation in the digital domain. Time-stretching vocals and reducing drum loops to eight bits or less were some of the first techniques used in creating artefacts and exposing them as timbral content. The more experimental side of electronica was still growing and slowly establishing a vocabulary."
> Kim Cascone *The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music*, Computer Music Journal 24:4 Winter 2002, MIT Press.

As an attestation to the cultural influence of this movement and its foregrounding of such digital artefacts in the production of music, the series of compilation albums entitled 'Clicks and Cuts' (initiated in 2000 and which currently runs to 6 volumes) released by the German electronic music label 'Mille

Plateaux', offers a good introduction to both the breadth of techniques and compositional devices issuing from this perspective on digital technologies for music creation. Indeed, by the early years of the 21st century it would seem difficult to ignore this movement in music creation as the characteristic tropes evidenced in the work of artists surveyed by compendiums such as 'Clicks and Cuts' became more influential in mainstream commercial music[9]. Indeed, as Cascone acknowledges; "In order to help better understand current trends in electronic music, the researchers in academic centres must keep abreast of these trends."[10]. This said, despite progress in the sphere of cultural studies[11], surveying such a diaspora of techniques and their implications for music theory is problematic at best and perhaps for this reason, the study of digital techniques and technology in music creation remains at best a footnote to the more quantifiable lexicon of Western European Art Music[12].

2.3 The Fast Fourier Transform

As the processing power of personal computers increased so too did the scope of techniques software developers and engineers could integrate into software. By the early 2000s a digital technique called the Fast Fourier Transform (FFT) had begun to gain traction in commercial music software for the possibilities it offered to decompose, analyse, transform and re-synthesise digital audio recordings. Digital audio processes that employed FFTs differed from other digital methods of signal processing in that their operations and transformations were conducted on the results of an FFT calculation, or in what is known as the 'frequency domain' in signal processing terminology:

> "The Fourier transform decomposes a function of time (a signal) into the frequencies that make it up, similarly to how a musical chord can be expressed as the amplitude (or loudness) of its constituent notes. The Fourier transform of a function of time itself is a complex-valued function of frequency, whose absolute value represents the amount of that frequency present in the original function, and whose complex argument is the phase offset of the basic sinusoid in that frequency. The Fourier transform is called the frequency domain representation of the original signal." from the Wikipedia entry on the Fourier Transform.

[9] A phenomenon that is perhaps most overtly portrayed by the rise of Electronic Dance Music (EDM), for an overview see Danny Feinstein & Colin Ramsay, *The Rise of EDM*, Huffington Post, 2012.

[10] Kim Cascone *The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music*, Computer Music Journal 24:4 Winter 2002, MIT Press.

[11] As is evidenced by both the terms 'Remix Culture' and Remix Studies' alluded to earlier.

[12] "Art music - also known as formal music, serious music, erudite music, or legitimate music - is an umbrella term that refers to musical traditions, implying advanced structural and theoretical considerations and a written musical tradition." Wikipedia entry on 'Art Music'

Whilst Fourier transforms owe their name to the eponymous mathematician who first described them in 1822, they have only been used widely in engineering contexts since about 1965, when the evolution of the Fast Fourier Transform allowed for a reduction of the complexity of computing Fourier Transforms so as to make them practical. Despite this, it was not until almost the turn of the millennium that commercially available computers had evolved enough computing power to make the application of FFTs relevant beyond a purely academic perspective. This was for the simple reason that before this, as a musical analysis tool, an FFT could only be calculated in deferred musical time and not in so called 'real time', meaning that the world of frequency domain analysis and processing remained a comparatively abstract realm given that the time needed to get results and in turn process digital audio was often negated by other more readily accessible tools that might convincingly approximate their results.

Despite the relative difficulty of implementing and analysing a Fourier transform in the late 20th century, the early repercussions of the frequency domain in music are notable, mainly evidenced by the work of a loosely knit group of composers from the late 1970s whose work has come to be described as 'Spectralism'. As with any loosely encapsulated genre of music theory, there is a certain amount of dispute as to the genesis and conventions of 'Spectral' music, with various exponents seemingly competing for directorship of the term itself. For the purposes of this study I limit my definition of 'Spectralism' to a subset of the broader field it implies and define it as composition that incorporates data derived from Fourier transforms.

Tristan Murail's work for computer generated electronic sounds and 17 instruments; 'Désintégrations', premiered at IRCAM in 1983 is arguably the definitive statement of 'Spectral' music as defined above:

> "This piece constitutes perhaps the most thorough and exhaustive work Murail has done to date on the examination of purely instrumental spectra. All the computer-generated spectra are directly modelled on real instrumental sounds. The computer does not however, attempt any direct simulation of the instruments concerned. Rather, it is a question of using certain spectra as structural analogies for the entire pitch content of the work (whether on instruments or tape) and likewise to generate its large-scale forms." Julian Anderson, Sleeve Notes in Tristan Murail, Accord AC4653052

Murail himself has written on the details of his compositional approach in the score to 'Désintégrations'[13]and it has been the subject of many detailed analyses by numerous academics [14] to the extent that it is not seen as necessary to attempt an overview or analysis of the work itself in this study given that our main rational for including it as an example is to point to it as a landmark in the application of digital frequency domain analysis using computers.

[13]Score accessed via www.tristanmurail.com

[14]A Google Scholar search using the keywords "Tristan Murail" and "Désintégrations" lists around 73 results

This said, in his theoretical writing on 'Spectralism' as a more general compositional 'philosophy', Murail makes several interesting critical distinctions concerning many of the building blocks of both modern instrumental music and electronic music. The following quotation, although extensive, is seen as useful here in that it outlines relatively succinctly the implications and potential Murail believes a comprehensive study of the frequency domain will herald for the organisation of music:

> "In fact, why divide this frequency space into octaves in the first place, and then the octave into 12? The only reasons are historical and practical. It is well known that for ages people have tried to divide the octave differently: into 24 (quarter-tones), into 18 (third-tones) sometimes even into wild numbers like Harry Partch. Even 'non-octave space' has been discussed. But finally all this is also arbitrary. And there isn't even an historical justification any more for any such division; micro-intervals are usually just plain painful if they are thought of as extensions of normal octave divisions. Frequency space is continuous and acoustical reality only has to define its own temperaments. If we push this reasoning to an extreme, the combination of pure frequencies could be used to explain all past categories of musical discourse and all future ones Harmony, melody, counterpoint, orchestration, etc. become outdated and are included in larger concepts. These fundamental elements, these pure frequencies (sine waves) have their own life, separate, fuse, converge or diverge, and create diverse perceptual phenomena according to their loudness, interrelations, movements
>
> Of course electronic music destroyed these categorical limits long ago. Electronics opened our cars. But electronic music often suffers from the opposite excess: a lack of formalisation, of 'écriture' or writing in the largest sense, of structuring the sonic universes that it discovers.
>
> How in fact is it possible to organise these infinite sonic spaces which are continuous and unlimited? How to organise the frequency space if all temperament is negated, equal or not, or durations if common ones are not used? Since there are no longer any 'absolute' reference points it is necessary to fall back on 'relative' ones, and work on differences, on relationships between the elements themselves, and not on the relationship between objects and an external frame of reference. This is the definition of a new kind of music: a 'differential' conception where the interest is in the relationship between objects rather than in the objects themselves, where time is organised by flux and not by segment." Tristan Murail as interviewed by Tod Machover for *Musical Thought At IRCAM*, Contemporary Music Review, Volume 1, Part 1, 1984.

Here Murail presents in a microcosm the equivalent of the 'multiverse' hypothesis both temperament and the concept of organisation in musical composition is subjected to with the dawn of the frequency domain as a tangible resource available through the use of computers and digital audio. Critically his analysis also reflects upon the analytical relativism that is a hallmark of so called 'Post-Structuralist' thought, something this study also interrogates on a practical level with relation to the creation of musical works.

Murail's detailed use of FFT data to frame compositional processes is also prescient, in that it advances the use of FFTs as a tool for analysing the physical properties of sounds recorded via digital audio, something that has since developed into an extensive research area in the form of audio descriptors and analysis for automatic feature extraction from digital audio[15].

Without segmentation and conversion of an audio signal into the frequency domain using an FFT, audio description through mechanical means is very limited and focused on analysis on how the waveform of the sound varies over time. Thus, various calculations concerning the energy of the signal can be made[16] and the rate at which the signal goes from positive to negative, called the 'zero crossing rate' can also be calculated (allowing for a crude approximation of the signal's periodicity). Through analysis of different time scales of the signal by these means it is possible to extract features related to the dynamics of the audio and its relative noisiness, however, other key attributes used to describe sounds such as fundamental frequency, brightness, harmonicity and timbral similarity remain elusive.

The vast majority of audio descriptors are therefore calculated in the frequency domain, using FFT analysis data. The availability of this data has allowed researchers and engineers to evolve numerous methods for calculating perceptually pertinent features from audio signals[17], opening up the prospect that a combination of these mechanically extracted features in conjunction with other compatible pattern recognition and data processing techniques might convincingly approximate the act of listening[18]. Thus the FFT can be seen as one of the fundamental engineering building blocks for 'machine listening'[19].

2.4 The Digital Ontology of Music

The dawn of digital audio and the arrival of frequency domain analysis via the FFT has a direct a profound impact on the ontology of recorded music:

> "If music gained a kind of permanence when it became a thing, it stands to gain a higher kind of permanence: not from the (imperfect) imperviousness of the disk itself, but from the fact that

[15]A Google Scholar search for the term 'Audio Descriptors' yields over 150,000 results.

[16]The 'root mean square' method or RMS of the signal being one of the most widely used to calculate the energy of a signal directly from waveform data.

[17]See Geoffroy Peeters 'A large set of audio features for sound description (similarity and classification) in the CUIDADO project' for a comprehensive overview.

[18]For a detailed explanation see Robert G. Malkin *Machine Listening for Context-Aware Computing*, PhD Thesis, 2006

[19]The subject of 'machine listening' is discussed in relation to the music of this thesis in Chapter 5.1.3

> music is now a string of numbers that can be faithfully transcribed, without degeneration, from one generation to the next, like letters copied by the scribes of the Torah. Or like quavers on a staff - except that, instead of a hieratic language known to a few, this is the universal, instantly machine-readable language of information." Evan Eisenberg. *The recording angel: Explorations in phonography*, Yale University Press, 2005, p.213.

Eisenberg's acknowledgement here of the becoming informational of digitally reproduced music is a key moment in the ontological discourse on music explicitly because it is an acknowledgement of the burgeoning field of the philosophy of information, whose objective it is to investigate the metaphysical implications of such an ontological shift in reality. This shift that Eisenberg describes above can perhaps be least problematically described as the advent of a digital ontology in music.

The digital ontology of music as instantiated by digital audio and the FFT, and the resulting contingency of music as information radically extends notions of what musical language is and could be by irrevocably illuminating, both physically and temporally, the mechanics of sound as a medium. As we have seen above, not only does digital audio as a format for storing music, but also as a paradigm for making music radically transform the environment within which music can be said to exist, critically digital audio as a medium can also be considered as informational. This digital dimension of music is also theoretically unbounded by traditional notions of performative musical time and space invoked by humans; all music that is created digitally or digitised occupies the same digital space, a space that can be acted upon through numerous methods and which has, with the advent of the internet and cloud computing been more or less coalesced into a continuum. This has far reaching implications for musical works as creative acts, which, in line with the mechanisation of other production processes become relatively unencumbered by both considerations of physical time and space and also ultimately the logocentrism of human readability. Furthermore, when this ecology of digital audio is subject to algorithmic processing via a computer we open the door to an entirely new genre of digital music performance.

2.5 Nonlinearity and Hypertext

> "There were two enormous influences, beyond the general cultural climate, on early twentieth-century composers that proved decisive in the establishment of an aesthetic of nonlinearity. These influences did not cause so much as feed the dissatisfaction with linearity that many artists felt, but their impact has been profound. They are, respectively, the influence of non-Western music and the impact of recording technology." Jonathan D Kramer, *The Time of Music; New Meanings, New Temporalities, New Listening Strategies*, Schirmer Books, 1988, p.43.

With the advent of the various electronic and digital technologies that have shaped musical practice, the space of intra-musical reference has expanded incalculably. Even without considering the possibilities afforded by digital audio analysis using FFTs, we have seen how the digital sampler, with its ability to easily turn small sections and phrases of recorded music into material for the construction of new music, had vast implications for composers and producers of music at the point that it became a mass market instrument in the early 1990s. In this sense, the sampler concretely contributes to the possibility for musical nonlinearity through the referencing of recorded music from previous times and different contexts. Here it is worth pointing out that no claim is being made that the sampler was responsible for the introduction of this practice into musical composition in the broader sense, clearly this would be erroneous as musical quotation is widespread in the history of music both in purely instrumental music and tape music before samplers. Moreover, our focus here is on how samplers not only contributed to the proliferation of quotation in music (a phenomenon that also has its roots in the widespread availability of recorded music), but also how this phenomenon can be seen as a defining logical structure of the informational reality of digital audio.

> "We are modifying our everyday perspective on the ultimate nature of reality, that is our metaphysics, form a materialist one, in which physical objects and processes play a key role, to an informational one. This shift means that objects and processes are de-physicalised in the sense that they tend to be seen as support-independent (consider a music file). They are typified in the sense that an instance of an object (my copy of a music file) is as good as its type (your music file of which my copy is an instance). And they are assumed to be by default perfectly clonable, in the sense that my copy and your original are interchangeable. Less stress on the physical nature of objects and processes means that the right of usage is perceived to be as least as important as the right to ownership. Finally, the criterion for existence - what it means for something to exist - is no longer being actually immutable, or being potentially subject to perception, but being potentially subject to interaction, even if intangible. To be is to be interactable, even if the interaction is only indirect." Luciano Floridi, *Information: A Very Short Introduction*, Oxford University Press, 2010, p.12.

Floridi makes the point here that in an informational reality the traditional distinction between master and reproduction ceases to exist and hence the relation between two identical instances of a digital music file (for example) is contingent on other factors. Significantly, the definition of interaction Floridi invokes can be considered in the broadest sense, whereby even the creation and location of the information is necessarily defined as an interaction in order to distinguish it from other potentially identical pieces of information. The reality of the information therefore emerges through the interactions it is the subject of.

This informational dimension of the digital ontology of music necessitates an evaluation of the methodology of relationality in digital systems in order to understand the type of interactions that are possible for the creation of digital music. Supplementary information obtained either through human notated metadata or analyses derived from FFT data creates a multiplicity of intersections and relations with other pieces of music to form a topology. Traditionally, this type of knowledge was the reserve of enthusiasts and collectors who would compile and index this type of information for their own personal use or to be included in specialist publications. Extending this tradition, their now exist a number of wiki style websites[20] that act as a repository for this type of knowledge. More recently, the domain of Music Information Retrieval (MIR) has added to this dimensionality of music analysis through software designed to extract pertinent features directly from the audio itself. Taken as a whole, all of the above constitutes a significant embedded archive of data, whose dimensions and nodes are navigable in principle through the concept of hypertext.

> "In S/Z, Roland Barthes describes an ideal textuality that precisely matches that which has come to be called computer hypertext - text composed of blocks of words (or images) linked electronically by multiple paths, chains, or trails in an open-ended, perpetually unfinished textuality described by the terms link, node, network, web, and path. "In this ideal text," says Barthes, "the networks [reseaux] are many and interact, without any one of them being able to surpass the rest; this text is a galaxy of signifiers, not a structure of signifieds; it has no beginning; it is reversible; we gain access to it by several entrances, none of which can be authoritatively declared to be the main one; the codes it mobilises extend as far as the eye can reach, they are indeterminable ... ; the systems of meaning can take over this absolutely plural text, but their number is never closed, based as it is on the infinity of language"" George P. Landow, *Hypertext 3.0: Critical theory and new media in an era of globalisation*, John-Harvard University Press, 2006.

Here, Bathes speculative definition of hypertext and Kramer's observations concerning the increasing nonlinear space being explored by musical composition begin to coalesce as the *a priori* functionality of a networked digital ontology. Seen in this light, it is a hypertextual logic that would seem to most readily characterise the domain of composition in the digital age:

> "... the space of reason and meaning - including the narrative and symbolic space of human memory - is now externalised in the hypertextual infosphere, and this brings about four more consequences concerning the rhetoric of spatiality. (l) A linear narrative, which is necessarily associated with time, makes room for a multi-linear

[20]Discogs being perhaps the most extensive. Also notable are AllMusic and MusicBrainz.

> narrative that is naturally associated with space. In the past, writers constructed their narrative space virtually within the mind of the reader. Now writer and reader live within a common infosphere and the former no longer needs to weave the narrative, diachronically, within the mind of the latter, as an ongoing textual Web, since all signieds can co-exist synchronically outside, in the public and intersubjective environment represented by the hypertextual infosphere. (2) In this public domain, writing and reading become spatial gestures, and if time still plays a role, this is only as far as the fictional time of narrative is replaced by the real time of information transmission and retrieval. (3) Consequently, a whole new vocabulary develops, one based on extensional concepts borrowed from the various sciences of space: cartography, geography, topology, architecture, set theory, geology and so forth. (4) It follows that logic, broadly understood as the science of timelessness, hence as intrinsically a topo-logy, tends to displace history, broadly understood as the science of the timed, i.e. a chronology" Luciano Floridi, ed. *Philosophy and computing: An introduction*, Psychology Press, 1999, p.129-130.

Following Floridi's logic, the effect of a hypertextual non-linearity for music is therefore felt through the expansion of the reality of musical time with respect to information transmission and retrieval, wherein sound as a medium, through its becoming informational as digital audio, collides with our experiential perception of it as a physical manifestation that is necessarily chronological. Thus, digital audio by turning sound into data opens up vast new perspectives for potential networks of signification in music based on computational frameworks such as audio analysis and MIR, perspectives that in their analysis and restructuring of the traditional musical devices and narratives of Western European Art Music, create potential parallels with the philosophical insights deconstruction bought to literary criticism.

We have seen from our descriptions above how the analysis of digital audio and its association with other types of metadata might effectively constitute a hypertextual system for music. Moreover, we have also seen that such a hypertextual logic might well be able to theorise the nonlinear patterns of contemporary music production that prove elusive to traditional music theory. Nevertheless, no one project exists that attempts to instantiate *hypertextuality* in the realm of digital audio although it is to all extents and purposes achievable. Rather, this open-ended, networked approach is only able to be approximated via a myriad of separate tools and means, the exploration of which is the aim of the following chapters of this thesis as presented via the critical analysis of influential works, their catalysing effect on the motivations behind both the technical prototyping of software systems and ultimately, the production of music.

Chapter 3

Contexts

It has been my intention in the preceding chapters to give a technical and philosophical overview of the climate I consider fostered the increasing deconstruction of musical time to the point of *hypertextuality*. Here we will begin the task of contextualising my own musical practice by turning our attention to several key musical works that inform this perspective on music.

3.1 Hymnen

We have seen that by the early 1950s, the advent of technologies for reproducing and broadcasting sound and music had radically changed the ontological space available for the creation of music, something which the many radio studios of Europe were set up to investigate (notably GRM in Paris, Studio for Electronic Music (WDR) in Cologne and the BBC Radiophonic Workshop in London). In parallel to this, in the USA, Bell Laboratories were actively researching and developing contexts for information theory, part of which focused on speech and hearing. This research crossed over into music through Max Mathews experiments with digital synthesis and composition using computers[1].

During this period, composers actively wrestled with the implications of these technological developments for music resulting in a litany of incisive early works of electronic music. Karlheinz Stockhausen's 'Hymnen' both sits clearly in this tradition, but is also marked out by the scale of its ambition. Notwithstanding the fact that Hymnen is a fastidious work that seeks to combine both electronic and concrete music in almost two hours of realised tape music, moreover, it also seeks to investigate the implications electronic and tape music has on the traditions of musical performance and composition. It does so, firstly by investigating the Schaefferian idea of a 'musical object', the quintessence of which Stockhausen identifies in national anthems, both as embodiments of nationhood and physical boundary but also because of their ubiquity, whereby

[1]For an overview of Mathews life and work see his obituary in The New York Times.

everybody “knows at least one and can recognise many others”[2]. Secondly, Hymnen exists not only as a piece of tape music, but can also be played ‘with soloists’, where several instrumentalists react to the music on the tape via a set of rules that seek to specify desired types of musical gesture and interrelation, hence it can also be seen as informational; providing a font of sonic ideas which are designed to incite further musical investigation as much as be a source for contemplation through listening.

From our hypertextual perspective then, the tape music of Hymnen can be seen as instructive on numerous levels, the most basic one being that of simply ‘tuning’ a radio. Region 1 of Hymnen begins with exactly this; a short wave radio being tuned in and out of channels and discovering national anthems. Structurally, this is a quintessential metaphor for how a technology such as radio modifies both the linearity and space of music; the person tuning the radio is able to jump from programme to programme, effectively creating a new meta-narrative that juxtaposes different sections of pieces of music and speech irrespective of any internal ordering principles. The new narrative uses the identity of these streams as a basic syntax, where chance intersections and dissonances become the central dynamic. Additionally, the jumps between channels represent actual physical displacements between the antennas broadcasting the different stations. In Hymnen this is especially significant as the primary musical material is identified as being national anthems, making explicit the conflict between the physical national boundaries of a country and the possibility for their transgression via technologies such as radio. Finally, the central methodology for the manipulation of the anthems, that of modulation and inter-modulation is itself the technical basis of radio, where the carrier waves are modulated by the signal wave, which carries the auditory information. The tape composition in Hymnen operates across all of these trajectories, exploring their symmetries and possibilities for inference.

Through the ‘versions for soloists’ of Hymnen, Stockhausen then goes on to explicitly investigate how the compositional world manifested on the tape pieces might catalyse instrumental performance. This interest can be traced in Stockhausen’s work most easily with the evolution of ‘Kontakte’, where his original intention was not to have a fixed score that went alongside the music played on the tape. However, after a certain number of trials, this approach was abandoned and the piece was scored. The rational for using anthems in Hymnen can in part be traced to a desire to offer instrumentalists a concrete opening onto the manipulations of the electronic sound-world through a familiarity with the source material used for the manipulations. As with Kontakte, Stockhausen envisaged that the instrumentalists would then improvise their own musical path using the tape as a guide. With Hymnen, Stockhausen achieved measured success in this respect. The premieres of Hymnen were all performed with an ensemble of musicians well versed in his composed music and in this respect made for ideal collaborators. The fruits of this ensemble were recorded and comprises the official recorded edition of the work, however, on hearing interpretations of

[2] Stockhausen as quoted in the liner notes to the Stockhausen Verlag edition of *Hymnen*.

Hymnen by other soloists, Stockhausen recoiled from his initial more open conception of the methods by which instrumentalists could interface with the piece. Henceforth, Hymnen could only be performed by soloists personally approved by Stockhausen and additionally a sketch score was produced.

In this respect, Hymnen with soloists presents us with an unrealised ideal, whose telemetry can be glimpsed through the official recorded version from 1971; that of a seamless conversation between the varying scales and topologies of of electronic and concrete music on the one hand and the space of human musical intervention on the other. Hymnen thus interrogates, with an intellectual rigour for both the technological and compositional aspects of the work, the possibility of a musical domain whose syntax is vastly expanded as a result of both technology and information theory:

> "All of this allows us to see Stockhausen's musical interests in Hymnen in terms of the wider issue of information science through the 1950s and 1960s as exemplified in the researches of figures such as Max Mathews, Hiller and Isaacson, John von Neumann and others. This was a joint investigation into the deconstruction and reformulation of coherent musical sentences, and it focused quite deliberately on national anthems and folk melodies as sources of the basic units of musical speech. (...) The whole point of the exercise lies in the transformation process of one melody into another. So one can see Hymnen in this context, a major-length tape composition dating from exactly the same period and sharing exactly the same intellectual premises as the Mathews/Rosler paper, as a magisterial response from the German musical and intellectual tradition to a US cold war agenda of speech recognition and translation, the difference being that whereas the US effort is focused on one thing only (the process) and is intentionally lacking in aesthetic or human interest, from the same starting-point Stockhausen has generated an extraordinary musical composition that also comprehensively addresses underlying issues of melody synthesis by interpolation and substitution programming." Robin Maconie, *Stockhausen at 70*, The Musical Times, Volume 139, Number 1863, 1998.

3.2 From Sinfonia to Plunderphonics

3.2.1 Sinfonia

We have discussed in technical terms how the ubiquity of digital audio and the tools for composing with it as a medium have fuelled the phenomenon of musical quotation and noted a number of philosophical implications this has for music creation. Amongst the many examples I might choose to contextualise this with regard to my own practice, I will nevertheless limit myself to a discussion of Luciano Berio's 'Sinfonia' and John Oswald's 'Plexure'.

Sinfonia is without a doubt one of the most analysed works of 20th century classical music, at the time of writing, Google Scholar alone lists some 500+ results for articles that include analyses of it and it is for precisely this reason that I wish to make reference to it here. Sinfonia stands out in the canon of compositions that make extensive use of quotation for not only the sheer breadth of its references, but also the rigour with which these quotations are re-contextualised, layered and woven together, it is perhaps the definitive attempt to refute the perceived reductioninsm implied by information theory on the concept of the archive which historically, can be considered one of the essential projects of civilisation.

If Hymnen provides us with a quintessential investigation into how the growth, systematisation and technological dissemination of knowledge and information expands the space of composition from an ontological perspective, Sinfonia is perhaps the clearest statement of the epistemological challenges such an informational view of reality has to scale. Sinfonia does this by presenting us with a musical world that is simultaneously heavily codified and deliberately evocative. Berio consistently conflates one with the other throughout the course of the piece, one the one hand, forcing an analysis that invokes semiotics through the myriad references and quotations and on the other, confounding these references through their immediate musical affect on the listener. In this respect, Sinfonia explicitly occupies itself with questions of relativity; Is understanding the piece contingent on knowing the various musical works it cites? How is a sung quotation different from when it is spoken or indeed written? At what point does polyphony become noise? And, perhaps ultimately, is the notion of 'symphony' (of 'sounding together') something that is subjective or objective, structural, ephemeral, performative, reproductive or any of these individually or concurrently? As Berio himself expounds:

> "A persistent analysis of the links between theory and practice and the tendency to theorise and formalise musical behaviour is an obvious, universal aspect of our culture. It underlies the notion of music as Text, as a document of an investment and of an encounter of ideas and experiences. But these days we have no permanent conceptual tools, no theory of proportions, of the affects (*die Affektenlehre*) of harmonic functions, not even of total serialisation. We don't have *trivium* or *quadrivium*, and we don't live in a homogeneous musical society. Nor do we have a *lingua franca* that would allow us a free and peaceful passage from one musical domain to another. What we do have at our disposal, instead, is an immense library of musical knowledge, which attracts or intimidates us, inviting us to suspend or to confound our chronologies. (...) I think that the search for a universal answer to the questions raised by musical experience will never be completely fulfilled; but we know that a question raised is often more significant than the answer received. Only a reckless spirit, today, would try to give a total explanation of music, but anyone who would never pose the problem is even more reckless."

Luciano Berio, *Remembering the Future.* Harvard University Press, 2006, p.8-9.

Thus, perhaps one of the central significances of Sinfonia is that it not only demonstrates that when the manifest dimensions of a musical work are sufficiently large, that any interpretation must be seen relative to the level of abstraction it is perceived through, but moreover, that even if a totalising view of such a work were possible, it would still be subject to the linearity of time. The implication here is that, while we might be able to say unequivocally that it is possible to know the totality of such a work, the time it would take to communicate this totality is potentially infinitely large. This view draws on a phenomenon in computational complexity theory, where a problem is said to be NP-Complete when, even if it can be proved that a solution exists, it is not possible to discover the solution efficiently. A common example of such a problem is prime factorisation:

> "By the fundamental theorem of arithmetic, every positive integer greater than one has a unique prime factorisation. However, the fundamental theorem of arithmetic gives no insight into how to obtain an integers prime factorisation; it only guarantees its existence." from the Wikipedia entry on prime decomposition.

Or, to formulate this in another manner; it is possible to find a solution but not to know how long that might take. For precisely this reason, prime factorisation of extremely large numbers is the most common methodology for encryption, in that, even given the exponential rise in the processing power of computers, finding the prime factorisation of a number several hundred digits long is still completely intractable given the fact that the encryption is only required to be functional in most cases for a matter of minutes.[3] The statement of the NP-Complete problem in computational complexity theory acknowledges an everyday philosophical conundrum; that while one can admire a solution to a problem or by extension appreciate a piece of music for its ingenuity, the acknowledgement of this comprehension does not turn us by inference into great mathematicians or composers:

> "If P=NP, then the world would be a profoundly different place than we usually assume it to be. There would be no special value in "creative leaps," no fundamental gap between solving a problem and recognising the solution once its found. Everyone who could appreciate a symphony would be Mozart; everyone who could follow a step-by-step argument would be Gauss; everyone who could recognise a good investment strategy would be Warren Buffett. Its possible to put the point in Darwinian terms: if this is the sort of universe we inhabited, why wouldn't we already have evolved to take advantage of it?" Scott Aaronson, *Reasons To Believe* www.scottaaronson.com

[3] This is the principle of the RSA encryption system which is widely used over digital networks for secure data transmission.

Returning to Sinfonia, I propose that one of Berio's intentions in writing the piece, however tangentially, was precisely to state the boundedness of an information theory perspective on musical creation; to let his audience draw exactly the conclusion Aaronson highlights above, whereby we are liberated from the notion that works of music are inherently tractable and bounded, but moreover that every individual reading of the whole is not only valid but encouraged. In this respect, Sinfonia, is a work whose logic, whilst not hypertextual could certainly be described as deconstructive, at a time when the implications of a nascent information theory were wide ranging and controversial, especially in the USA, the country in which it was commissioned.

3.2.2 Plexure

So far we have outlined what could be termed the 'prehistory' of the hypertextual imperative I am seeking to outline for music in this thesis. In moving into what might by extension be termed 'early history', we cross the border into the realm of the digital, where the sampler is a mass-market commercial tool for music creation, whilst the internet still remains a nascent force. Plunderphonics was a term coined by artist and composer John Oswald with his manifesto text 'Plunderphonics, or Audio Piracy as a Compositional Prerogative' in 1985. In the article, Oswald sets the stage for the Fair Use/Creative Commons debate concerning music:

> "All popular music (and all folk music, by definition), essentially, if not legally, exists in a public domain. Listening to pop music isn't a matter of choice. Asked for or not, we're bombarded by it. In its most insidious state, filtered to an incessant bass-line, it seeps through apartment walls and out of the heads of walk people. Although people in general are making more noise than ever before, fewer people are making more of the total noise; specifically, in music, those with megawatt PAs, triple platinum sales, and heavy rotation. Difficult to ignore, pointlessly redundant to imitate, how does one not become a passive recipient?" John Oswald, *Plunderphonics, or audio piracy as a compositional prerogative*, Wired Society Electro-Acoustic Conference. 1985.

In his identification of the increasingly capitalised public spectacle of music as an affront that necessitates a response, Oswald differentiates Plunderphonics from other contemporaneous forms of sample based music culture such as Hip-Hop, where the overarching rational for the selection of samples used to produce the music might be generalised as one of identification and not alienation. Conversely, Oswald portrays the act of making plunderphonic music as a kind of necessary reaction in much the same way that Guy Debord and the Letterist/Situationists conceived of 'Détournement', whereby:

> "Détournement is the opposite of quotation, of appealing to a theoretical authority that is inevitably tainted by the very fact that

> it has become a quotation - a fragment torn from its own context and development, and ultimately from the general framework of its period and from the particular option (appropriate or erroneous) that it represented within that framework. Détournement is the flexible language of anti-ideology. It appears in communication that knows it cannot claim to embody any inherent or definitive certainty. It is language that cannot and need not be confirmed by any previous or supracritical reference. On the contrary, its own internal coherence and practical effectiveness are what validate the previous kernels of truth it has brought back into play. Détournement has grounded its cause on nothing but its own truth as present critique." Guy Debord, *The Society Of The Spectacle*, Chapter 8, Paragraph 208. 1967.

In Oswald's early work as compiled on 'Plunderphonic 69/96', there is an obvious sense in which this logic can be traced; the release is separated into two distinct categories of 'Songs' and 'Tunes', whereby the material for 'Songs' are plundered from specific rock and pop songs with vocals and 'Tunes' plunder from genre based instrumental music. The process of plunderphonic détournement on the release is perhaps quintessentially encapsulated by Oswald's reworking of the Michael Jackson song 'Bad' as 'Dab', where, over the course of three minutes, the song is variously re-edited at a micro-scale and Michael Jackson's voice transformed to such a degree that the overriding impression is of a kind of schizophrenic transubstantiation. Yet, despite the counter-culture, reactionary credo of Plunderphonics, these are works that nevertheless exhibit a phenomenal amount of thought, detail, skill and compositional intent such that they are engaging almost in-spite of their identity as forms of détournement. Indeed, within the framework of Plunderphonics, Oswald characterises his incentives for composition as being implied by what he identifies as 'Active Listening':

> "As a listener my own preference is the option to experiment. My listening system has a mixer instead of a receiver, an infinitely variable speed turntable, filters, reverse capability, and a pair of ears. An active listener might speed up a piece of music in order to perceive more clearly its macro-structure, or slow it down to hear articulation and detail more precisely. Portions of pieces are juxtaposed for comparison or played simultaneously, tracing "the motifs of the Indian raga Darbar over Senegalese drumming recording in Paris and a background mosaic of frozen moments from an exotic Hollywood orchestration of the 1950's (a sonic texture like a "Mona Lisa" which in close-up, reveals itself to be made up of tiny reproductions of the Taj Mahal."" John Oswald, *Plunderphonics, or audio piracy as a compositional prerogative*, Wired Society Electro-Acoustic Conference. 1985.

Above, Oswald quotes from the liner notes from Jon Hassell's LP 'Magic Realism' to lend a context to his methodology of transformation, the spirit of which is stretched to extremes on his 1993 work ‘Plexure’. ‘Plexure’ takes the spirit of sonic alchemy intrinsic to Plunderphonics above the emblematic watermark of pop-song duration into a 19 minute long-form composition that samples thousands of popular artists whose work was released on CD up until that point (1982 - 1992). Here, the vast scale of the task and the self-imposed compositional rigour Oswald demanded of himself coalesce into a larger narrative and we are immersed into a work that is not only a historical kaleidoscope, fragmenting and re-combining genres, tempi and timbre, in a whirlwind of musical gesture, but also a bold manifestation of the new informational structural reality proposed by digital audio. In the sonic constellation that is ‘Plexure’, it becomes possible to imagine the compositional process as a metaphorical ‘travelling salesman problem’, where each node is a few hundred milliseconds of digital audio and where the composition we hear represents a path through this huge atomised archive of information according to a set of discernible rules. In this respect, the composition is not only defined by what Oswald chooses to let us hear, but, almost in equal measure, what we imagine would happen if the trajectory of the composition had been different. The sum total of possibilities is bewildering and yet in foregrounding procedure in its interrogation of this vast archive, ’Plexure’ opens itself up to the possibility that the entirety of such a compositional space might conceivably be interrogated through simulation.

In this respect, ‘Plexure’ is prescient not only as a conscious investigation of the possibilities for an emergent semiotics within the growing archives of data proposed by the burgeoning digital revolution, but also as an affirmation of what Baudrillard identified as the transition in modern technological societies to the ‘hyperreal’, something that will occupy us in detail in the next section.

3.3 Hyperreality and the Imperative of Improvisation as a Structural Paradigm

With the advent of mp3 file-sharing and later digital music services such as iTunes, we enter into the modern era, where access to the totality of recorded music, if not the norm, is certainly the desire, even if the majority of it is never listened to,

> “Being inside this cyclotron of atomised information from my own vantage point produces a palpable sense of vertigo. A feeling that it could be anything in any order by anyone at any time for any reason. Everything pointing in all directions quaquaversally but arriving at no destination. And its effect is a cancellation of affect. A feeling like Baudrillard’s screen stage of blank fascination has reached its terminal phase and all previous depths are collapsing into an endless vista of dazzling surface play.” Eric Lumbleau of Mutant Sounds www.theawl.com

Such a statement is emblematic of the situation the majority of listeners to music now find themselves in; able to navigate at will (via music streaming services such as Apple Music and Spotify) a space that is composed of over 40 million individual pieces of recorded music (a number which is significantly increased when YouTube and Soundcloud as a source of listening is also included).

In such an environment, as we have begun to see from our analyses of Sinfonia and Plexure above, both the archive of gestures and the possible strategies for their composition multiplies ad inifinitum. Indeed, on the one hand, the sheer intractability of such an archive from any human perspective (where the time of listening is a mitigating factor) and on the other, its dissemination into the public domain via any number of public broadcast systems manifest in the urban environment (in shops, in restaurants, in cars and from mobile phones to name but a few) ushers us to a point in the history of music where the dominion of musicians and composers as the authors of musical experiences has never been less assured.

From this perspective John Cage's embracing of indeterminacy as a necessary function of musical expression is seen as prescient not only from the perspective that it theorised the inevitable diversification of the tools for musical production (legitimate or not) but also in the sense that it emphasised the immediacy of time as a critical foundation for a definition of music as an 'assemblage' [4]. Indeed, I believe one possible reading of Cage's emphasis on the 'momentariness' of music leads to the interpretation that music is a totality, whose parts are related so strongly that their identity is only completely constituted by their relations within the whole. In such a reading, the timedness of any musical expression effectively renders it unique, no matter how similar it may be in every other respect to another musical expression:

> "... the identity of an assemblage should always be conceived as the product of a historical process, the process that brought its components together for the first time as well as the process that maintains its integrity through a regular interaction among its parts. This implies that the identity of an assemblage is always contingent and it is not guaranteed by the existence of a necessary set of properties constituting an unchanging essence. Or to put this differently, assemblages are not particular members of a general category but unique and singular individuals. Even if two assemblages resemble each other so much that no one can tell them apart, each will still be unique due to the different details of its individual history. (...) All these different assemblages are born at a particular time, live a life, and then die. It follows that knowledge about an assemblage does not derive from a "botanical" classification that takes properties for granted but from an account of the origin and endurance of those properties." Manuel DeLanda, *Philosophy and Simulation: The Emergence of Synthetic Reason*, Bloomsbury Publishing, 2011.

[4]Here I reference Manuel DeLanda's definition as outlined in *Philosophy and Simulation: The Emergence of Synthetic Reason.*

The advantage accepting this 'assemblage' view of music is that all musical gestures regain their individuality as a result of their timedness and furthermore, that the tendencies and capacities of sounds become increasingly important in the spectrum of musical concerns irrespective of their provenance. In practical terms music is also only ever provisionally defined; contingent on the ability of musical agents to identify and act on the tendencies and capacities of sounds in the present moment. In other words, the emphasis of music making is shifted from the externalised structuring procedures traditionally associated with composition to embedded local rules and variables that are refined and expanded on by agents that in themselves form part of the larger assemblage of music. I would argue that to greater and lesser extents, the description above applies to what is variously called 'improvised music', 'free improvisation' and 'non-idiomatic improvisation':

> "My attitude is that the musical and the real worlds are one. Musicality is a dimension of perfectly ordinary reality. The musician's pursuit is to recognise the musical composition of the world" Cornelius Cardew, *Towards an Ethic Of Improvisation*, Treatise Handbook, 1971, p.17-20.

where:

> "(...) if anyone is dispensable in the production of music it is the score maker or the composer as he is often called. My ideal music is played by groups of musicians who choose one anothers company and who improvise freely in relation to the precise emotional, acoustic, psychological, and other less tangible atmospheric conditions in effect at the time the music is played." Evan Parker, quoted in Derek Bailey, *Improvisation: Its nature and practice in music*, Da Capo Press, 1992, p.81

and

> "Diversity is its most consistent characteristic. It has no stylistic or idiomatic commitment. It has no prescribed idiomatic sound. The characteristics of freely improvised music are established only by the sonic-musical identity of the person or persons playing it." Derek Bailey, quoted in Derek Bailey, *Improvisation: Its nature and practice in music*, Da Capo Press, 1992, p.83

Along with figures such as Cecil Taylor, Peter Brotzmann, Han Bennink, Anthony Braxton, George Lewis, groups such as AMM and Gruppo di Improvvisazione Nuova Consonanza, Cornelius Cardew, Evan Parker and Derek Bailey are considered by many to be central figures in the evolution of 'non-idiomatic' improvisation as a defining structural principle of musical organisation in the 1960s. However it is perhaps John Zorn's music of the early 1980s that is widely regarded as pre-eminent in its ability to cross genre lines and deconstruct aesthetic concerns so vividly, most notably in the improvised game piece ‘Cobra’, a piece which in itself owes its vehemence to his various improvising collaborators in the form of Zeena Parkins, Bill Frisell, Arto Lindsay, Anthony Coleman, Wayne Horvitz and Bobby Previte.

‘Cobra’ is the last in a series of ‘game pieces’ Zorn wrote that begin with ‘Lacrosse’ and include ‘Hockey’, ‘Pool’ and ‘Archery’. Zorn describes Cobra as:

> “Where I really started eliminating the time line, was in a piece like Cobra where the sequence of events can be ordered at any time by anyone. There, I just created relationships, abstract concepts that the players can order in any way they want, so that, at any moment in the piece, if they want to do something like play solo or play duo, or have the whole band play, they can actualise that.” John Zorn, quoted in Derek Bailey, *Improvisation: Its nature and practice in music*, Da Capo Press, 1992, p.76

Significantly, no definitive published ‘score’ or set of instructions exists for ‘Cobra’ although many have emerged, mostly put together by individuals wishing to play the piece from accounts of people who have played the piece or from video footage of Zorn himself performing the piece and Zorn has said specifically that he values precisely such an approach to ‘Cobra’

> “(...) if you write the rules out for the game of Cobra they are impossible to decipher. But when someone explains the practice of it, it’s very simple. These games, like Cobra, have a kind of oral tradition.” John Zorn, quoted in Derek Bailey, *Improvisation: Its nature and practice in music*, Da Capo Press, 1992, p.76

Here, Zorn can be seen to operating in almost direct contrast to the detailed specificity of a work like ‘Hymnen’ by Stockhausen, although it is clear that the two pieces interrogate, through different means, the possible analogy of music as a prototypical linguistic structure, where events themselves are not specified, but directed by a grammar, whose elucidation and formalisation is the role of the composer. This view is compounded by the act of performing Cobra, where as Dylan van der Schyff lucidly explains:

> “(...) Cobra confronts the challenging interactive semiotic process inherent in free improvisation - where the entire musical environment is continuously being enacted and re-enacted through the ongoing exchange and interpretation of sounds, actions, gestures, and signs (including highly idiosyncratic musical symbols or vocabulary). With this in mind, it seems that models of musical expressivity and communication that rely on deviations from musical (structural) norms - e.g. rhythmic (Desain and Honing, 1992), phrase-timing (Repp, 1992), melodic and harmonic structure (Lerdahl and Jackendoff, 1996) - may not always be relevant in this context. Indeed, the complex interactive and recursive process Cobra entails, as well

> as the often non-idiomatic nature of free improvisation, pose serious challenges to the descriptive capacities of linear, objective or generative conceptions of musical semiotics and expressivity - which, as Clarke points out, often fall into the trap of focusing too heavily on the putative relationship between structure and expression (1995, p. 53)." Dylan van der Schyff, *The Free Improvisation Game: Performing John Zorns Cobra*, Journal of Research in Music Performance, 2013.

Here, Dylan van der Schyff's observations as evidenced by his own experience of Cobra (which, having performed the piece myself, I concur with) highlights not only the problematic of such music for more structured models of musical analysis but also the level to which music of this nature exhibits many of the traits we have hitherto referred to here as being 'hypertextual', namely:

> "(...) the networks are many and interact, without any one of them being able to surpass the rest; this text is a galaxy of signifiers, not a structure of signifieds; it has no beginning; it is reversible; we gain access to it by several entrances, none of which can be authoritatively declared to be the main one; the codes it mobilises extend as far as the eye can reach, they are indeterminable . . . ; the systems of meaning can take over this absolutely plural text, but their number is never closed, based as it is on the infinity of language" Roland Barthes, *S/Z.* Trans. Richard Miller. New York: Hill and Wang, 1974.

Chapter 4

Motivations

In setting out to make the work that is contained within this thesis, there are three clear motivating forces whose confluence establish the practical trajectory of my enquiry. In part these motivations evolve out of the formative roll played by the music and contexts I have discussed in the two previous chapters, but critically, it is the real world scenarios and contexts I have had the fortune to be involved in over the years this thesis has been in development that have given my hypotheses form. With respect to this, special consideration should be given to the group of artists, musicians and researchers who form the loosely knit collective 'Not Applicable':

> "Not Applicable is a group of musicians, composers, visual artists and filmmakers collaboratively developing and openly prototyping new approaches to their respective artistic pursuits. Not Applicable is an open-ended framework which encompasses both the realisation and documentation of these collaborations in the form of performances, installations, CDs, DVDs and on the web. ... Not Applicable presently consists of nine people; Isambard Khroustaliov, Oliver Bown, Maurizio Ravalico, Lothar Ohlmeier, Rudi Fischerlehner, Oliver Duckert, Alex Bonney, Martin Hampton and Britt Hatzius. (...) Tom Arthurs was a member of Not Applicable from the outset and until the end of 2015." From the website for the Not Applicable label and artists: www.not-applicable.org

Not Applicable was initiated by myself and Oliver Bown in 2001 and as such also proposes a practical evolution of our work as 'Icarus' (begun in 1997) which itself was born out of the context of 'post-dance music' discussed earlier. The music of this thesis was predominantly realised through the framework of this collective, to whom I am indebted for both their counsel and creative collaboration. Within this framework I pursued a line of enquiry theoretically informed by the following articulations.

4.1 The Insufficiencies of a Traditional Compositional Model for Computer Music Creation

Perhaps the principle motivation which has guided the work contained in this thesis concerns what I see as the need for a deeper appraisal of the vehemency with which computer music is shaping music culture irrespective of the various European studios and institutions set up to advocate and investigate its possibilities.

Of the institutions and studios set up with an explicit remit to investigate the possibilities for new technology in music creation, IRCAM is perhaps the epicentre[1]. During my time studying at IRCAM[2] I became progressively frustrated by the role of the composer, as enshrined in the tradition of Western European Art Music, which I felt was increasingly not a model that was well suited to the investigation of the nascent real-time/algorithmic possibilities afforded to electronic music production. Indeed, the ontological challenge I believed real-time audio analysis and machine listening, when combined with algorithmic and computer music processes posed for music creation in general, seemed to lie beyond the possible remit of IRCAM given that they effectively destabilised the hierarchies IRCAM was invoked to serve.

> "With its retention of the conventional musical score alongside the new textuality of computer music, IRCAM is characterised not by a search for notations and codes to supersede orthodox musical notation, but rather by the addition of many more new codes and texts. IRCAM is, then, strongly text-centred. Yet this proliferation of texts and codes fails as yet to solve a central problem in computer music inherited from electronic music: that of finding a specifically musical textual representation, a musically appropriate and expressive notation, for tape-based musics. At IRCAM the musical score, with its strong visual form, remains the central authoritative text, often buttressed by theoretical exegesis. This contrasts markedly with the displacement of the score in electronic music history, in which existing music notations were often considered inadequate for the complex new sound-world." Georgina Born, *Rationalising culture: IRCAM, Boulez, and the institutionalisation of the musical avant-garde.* University of California Press, 1995. p.223-224.

Moreover, during the time I was at IRCAM, the increases in the speed and computational power of commercially available portable computers facilitated ever more elaborate and nuanced algorithmic and parametric experiments with

[1] "Rarely in its history has music received patronage on the scale that IRCAM, with its extensive public funding, has enjoyed. It is thus a privileged institution and has, not surprisingly, triggered much debate." Nicholas Cook and Anthony People. *The Cambridge history of twentieth-century music.* Cambridge University Press, 2004.

[2] From 2005 - 2006 I was a student on the 'Cursus' masters course in electronic music and composition at IRCAM

digital audio such that questions of computational hardware virtually evaporated in lieu of questions surrounding software and implementation. This paradigm shift away from hardware concerns only heightened the sense in which an electronic musician versed in the designing of software systems and armed with a laptop computer had little need for an institutional framework to support his/her musical research and creation.

4.2 The Paradigm of the *Artist-Programmer*

This realisation led me to look further afield in search of a confluence between the acts of both creating music and programming the tools through which it is created. In doing so, I crossed paths with various practitioners in computer music whose research echoed such concerns, most notably a number of practitioners whose work is collectively encapsulated by the 'live coding' movement in computer music[3]. Of particular interest to me was the sense in which many affiliates of this loosely knit group were involved in the championing of the notion of the *artist-programmer* as a kind of quintessential hybrid modus operandi in the age of the digital computer:

> "As abstract machines, computers are multi-purpose, and are used in many ways towards many different ends. Judging by the contents of newsstand magazines dedicated to them, the computer arts are most often framed as the use of software applications as design tools. Here software is produced by software houses, and bought and used by creative professionals. This situation has its merits, but is a diversion from our theme: we are interested in artists who write programs, not in those who only use programs written by others. Neither are we greatly concerned with the notion of computer programs as autonomous creative agents, although we will touch on this within broader discussion of programmer creativity. Instead we are interested in the practice of artists who get directly involved with computer languages as environments in which to create. They are end-user programmers, in that they create software not for others to use as tools, but as a means to realise their own work. We refer to such people as *artist-programmers*." Christopher Alex McLean, *Artist-Programmers and Programming Languages for the Arts*, PhD Thesis, 2011, p.14.

My identification with the concept of the *artist-programmer* as expounded by live coding led me to attend events they hosted and also perform alongside

[3] "Live coding (sometimes referred to as 'on-the-fly programming', 'just in time programming' and 'conversational programming') is a performing arts form and a creativity technique centred upon the use of improvised interactive programming. Live coding is often used to create sound and image based digital media, as well as light systems, dance and poetry, though is particularly prevalent in computer music, combining algorithmic composition with improvisation." Live Coding entry on Wikipedia.

live coders in various contexts[4], as 'Icarus', Oliver Bown and I also performed at an "algorithmic rave" or 'Algorave'[5]. However, despite my conceptual appreciation for the live coding approach, I ultimately felt that my own exploration of the territory proposed by the concept of the *artist-programmer* lay outside of the manifesto of live coding. Moreover, my desire to explore the possibilities for machine listening necessitated a functionally higher level modular architecture, able to encapsulate numerous individual programmes whose aim was to enact specific strategies relative to numerous musical contexts (from free improvisation, to more declarative rhythmic music and composed works). In this schema, emphasis was placed not on live coding as such, but on the combination and structuring of already declared individual modular programmes into a larger assemblage, wherein any number of already prototyped programmatic behaviours could be called upon and structured at will to either create, act within or intervene in a musical context.

4.3 Improvised Music as a Forum for Prototyping Computer Music Interaction

It was with this methodology in mind and in light of my interest in strategies made explicit by works such as John Zorn's 'Cobra' that I began to familiarise myself more ardently with the music of improvising musicians such as Derek Bailey, Evan Parker, Han Bennink and Cecil Taylor and moreover the contemporaneous improvised music scene in London, discerning in their approach and practice a sensibility that I felt reflected the type of musical structuring I sought in digital audio through software processing. As David Toop elaborates:

> "Above all, improvisation turned its back on the final authority of the composer, turning inward to body, feeling, thought; outward to group and place. This is not to say that improvisation has lacked compositional sensibilities or refused composition entirely; only that it hands over responsibility to the undirected group."
>
> and
>
> "Implicit within music predicated on spontaneity of utterance and response is the unlearning of language at each moment of hearing. Routines and habits adapt to perpetual changes in relationship between individual players, the dynamics of a group and conditions of performance." David Toop, *Into the Maelstrom: Music, Improvisation and the Dream of Freedom Before 1970*, Bloomsbury, p.28 & 37

[4] In particular Matt Yee-King on various occasions, most notably at Cafe OTO, London in August 2009, but also in the context of LAM (Live Algorithms for Music) and MuMe (Musical Metacreation) events

[5] "An Algorave is an event where people dance to music generated from algorithms, often using live coding techniques" from the Wikipedia entry on Algoraves. Oliver Bown and I performed at an Algorave as 'Icarus' in Brighton on the 4th July 2014.

The declared openness of such music and its democratic sensibility seemed to me to create an ideal forum in which to test potential musical propositions arising form the combination of machine listening and algorithmic processing that I was interested in exploring, something echoed by the Live Algorithms for Music (LAM) research group based at Goldsmiths University, with whom I also had the fortune to associate with[6].

> "Live algorithm research is not concerned with systems that imitate human behaviour; genuinely novel outcomes are sought, a product of renewed forms of human-computer interaction. We propose a pragmatic approach. placing machines in a functional, social setting of improvised music-making, where semantics are imprecise and behaviours (or system outputs) must be assimilated on-the-fly. We hope that this practice can further our understanding of articial creative intelligence." Michael Young and Tim Blackwell. *Live Algorithms for Music*, The Oxford Handbook of Critical Improvisation Studies, Volume 2. 2013.

My speculations concerning the possibilities for a modular approach to designing an improvising system based around audio analysis were catalysed by seeing George Lewis improvise with his *Voyager* system at IRCAM during the course of the NIME[7] conference in 2006[8] and through a workshop hosted subsequently by the LAM group in which he talked through the mechanics of *Voyager's* software implementation[9]. Whilst *Voyager* bore little resemblance to the ideas I was formulating for a digital audio system that could be used in the context of improvised performance[10], the revelation was to see a musician such as Lewis not only engaged in constructing music of this nature both as a performer and a programmer but moreover to begin to envision the myriad potentialities that present themselves when a computational system is used as an active partner in performance. Lewis himself describes this relationship as follows:

> "This work, which is one of my most widely performed compositions, deals with the nature of music and, in particular, the processes by which improvising musicians produce it. These questions can encompass not only technological or music-theoretical interests but philosophical, political, cultural and social concerns as well. (...) *Voyager's* unusual amalgamation of improvisation, indeterminacy,

[6]See Chapter 6.4 for a details.

[7]New Interfaces for Musical Expression

[8]This concert, billed as a 'Trio Improvisation' between George Lewis, Alexander von Schlippenbach and the *Voyager* system took place on June 6th 2006 and involved several encounters between *Voyager* Lewis and Schlippenbach both individually and collectively.

[9]Presented as part of the *Live Algorithms for Music Network Conference*, Goldsmiths, University of London, 18 - 19th December 2006.

[10]*Voyager* was built in MaxMSP in the 1990s and is primarily a MIDI based system which relies on a 'Disklavier' player piano to sound its output and a basic pitch tracker through which it parses MIDI notes for its input.

> empathy and the logical, utterly systematic structure of the computer program is described throughout this article not only as an environment, but as a "program," a "system" and a "composition," in the musical sense of that term. In fact, the work can take on aspects of all of these terms simultaneously - considering the conceptual level, the process of creating the software and the real-time, real-world encounter with the work as performer or listener. Flowing across these seemingly rigid conceptual boundaries encourages both improvisers and listeners to recognise the inherent instability of such taxonomies." George E. Lewis, *Too Many Notes: Computers, Complexity and Culture in Voyager*, Leonardo Music Journal, Volume 10, 2000, p33-39.

This sense of an emerging territory for electronic music performance, in which digital machines and their associated code are accepted as actors on the stage of music creation can also be traced to a lesser degree in the work of Stockhausen. In the context of my previous analysis of 'Hymnen', we have seen the degree to which Stockhausen's interrogation of the possibilities proposed by electronics for composition had an enormous influence on the way he conceived of scores[11]. Furthermore, the scores for works such as 'Kontakte' are notable in that they contain complete documentation of the systems used to realise the electronic part of the score, serving to de-mystify the electronics and seeking to ground both the performer and the listeners perception of them as structured as opposed to gestural processes. However, as I have said previously, this inclination was ultimately overwhelmed by the need to uphold the aesthetic conventions demanded of a *composer* in the realm of music creation in which he functioned.

The desire to set free the organisation and programming of sound and technology from this dogma of *composition* in the domain of music creation, whilst not compromising the formal rigour proposed by the act of *composing* has driven the research presented in this thesis and moreover also serves as an anchor for my own practice as an *artist-programmer* in which I have sought methods through which such a process of music creation might articulate itself critically.

Having drawn inspiration from the various contexts I have detailed in this chapter, I set about adapting and building my own software, at the same time as forging collaborations with musicians through Not Applicable in order to realise and document this musical aim, the pursuance of which constitutes this thesis.

[11]'Plus Minus', with its invocations of circuitry and procedural dynamics epitomises this.

Chapter 5

Technics

The following section details the various systems and programmes developed to realise the music of this thesis and explores, through the design and programming of software, the hypotheses raised above. Here it is important to note that the system described below is realised through a process of end-user development and in light of this, I make no claim for it as a tool outside of my own musical investigation.

A notable problematic of an 'end-user programme' concerns how it is defined with relation to its nature as an assemblage of idiosyncratic processes and systems designed to effect a specific outcome. In line with Lewis' observations concerning the fluid nature of such a set of systems and programmes and their related affordances[1]; as to whether, as a whole, they constitute a "program," a "system" or a "composition," it would seem necessary at this stage to define for the sake of clarity how such a set of interrelated parts is referred to henceforth.

It is tempting, as Lewis does, to simply give the end-use software implementation a name, however from a theoretical perspective this potentially obfuscates the desire for it to remain a set of loosely interrelated tendencies, whose dependency on each other is not critical in the sense that it will cease to function should one piece fail (there is no beating heart). Indeed, such a definition would also seem critical to reinforce the sense in which the work is envisioned as hypertextual. Nevertheless, as with a book, it is practically necessary to acknowledge the container as a point of orientation.

In light of all of the above, I propose to appropriate a term popularised by the anthropologist Claude Lévi-Strauss in his book 'The Savage Mind' and subsequently extended and further articulated by the philosopher Jacques Derrida[2] amongst others; that of *bricolage*.

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[1] Expressed here in the form of audio files used by the systems and associated knowledge coded into the systems arrived at through associated research and experiments

[2] "If one calls bricolage the necessity of borrowing one's concept from the text of a heritage which is more or less coherent or ruined, it must be said that every discourse is bricoleur." Structure, Sign, and Play in the Discourse of the Human Sciences, Jacques Derrida, Writing and Difference, trans. Alan Bass. London: Routledge, p.278-294

As a term of reference *bricolage* has the advantage that it is not only non-prescriptive as to its constituents but moreover invokes the sense in which it both envelopes action[3], encapsulates the diverse components that might constitute it and also affirms the hybrid concerns of the *artist-programmer*.

In addition to the descriptions below, a complete schematic for the *bricolage* is provided as an appendix (Appendix A).

5.1 Mechanics

The majority of the work realised in support of this thesis utilises a set of core tools, namely an Apple Macintosh computer running Cycling 74's Max/MSP[4] the visual programming language and associated framework extensions, notably FTM[5]. An RME Fireface 800 audio interface allows for the capturing of sound from up to 4 microphones, converting it into digital audio for use in the software. Digital audio is also converted to analogue electrical signals and output from the RME audio interface.

5.1.1 Software

Cycling 74's Max/MSP software forms the principle paradigm in which the music of this thesis was prototyped and/or composed. Whilst various digital audio workstations (DAWs)[6] were utilised for the purposes of multi-track digital audio recording, editing and mixing, their role was essentially unremarkable, and ultimately interchangeable, in that they functioned as a means of documenting the output of the processes constructed in Max/MSP both on their own and in combination with instrumental performers.

In light of this I do not intend to detail the functioning of a DAW[7]. However, with regard to Max/MSP, it would seem both necessary and important to give an overview of the particular affordances of the software that make it uniquely relevant in light of the philosophical considerations we have outlined above.

[3]The word is derived from the French verb *bricoler* ("to tinker")

[4]Notwithstanding earlier observations about Pd and the desire to engage with the open source community, I ultimately found the long term stability engendered by Max/MSP as a piece of commercially developed software to be advantageous as a framework to develop music in, wherein I could rely on a reasonable expectation that the software code would continue to be maintained and ensure not only compatibility with changes in operating systems and hardware but also provide a stable platform through which to perform live with other musicians.

[5]"FTM is a shared library for Max/MSP providing a small and simple real-time object system and a set of optimised services to be used within Max/MSP externals. The basic idea of FTM is to extend the data types exchanged between the objects in a Max/MSP patch by complex data structures such as sequences, matrices, dictionaries, break point functions, tuples and whatever might seem helpful for the processing of music, sound and motion capture data. FTM is developed in the Real-Time Musical Interactions team at IRCAM." From the FTM website

[6]MOTU Digital Performer was used from around 2007-2009 and Ableton Live or Avid Pro Tools thereafter.

[7]For an comprehensive overview of the history and functions provided by contemporary DAWs see Colby Leider, *Digital audio workstation: Mixing, Recording and Mastering Your MAC or PC*. McGraw-Hill, Inc., 2004.

Max/MSP was created by Miller Puckette at IRCAM in the mid 1980s and traces its ancestry to Max Mathew's RTSKED (real-time scheduled language for controlling a music synthesizer) scheduling protocol:

> "A schedule differs from a normal program in that commands and the times at which these commands are executed are separately specified, thus making a clean separation between what the computer does and when it is done. Times can be specified in absolute terms (wait so many milliseconds) or be specified in relative terms (wait until a performer presses a particular key). The language is intended to control realtime performance." RTSKED, a real-time scheduled language for controlling a music synthesizer, Max V. Mathews, *RTSKED, a realtime scheduled language for controlling a music synthesizer*, The Journal of the Acoustical Society of America 74.S1, 1983.

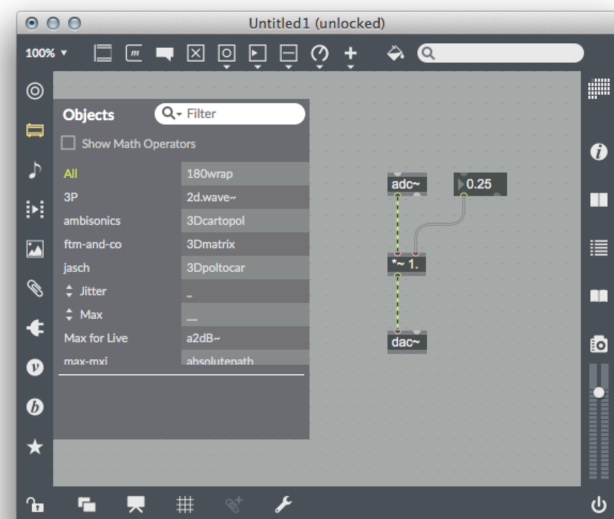

Figure 5.1: Here we see a Max/MSP patcher in 'edit' mode. Around the frame of the patcher window are numerous menus that allow the user to call on different affordances of the software. Inside this frame to the left a menu of objects or operators can be seen. To the right of this a basic patch that enables a user to control the gain of an audio signal can be seen. From top to bottom, the patch takes an audio input from the adc˜object, routes it to a *˜(multiplication) object and then on to a dac˜object which outputs the audio. A floating point object connected to the multiplication object allows the user to scale the input signal.

Users programme in Max/MSP using a visual interface, wherein individual operators or 'objects' that perform specific functions are connected together into chains to create algorithmic processes or 'patches'. These algorithmic processes contained within 'patches' are then called either by a scheduler or through interactions from external sources routed to Max/MSP and the results are either sent (via MIDI or OSC) to a third party instrument (such as a synthesizer or a sampler) or sonified directly within the software using Max/MSP's dedicated digital audio engine. While Max/MSP is defined as a visual programming language, its functionality can be categorised as procedural, where the user specifies the steps the program must take in order to reach the desired state. In this sense, programming in Max/MSP strongly resembles the process of patching a modular synthesizer, with the advantage that it is theoretically infinitely extensible (up to the maximum processing power of the computer). It therefore follows that there also exists a comparably vast space of possibilities for programming in Max/MSP, the defining of a relevant subset of which is in part seen as the process of composition.

> "... designing a circuit was like composing a piece, the piece and the circuit were the same thing. The circuit was the score, the circuit was maybe your performer. The circuit had a complex role ..." Nicholas Collins, In Conversation with Martin Conrads, 1997. www.art-bag.org

The music of this thesis documents in part the process of evolving Max/MSP patches, both from the ground up; investigating empirically the strengths of the software in open ended musical creation and from the top down; identifying desired processes and traits from musical practice and evolving comparable gestures through the software.

5.1.2 Morphology

Running parallel to the evolution of the use and architecture of the software is the progressive delineation of a space for musical investigation and intervention. The digital ontology of the *bricolage* means that all performance actions, whether continuous (real) or discreet (digital) are encoded as digital audio and furthermore, that digital audio is also the means of realisation of the music. This normalisation of all data within the *bricolage* to the medium of digital audio has two significant implications; firstly that for the *bricolage* itself, the dichotomy between real world events and synthesised events no longer exists (they are all manifest in digital audio) and secondly that any resultant output from the *bricolage* can also be potentially used as an input for it.

5.1.3 Machine Listening

The architecture of the *bricolage* is designed to allow microphones attached to the RME soundcard to interface directly with Max/MSP, with the result that this opens up perspectives on machine listening as part of the compositional process.

Machine listening is the process by which an incoming digital audio signal is analysed for specific attributes that are generally modelled from a human perception of sound. Examples of this would be our ability to distinguish between quiet sounds and loud sounds, noisy sounds from sounds that contain identifiable pitches and sounds that have a clear start or attack verses sounds that build slowly. Implicit in this perceptual modelling is a human level of abstraction, whereby such models are seen to either succeed or fail based on their evaluation with respect to human listening.

The process of designing and implementing software that is able to extract this type of meta-information from digital audio can take on many different forms which, generally speaking are dependent on the constraints of the system being used to effect the analysis and the methodology adopted by the programmer. Different contexts and approaches to identifying a particular characteristic of sound through digital audio analysis therefore means that there exist many competing models in any specific field.

> "There are a multitude of useful audio descriptors, and each can be calculated in a number of ways and variants[8]. This multitude means that a monolithic approach to descriptor analysis can never satisfy the needs for either comprehensiveness or flexibility in exploring different descriptors and versions." Diemo Schwarz and Norbert Schnell. *A modular sound descriptor analysis framework for relaxed-real-time applications*, International Computer Music Conference (ICMC). 2010.

A pertinent example of this is the challenge of identifying the fundamental frequency of a pitched sound. Google scholar lists over 20,000 papers outlining different methodologies to achieve this aim in an enormous number of differing contexts from speech and in monophonic instruments to polyphonic and noisy sounds. Within the framework of Max/MSP alone there exist numerous external objects dedicated to achieving this task (fzero˜, fiddle˜, sinusoids˜, yin˜, zsa.fund and f0˜to give a number of examples), all of which have their own strengths of implementation specified by their intended context.

In line with these observations and in contrast to an engineering methodology, the approach adopted to machine listening in this thesis is one where modularity and flexibility are seen as essential features; whereby the ability to evaluate and make use of the idiosyncrasies of these varied approaches (whether desired on the part of the programmer or not) informs the methodology through which the resulting music is structured and created. Therefore, within the framework of the *bricolage*, numerous audio descriptors are implemented along with an architecture that allows the user to preference particular descriptors, thereby allowing for the tailoring of the machine listening in real time with respect to an incoming signal.

[8]See Geoffroy Peeters 'A large set of audio features for sound description (similarity and classification) in the CUIDADO project'

5.2 Audio Analysis as a Compositional Tool

Given the availability of audio analysis information in the *bricolage* we have described, we now turn to how it is possible to use this data for the purposes of composition from a technical perspective.

In general terms, it should be noted that any system of classification is only useful as far as it is adopted and put into practice, something that is potentially problematic given the perspective of maintaining a methodology of implementation that is as open and modular as possible. Here, a balance must be struck between the flexibility of implementation, its effectiveness given the enormous range of source material the system will be subject to and the potential such a system offers compositionally.

What follows are technical descriptions of two specific implementations I have investigated to this end.

5.2.1 Real-Time Corpus-Based Concatenative Synthesis

> "Concatenative data-driven sound synthesis methods use a large database of source sounds, segmented into heterogeneous units, and a unit selection algorithm that finds the units that match best the sound or musical phrase to be synthesised, called the target. The selection is performed according to the features of the units. These are characteristics extracted from the source sounds, e.g. pitch, or attributed to them, e.g. instrument class. The selected units are then transformed to fully match the target specification, and concatenated. However, if the database is sufficiently large, the probability is high that a matching unit will be found, so the need to apply transformations is reduced." Diemo Schwarz, *Data-driven concatenative sound synthesis*, 2004.

Here, Diemo Schwarz outlines the overarching concept of using frequency domain based audio analysis to match an incoming digital audio signal to a library (or corpus) of stored and previously analysed digital audio, a technique that is also called 'audio mosaicing'.

Schwarz's own CataRT system[9] does this by segmenting digital audio, performing an FFT and calculating a series of audio analysis functions on the FFT data (fundamental frequency, aperiodicity, loudness, spectral centroid, sharpness, spectral flatness, high frequency energy, mid frequency energy, high frequency content, first order auto-correlation coefficient (which expresses spectral tilt), and energy). The analysis data can then be grouped into descriptor sets (for example; fundamental frequency and loudness) and used to search a corpus of digital audio that has already been the subject of the same analysis. A

[9]For a detailed overview of this system see *Real-Time Corpus-Based Concatenative Synthesis*, Diemo Schwarz, Gregory Beller, Bruno Verbrugghe, Sam Britton, in the proceedings of DAFx-06, September 2006 and the dedicated CataRT web page hosted by IRCAM.

nearest neighbour match is performed on the corpus data and the most similar corresponding segment of audio is retrieved for use in re-synthesis.

Technically, this process encapsulates several core ideas surrounding *hypertextuality* in digital audio we have previously outlined from a theoretical standpoint, namely:

- The use of frequency domain audio analysis and descriptors as a way of segmenting, indexing and ultimately classifying nodes of digital audio.
- The creation of a network of relations between sounds, whereby nodes of digital audio become points in a multi-dimensional feature space.
- The almost instantaneous automatic pairing of the analysis of an incoming digital audio signal algorithmically with its nearest neighbour in a pre-analysed library (corpus) of digital audio.

In all, the architecture of Schwarz's CataRT system opens the door technically to the possibility for composed hypertextual performance, in that it becomes possible to create and navigate non-trivial dynamic links between segments of audio automatically through the use of a computer in real time. Furthermore, not only is the corpus of digital audio both potentially extremely large and also modular (in the sense that one corpus can be swapped easily for another), but equally, the network of links between nodes (the feature space) is also extensible by the addition of further audio descriptors.

These underlying technical achievements Schwarz brings to bear with CataRT in effect start to define the parameters of a form of hypertextual instrument, whose configuration and parametrisation become the subject of composition in this domain[10].

Here our previous observations concerning the necessity of modularity in such systems are significant. Schwarz's implementation of CataRT is technically beyond the capability of the standard library of objects included with Max/MSP, however it retains its modularity through utilising a framework extension to Max/MSP called FTM. CataRT's usefulness as a tool for musical composition is therefore further extended by the fact that it can be reverse engineered to suit a variety of contexts, something I found invaluable in order to integrate types of functionality proposed by my compositional inclinations. Furthermore, investigating the possibilities for re-engineering CataRT in the context of the *bricolage* fed back into the development of compositional possibilities such that this reciprocity became a prominent dynamic in the process of both performing and producing the music.

[10]A point made in a joint paper published with Diemo Schwarz: "CataRT is used as a compositional and orchestration tool in the context of a piece for banjo and electronics by Sam Britton. The work takes large databases of recorded instrumental improvisations and uses concatenative synthesis to re-sequence and orchestrate these sequences. In this context, the concatenation process acts as a kind of oral catalyst, experimentally re-combining events into harmonic, melodic and timbral structures, simultaneously proposing novel combinations and evolutions of the source material." Diemo Schwarz, Gregory Beller, Bruno Verbrugghe, Sam Britton, *Real-Time Corpus-Based Concatenative Synthesis* DAFx-06, 2006.

5.2.2 Frequency Domain Singular Value Decomposition And Retrieval

In addition to Diemo Schwarz's CataRT system, I also investigated the system of audio similarity mapping described by Michael Casey in the development of his 'Soundspotter' software.

'Soundspotter' evolved out of Casey's work on the specification of the MPEG-7 audio standard for descriptive audio and presents an efficient instantiation of these models via a hard coded implementation realised in the PureData visual programming language[11].

> "SoundSpotter is an open source software system for real-time matching of an audio input stream to a database of continuous audio or video. Among its novel features are real-time control over audio segmentation, feature selection and match radius. The system uses audio input to control selection of output from a database using similarity-based matching. The low latency methods employed create a feedback loop between the performer and the database, thus it is a type of electronic musical instrument." Michael Casey and Mick Grierson. *Soundspotter/Remix-TV: fast approximate matching for audio and video performance*, Proceedings of the International Computer Music Conference, 2007.

In contrast to Schwarz's methodology of storing a series of individual audio descriptors in a contiguous one dimensional array, Casey's methodology with Soundspotter is to store and retrieve a derivation of the FFT data directly. In order to do so efficiently, Casey calculates the Mel-Frequency Cepstral Coefficients (MFCCs) of the FFT frame data, a process that accentuates co-variance in the FFT spectrum data. The resulting spectral data is then subjected to dimensional reduction using Singular Value Decomposition (SVD) to further reduce the data set into a series of eigenvectors which are then stored and used for the purpose of matching and retrieval[12].

Based on this reading of Casey's research in this area, I prototyped my own version of the Soundspotter architecture in Max/MSP using FTM in order to investigate first hand the qualities it exhibits in contrast to Schwarz's CataRT system (see figure 5.2).

The disadvantage of Soundspotter (as realised in my implementation) in comparison to CataRT concerned its lack of modularity. As I have noted above, CataRT, in its flexibility of implementation lends itself to being adapted directly in live performance, allowing the user to either discard or weight more

[11] "Pure Data (Pd) is a visual programming language developed by Miller Puckette in the 1990s for creating interactive computer music and multimedia works. () Pd is very similar in scope and design to Puckette's original Max program, developed while he was at IRCAM, and is to some degree inter-operable with Max/MSP, the commercial successor to the Max language." From the Wikipedia page on Pure Data.

[12] For an expanded description of this process, see Michael Casey, *Soundspotting: a new kind of process*, The Oxford Handbook of Computer Music (2009), p421-53.

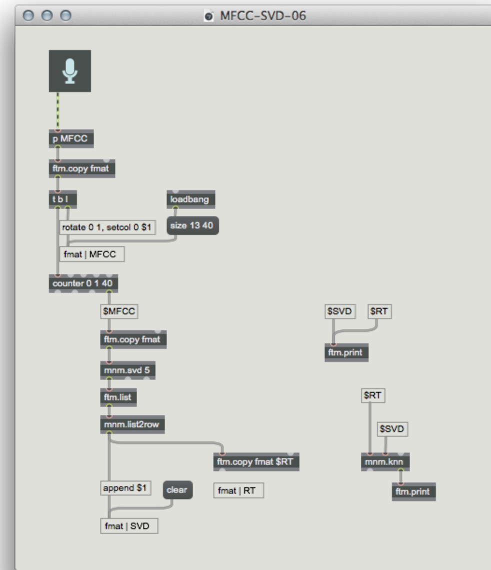

Figure 5.2: Prototype architecture for my implementation of 'Soundspotter' as realised in Max/MSP using FTM. From top to bottom, within the MFCC sub-patch an FFT transform is calculated on the incoming signal and the MFCC calculated. The MFCC vector is dimensionally reduced using SVD and the eigenvector stored as an index in a corpus. To the right, analysis of an incoming signal is then matched to the corpus using KNN mapping.

heavily certain audio descriptors, thus shifting the focus of the matching being performed in real time and with reference to specific features identified as pertinent by the user. By contrast, my implementation of Soundspotter, in using a derivation of the FFT data directly did not have this capacity, thus limiting its malleability in live performance.

After a period of experimentation, CataRT was thus adopted as the preferred architecture for audio analysis and data driven content matching within the *bricolage*.

5.2.3 Audio Analysis Driven Modulators

Whereas the reconfigured CataRT/Soundspotter architecture described above effectively constitutes a method of re-sequencing/arranging a corpus in a myriad of ways, it makes no provision for the transformation of those sounds other than through the process of re-sequencing.

To this end I implemented a series of modulators, with the aim of extending this principle of *hypertextuality* into the domain of sound processing. Here, the overarching concept was to find pertinent ways of using audio analysis data to drive the processing of a stream of digital audio.

Analysis Buffering and Parameter Mapping

One of the most critical negotiations the design of any system of mapping observed audio analysis parameters to parameters for synthesis/sound processing concerns the way in which such observed parameters are reformulated both in time and in the sense in which they are mapped to the sound processing engines. That reformulation is necessary is both logically implied in the sense that one of the primary materials of musical composition is time, but also through observation in performance contexts, as William Hsu makes explicit through his work on such systems with John Butcher:

> "In early versions of the system, listeners sometimes detected an undesirable characteristic in the interactions between the saxophonist and the system: when the saxophonist paused for a short period, the system eventually became silent, because timbral categories were not broadcast when the input signal level is very low. To alleviate this problem, we gave more autonomy to the generative algorithms in some of the agents. In addition, we added memory to the broadcast stream of timbral information; when the saxophonist pauses, the timbral description for the past few seconds is looped and still available to the agents. An agent may choose to continue playing through the pause, according to information from the recent past. Since the timbral categories are looped and made available, each agent continues to hear similar sounds, and respond in a consistent manner." William Hsu, *Using timbre in a computer-based improvisation system*, Proceedings of the ICMC. 2005.

This concept of memory is adopted here via the storage of analysis data in a variable sized buffer for retrieval by the *bricolage* (see figure 5.3).

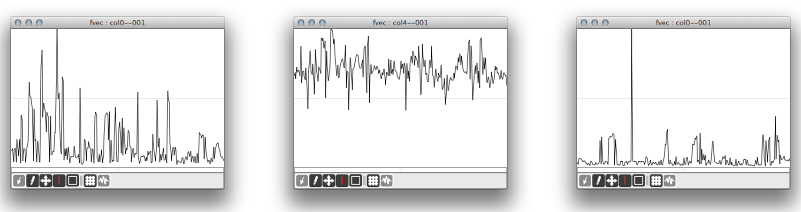

Figure 5.3: Data from Individual audio analyses as stored by the *bricolage* in buffers.

This memory is then queried and mapped to parameters for sound processing via a modular matrix architecture, allowing the user of the *bricolage* to design mappings for the specific context the system is being used in (see figures 5.4 and 5.5).

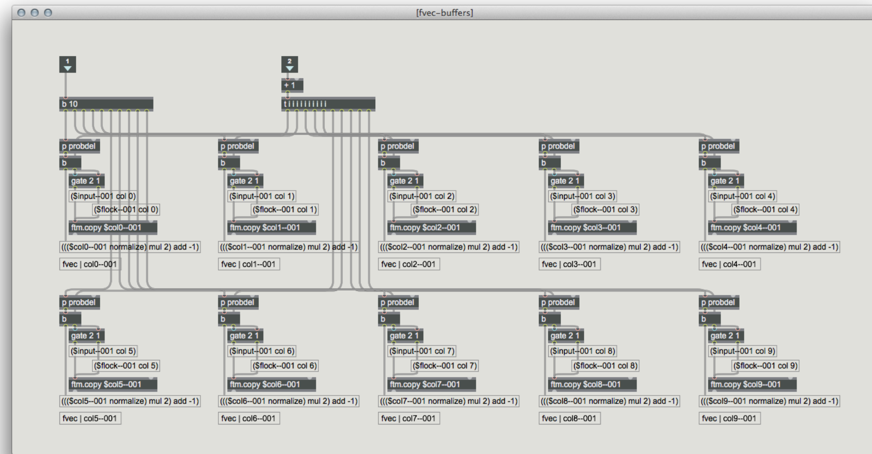

Figure 5.4: Architecture of the multiple buffers for storage and retrieval. Here we see ten different buffers each individually assigned to store one incoming analysis parameter. Above each buffer is a probability trigger used to retrieve the information stored in the buffer at a desired density.

These parameter mappings may then be saved and recalled along with other parameters in the *bricolage*, allowing for swift transitions and interpolations between specific states in live performance.

Having established a versatile method of mapping analysis data to potential audio modulators, the next sections will describe the various modulators and their parameters.

Timestretching/Compression

Perhaps the most basic transformation that the digital audio used for re-synthesis may be subject to is variations in pitch effected by playing the audio back at slower or faster speeds. There are no limits placed on the possibility for speeding up or slowing down digital audio in Max/MSP aside from the speed at which the CPU can process the digital audio, however, practicality the *bricolage* documented here is limited to speeding audio up by $10x$ the original speed and slowing it down to $1/100th$ of the original speed.

Nevertheless, as has been discussed, the effect of speeding up or slowing down digital audio becomes problematic when working with complex sounds that exhibit transients or unpitched/noisy artefacts as the speed also effects the pitch of these unvoiced sounds, rendering them unnatural. There are many different proposed solutions to this problem within the domain of digital signal processing, but almost none that work efficiently in real time without prior

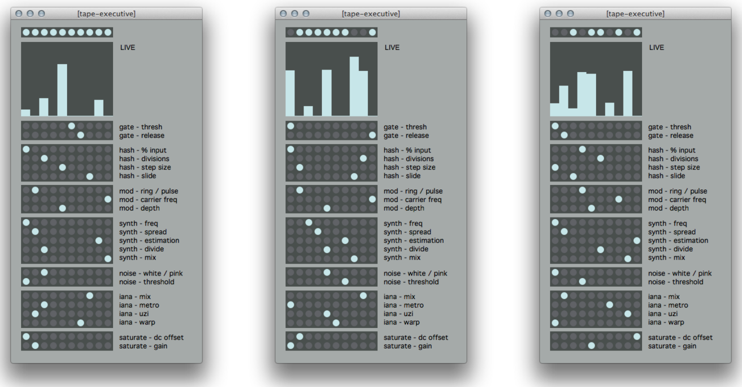

Figure 5.5: Modular assignment of analyses to sound processing parameters. The bars at the top of each window give a read out of the buffered analysis parameters and each separate matrix below allows for the parametrisation of a modulation process via the buffered analysis data. The matrix at the very top of the window allows for the buffering to be turned off and for that parameter to be controlled manually.

offline analysis of the digital audio to be processed[13].

Therefore, the solution here is to offer two idiosyncratic systems for re-pitching the audio in inverse proportion to the speed at which it is being played back (see figures 5.6 and 5.7 for descriptions of the implementations). The proposition being that the different types of artefacts these processes introduce into the signal path become part of the compositional decision making process, to be articulated and crafted like any other parameter for sound processing.

For situations where the pitching of audio is desired, these systems can be turned off in order to simply pitch the audio relative to the speed at which it is being played back (pitch jumps can be quantised to an equal tempered scale using a the formula: $2^{(n/12)}$ where n indicates the desired number of semitones for the transposition).

Analysis driven Ring/Frequency Modulation

Further manipulation of audio used for re-synthesis by the *bricolage* is enabled by a series of bespoke audio signal processors whose design is based on the methodology of harnessing audio analysis parameters directly to invoke transformations, with the aim that these signal processors add further dimensions through which audio can be shaped to reflect or mirror an incoming signal.

Perhaps the simplest of these is ring modulation, where the amplitude of the incoming signal is modulated by secondary signal (generally a sine wave). When the frequency of the modulating sine wave is low, the audible effect on the incoming signal is similar to a gate, where the incoming signal is faded up and

[13]One exception is 'Pitch 'n' Time DJ', a proprietary commercial timestretching/pitch shifting codec created by Serato.

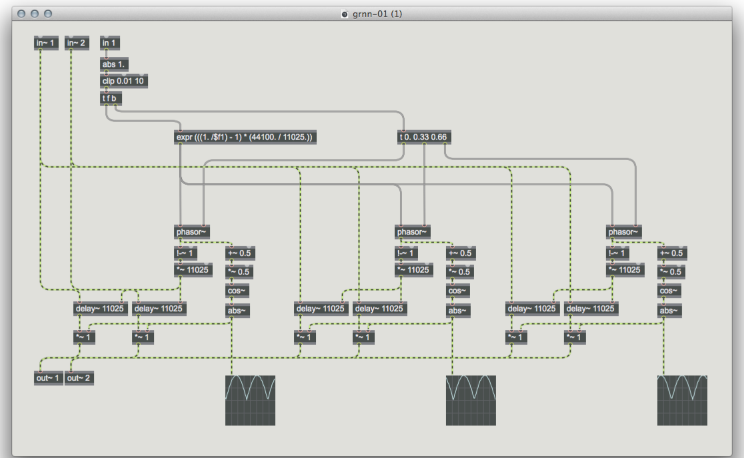

Figure 5.6: Implementation of an windowed equal-power overlapping harmoniser, where a fixed window length of 250ms is divided into three overlapping phase staggered delays whose playback rate is in inverse proportion to the playback rate of the sample.

down in volume at the rate of the sine wave. However, when the frequency of the modulating sine wave is increased to enter the audible range (around 20 - 30 Hz) the amplitude modulation starts to create side-band frequencies above and below the carrier frequency corresponding to the frequency of the modulation (see figure 5.8).

When the frequency of the modulating signal is paired to frequency analysis data (either fundamental frequency, spectral centroid) it becomes possible to produce a kind of shadowing or ghosting of the signal being analysed in the modulated signal, whereby the overtones of the modulated signal produced by the ring modulation mimic the pitch envelope of the incoming analysed signal.

This effect of overtone ghosting is made more explicit by also allowing the gain of the modulating signal itself to be modulated by the amplitude of the incoming analysed signal, whereby the effect of the overtone frequency ghosting is made more explicit through the following of the envelope of the analysed signal.

In addition to its functionality as a ring modulator, the design of the processor also allows for frequency modulation via the use of a variable delay over a set window length. The processor is configured such that it is only possible to cross-fade between amplitude modulation and frequency modulation and not apply both at the same time. The possibility for frequency modulation and its pairing with incoming analysis data radically extends the timbral possibilities of the processing unit to create cross-synthesis effects. The complex dissonant nature of many of these transformations provides a direct contrast to the simple side-banding of the ring modulation and as such is also useful specifically when

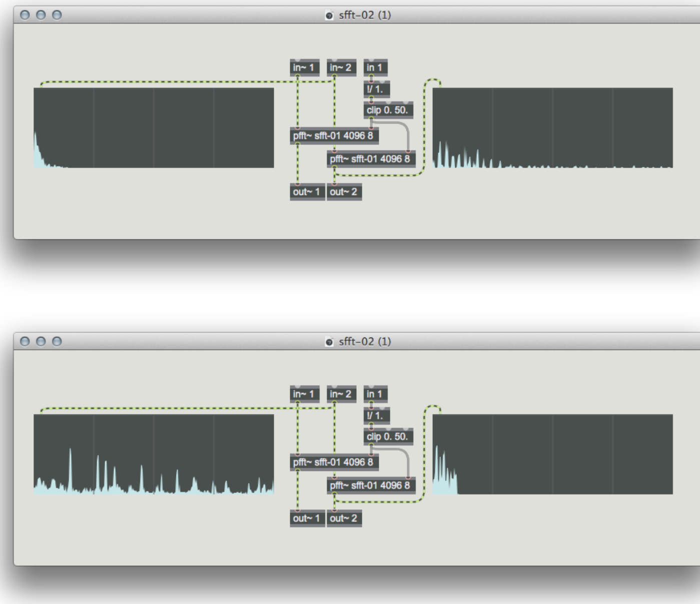

Figure 5.7: Implementation of Gizmo spectral shifting in inverse proportion to the playback rate of the sample. The top image shows a compressed frequency domain signature of an extremely slowed down source sound (left) and the corresponding expanded spectral mapping produced by Gizmo (right). The lower image shows the inverse.

mapped to the aperiodicity of an incoming signal, where complex transients are then represented by the frequency modulated signal and the pitched part of the signal by the ring modulation.

In its overall implementation, the signal processor therefore allows any incoming signal to be transformed in numerous dimensions through an analysis driven methodology.

Spectral Re-synthesis

If the effect of the Ring/Frequency Modulation signal processing lends itself to metaphorical descriptions of shadowing or ghosting, then perhaps the most apt metaphor for the functionality of the Spectral re-synthesis signal processor is one of mutation.

The unit is designed to take incoming analyses from and external signal and use additive synthesis to create a signal that represents this data both audibly (distribution and amplitude of partials) and over time (mapped to the envelope of the incoming analysis). This synthesis is then cross-cut into the carrier signal according to a final mapping of envelope and aperiodicity of the carrier signal, morphing the carrier signal into an abstracted synthesised representation of the incoming analysed signal.

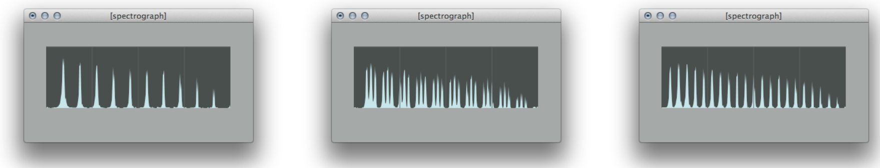

Figure 5.8: Side-band frequencies produced by modulating a 2000Hz Saw wave (from left to right); No modulation, Modulation frequency of 500Hz, Modulation frequency of 1000Hz (resulting in proportional doubling of the partials of the original waveform).

Here, the focus is on articulating the disparity between the carrier signal and the incoming analysis data, such that the two are morphed/contrasted in potentially useful ways which might then be interrogated by a higher level performance/compositional approach.

Partial based Additive Synthesis and Spectral Warping

In contrast to the material manipulations of the carrier signal the previous two sound processors propose the Partial based Additive Synthesis and Spectral Warping processing unit proposes a method for extracting overtones from the carrier signal and synthesising a progressively evolving hybrid harmonic/timbral drone that effectively underpins these evolutions taking place in the carrier signal. Here, there is no direct manipulation on the carrier signal, which is either mixed into the drone (thereby making explicit the material the drone is built from) or entirely faded out. The parameters associated with the synthesis of the drone (time between partial analysis, number of partials to reassign and spectral warp) are assigned to parameters obtained from an incoming analysis, meaning that the synthesis of the drone changes in correlation to the incoming signal.

Noise based Re-synthesis

Here, the function of the signal processing is similar to spectral re-synthesis although in noise based re-synthesis, the analysis of the incoming signal remains unvoiced and is represented only as a mixture of white or pink noise mapped to the amplitude envelope of the carrier signal. Rather than mutation/morphing, this produces an effect of masking, where we retain the auditory impression of the carrier signal although this is rendered discontinuous through this interference by the modulator signal, again based on analyses parameters presented in this signal. The effect of this masking can serve to highlight events occurring in the source signal, effectively backgrounding the carrier/re-synthesis signal given specific parameters of the source signal and manipulating the sonic depth of field in a similar way to photography, where the effect of a large aperture means that objects which are not in the immediate focal range become blurred and ultimately completely unrecognisable (This is particularly evident in the piece 'From Bloom to Bust - Part 1' with Tolga Tüzün).

Analysis Parametrised Gestural Gating

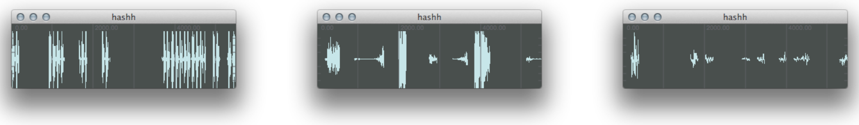

Figure 5.9: Examples of impulse trains used by the Gestural Gating sound processor. The incoming source signal is gated at different frequencies in relation to analysis parameters of that source sound to produce these impulse chains. The impulse chains are then used as wave-tables in a hybrid pulsar/shuffling synthesis engine.

The focus of this signal processor is on creating rhythmic trains of impulses from the source audio stream over a window of 5.5 seconds (see figure 5.9). These impulse trains are then played back according to parameters set by an incoming analysis that manipulates the speed of the traversal, the sub-division of the impulse train into rhythmic steps, the size of rhythmic jumps across the impulse train and finally the degree of slide between the jumps across these rhythmic cells. In effect, the processor takes its inspiration from a hybrid of Curtis Road's description of Pulsar Synthesis[14] and the GRM shuffler plugin[15], uniting the concept of pulse trains and audio shuffling into one hybrid unit whose final sonic fingerprint is most accurately described as performing a kind of gestural gating of the incoming audio based on incoming analysis parameters, where the sequence of incoming analysis parameters creates what is perceived as a kind of gestural variation in both the actual pulse trains being input and the way the gate slides or jumps across the impulse trains.

Storage/Recall and Shuffling/Alternation of Modules based on Incoming Impulse Detection

The numerous possibilities for manipulating the carrier audio using the sound processors described above also necessitated a method of automating changes in the signal chain such that numerous parameters and routings could not only

[14] for a detailed description of Pulsar Synthesis, see Curtis Roads' paper 'Sound Composition with Pulsars', 2001.

[15] "The Shuffler slices up the audio into short sections, shuffles them around and then spits them out at varying time-intervals. The Fragment length and Envelope shape of each fragment can be varied, as can the amount of randomised Delay before the output of each fragment. There is a simple pitch envelope for each fragment, which can be set using Initial, Final, and Random pitch-value sliders. Overall Feedback controls the number of repeats, while Density determines how often the fragments are output, from 100 percent (every single one) to 0 percent (silence). The results range from space and phasing effects to transposition, polyrhythmic fragment bursts, and cartoon-style pitch sweeps." description published in a review by Sound on Sound magazine, 2000

be stored and recalled but also randomised and generated on the fly during performance.

To effect this, two distinct systems were put in place; a simple storage and recall of all parameters across the *bricolage* and the ability to randomly generate sound processor sets based on pre-selection of desired modules.

Storage and recall of parameters was implemented using the standard Max/MSP 'pattrstorage' protocol with parameters for each performance/ensemble being stored in standard JSON[16] file. The advantage of this methodology was twofold; firstly that interpolation between successive stored states of the *bricolage* are possible, facilitating easy exploration of potentially pertinent intermediary/hybrid states. Secondly, successive stored JSON files of identical parameters open up the possibility of offline genetic recombination (a subject that is dealt with in the following section).

Beyond this capacity of accessing stored states, the ability to assign sets of sound processors randomly based on a pre-selection also proved to be extremely useful. Here, a selection of sound processors relevant to a particular context is made and these processors are then turned on or off at random based on the detection of an impulse/onset in an incoming (modulator) signal. This allows for dramatic changes in the character of the sounds being generated (whose relevance to the context has already been pre-set) to be effected concurrently with an incoming signal.

The usefulness of precisely this ability for pre-determined changes of parameters to be randomised/effected concurrently with the detection of an impulse/onset in an incoming modulator proved so effective that it was rolled out to a large number of parameters across the *bricolage*, from changes in pitch/time stretching to the triggering of a new segment to be matched by the sequencing engine. The addition of a simple probability engine to each instance of this triggering meant that cascades of parameters are able to be changed across the *bricolage*. This feature became one of the defining features of the morphology of the *bricolage*, whereby the progression of states across the *bricolage* is controlled by distributed probabilities.

5.2.4 Methodologies of Feedback and Re-composition

Beyond the scale of real time sequencing using the modified CataRT re-synthesis engine and the manipulation of their sequenced/synthesised output via the dedicated sound processing modules described above, I also implemented a number of processes described below as a way of providing further catalysts to the process of composition.

Offline Analysis, Similarity and Hierarchical Concatenation

Both CataRT and Soundspotter analyse audio files on input to the system, meaning that while analysis data is generated by the system, this is not stored for later retrieval. The advantage of this methodology is that the system is

[16] JavaScript Object Notation format

more robust in that analyses of files in the corpus cannot be 'lost' in an external file-system, however the disadvantage of this system is that files have to be analysed every time they are loaded and consequently the analyses can not be made available to other processes and applications.

For the purposes of the *bricolage*, the advantages of producing a separate analysis file were significant, firstly, in reducing the CPU consumption when loading new files into the *bricolage* in performance situations and secondly, in opening up these audio analyses to third party processes (external to the core *bricolage* itself), enabling transformations and experimental processes that could then be re-input into the *bricolage*.

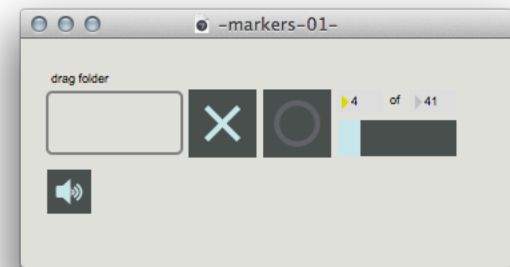

Figure 5.10: Dedicated analysis patch, allowing a folder of audio files to be dragged, dropped and analysed for subsequent use in the *bricolage*.

The structure of the analysis files has also evolved in parallel with the core system. Initially the analysis files simply stored a each vector of descriptor data output in a new row of a matrix. These frames could then be grouped into longer windows, with the mean or median calculated to give an overview of longer and shorter analysis time frames and the vector truncated or matching method weighted to define specific mapping sets. This process was echoed by the incoming analysis windowing, meaning frames of equal sizes and types were being compared by the software. In subsequent iterations, the windowing was considered as a function of onsets detected in the source file but not in the incoming analysis, meaning that different size windows were being matched. From an engineering perspective, the matching of the incoming analysis window to theoretically discrete events (in as much as these events exhibit a clear onset or attack) should help make the matching more perceptually transparent, as the analysis window of the matched event is not spread across two or more events. In practice, there proved to be more considerations that effect this assumption, which is only robust in certain well-defined situations as evidenced by the resulting music produced using both methodologies (a topic that is discussed in detail in the next chapter). Nevertheless, the architecture of offline analysis, storing analysis data and of being able to change and evolve the methodologies for its use within the *bricolage* in the knowledge that the analysis files could then be easily re-conformed proved essential in keeping the *bricolage* as efficient as possible for performance purposes.

A further advantage of having dedicated analysis files was the ability to identify and combine aspects of a multitude of files into a new file for use by the *bricolage*, through a process of non-realtime concatenation. Here, multiple analysis files are combined into one and events are picked from this larger corpus of different files according to certain search criteria. These events are then concatenated to yield a hybrid file whose structure cuts across the distinctions made in the file-system itself.

Lastly, a hierarchical system of picking files for use by the sequencing system based on longer term analysis of an incoming signal (minutes as opposed to fractions of seconds) was also trialled. Here, the mean, median or standard deviation is calculated over the entire analysis file and these figures are then used as the basis for matching whole files to the incoming analysis data, thereby theoretically allowing for the automatic evolution of the *bricolage* over large time scales.

De-mixing using Non-Negative Matrix Factorisation

Non-negative matrix factorisation is a method of data decomposition that has proved useful in data analysis and decomposition owing to its perceptual intuitiveness:

> "Non-negative matrix factorisation is distinguished from the other methods by its use of non-negativity constraints. These constraints lead to a parts-based representation because they allow only additive, not subtractive, combinations. (...) For these reasons, the non-negativity constraints are compatible with the intuitive notion of combining parts to form a whole, which is how NMF learns a parts-based representation." Daniel D. Lee and H. Sebastian Seung. *Learning the parts of objects by non-negative matrix factorisation*, Nature 401.6755, 1999, p.788-791.

More recently, NMF has found application in audio analysis and de-mixing, where the separation of a complex source sound is attempted into meaningful components which correspond to a human perception of audio source separation[17]

Here, NMF is investigated precisely for its ability to de-mix complex audio files into potentially perceptually valid simpler component audio files which can then be summed to reconstitute the original source file. This summing

[17]For a detailed technical overview see 'Non-Negative Matrix Factorisation Applied to Auditory Scenes Classification' (Benjamin Cauchi, 2011) and 'Real-Time Detection of Overlapping Sound Events with Non-Negative Matrix Factorisation' (Arnaud Dessein, Arshia Cont, and Guillaume Lemaitre, 2013)

corresponds to the function of mixing sounds together and is therefore extremely practical.

Although it is possible to de-mix files using NMF within Max/MSP using FTM, as the process itself is non-realtime, therefore, a command line implementation of NMF developed by Rémy Muller[18] was used in light of its ability to be easily scripted to de-mix multiple files. In both cases, the algorithm implemented corresponds to an NMF algorithm developed by Lee and Seung[19].

As outlined by Cauchi (2011) and Dessein, Cont and Lemaitre (2013), the effectiveness of Lee and Seung's algorithm at de-mixing audio is extremely variable and from an engineering perspective requires numerous adjustments to make it more robust for specific applications in music analysis. However, outside of this remit, Lee and Seung's algorithm nevertheless exhibits interesting properties that proved conducive to developing a de-mixer/selective re-mixer of audio files in Max/MSP.

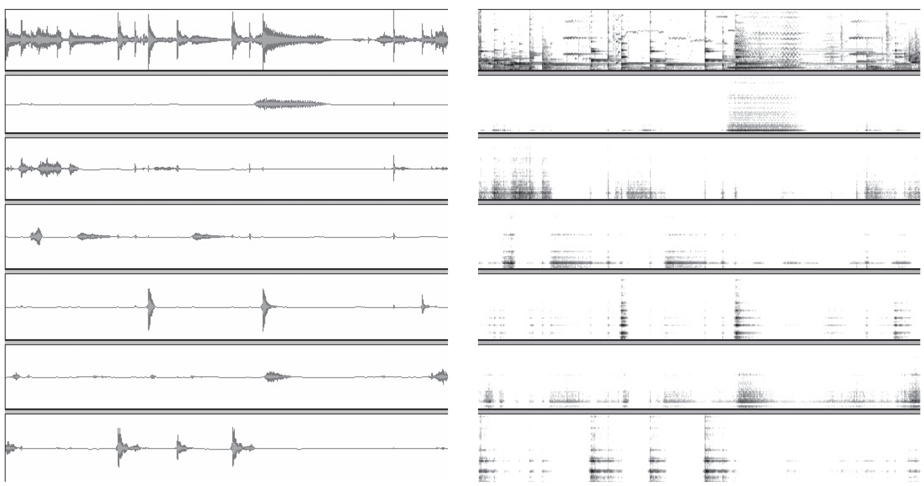

Figure 5.11: NMF De-mixing of a source sound into 6 components using Rémy Muller's command line tool 'nmfdemix'. The source sound is presented a the top of the image with the six components presented below. The spectrogram analysis to the right allows us to compare the common frequency domain characteristics of each event as split from the source sound in the component files.

The purpose of the selective re-mixer is to generate a re-composed audio file from a number of NMF de-mixed source files according to sets of algorithmic processes. This re-composed file could then be analysed and used in the performance system as an alternative to the original file. In this respect, NMF proved a useful tool for spectrally reducing and recombining audio to produce novel distillations of those source files that might then be used in the *bricolage*.

[18]See Remy's post on the IRCAM development blog for more details.

[19]For more information: Daniel D. Lee and H. Sebastian Seung, Algorithms for non-negative matrix factorisation, in Advances in Neural Information Processing Systems 13, Todd K. Leen, Thomas G. Dietterich, and Volker Tresp, Eds. 2001, pp. 556562, MIT Press.

Genetic Recombination of Parameters

Within the systems of analysis buffering and parameter mapping described above it became desirable to develop a system for algorithmically generating matrix configurations based on sets of meaningful configurations arrived at through testing. A crude system of genetically recombining parameters was trialled, whereby a patch with two or more presets (stored as individual matrix configurations) is subject to a simple random crossover processing of each of their parameters to produce a series of 'children' whose configurations are unique combinations of their 'parents' parameters.

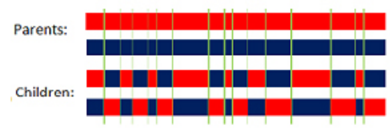

Figure 5.12: Diagram illustrating the principle of genetic crossover; the chromosomes (parameters in our context) of each parent are combined in novel ways through crossover in each child.

These genetic recombinations are then made accessible as presets for evaluation with respect to the originals. Useful 'children' may then also be genetically recombined to produce 'grand-children' and so on, allowing for a genetic evolution of matrix configurations, where fitness is seen as a function of their usefulness in the ability of the *bricolage* to produce novel, compositionally desirable results.

Figure 5.13: Genetic recombination patch that takes Max/MSP preset data and genetically recombines it, ensuring that each parameter of the resulting child is inherited from a dedicated parent parameter.

This chapter has described in detail the various processes and engines created for the sequencing and manipulation of digital audio using audio analysis within the *bricolage*, as well as describing the modular architecture of the *bricolage* itself. In addition to this, specific off-line processes used in the creation of audio files for the corpus and parameters for the *bricolage* have also been discussed. It is my hope that this documentation serves to underpin the sense in which such a system both informs and is informed by compositional concerns, wherein the architecture of the *bricolage* is critical in articulating the possibilities for performance and vice-versa, the experience of performance as critical for the evolution and development of the *bricolage*. In as much as this chapter has presented the theoretical/programmatic half of this equation, the following chapter will expand on the empirical/performative half of it through an analysis of music made using the *bricolage*.

Chapter 6

Music

Category	Title	Collaborator	Type	Length
Collaborative Composition	Haze	w. Lothar Ohlmeier	excerpt	03:18
	Scratch	w. Lothar Ohlmeier		13:08
	Avenue	w. Lothar Ohlmeier	excerpt	05:26
	Fear Of Bees	w. Maurizio Ravalico	excerpt	04:17
	The Leisurely Exploration of a Karstic Area	w. Maurizio Ravalico	excerpt	13:36
	Until Yet	w. Tolga Tuzun		14:01
	From Bloom to Bust 1	w. Tolga Tuzun		08:35
	Aporia	w. Philippe Pannier		07:28
	Entre Des	w. Philippe Pannier		01:27
	Irina Piperin	w. Tom Arthurs		05:59
Multiply Directed Composition	Ohka			11:55
Algorithmic & Parametric Composition	Sparkly Bear	w. Ollie Bown		07:27
	Colour Field	w. Ollie Bown		06:54
Contingently Autonomous Composition	Long Division	w. Lothar Ohlmeier & Tom Arthurs		09:05

Figure 6.1: List of musical works broken down by category, collaborator and type.

The musical content of this thesis consists of 12 complete works and 4 excerpts totalling just over two hours of recorded music. These works have been chosen to illustrate not only a chronological evolution of both the features embedded in the *bricolage* but also how these are developed and utilised in performance and composition. The works are also chronicled by type and in relation to the various musicians with whom many of the pieces have been collaborations with (see figure 6.1).

The nature of the musical works range from pieces of musique concréte where the *bricolage* is used ‘offline’ to orchestrate an instrumental part (Haze, Aporia), recordings of live performances; where the *bricolage* is being controlled by myself in a performance context with an instrumentalist (as is the case with all of the other works listed as ‘Collaborative Composition’ and also ‘Sparkly Bear’) to works where automatic, algorithmic, parametric and autonomous modes of control are investigated for the *bricolage* (Ohka, Colour Field, Long Division and NK).

As such the musical works presented attempt to describe the different methods and techniques evolved for using the *bricolage* relative to these varied scenarios and how characteristics developed through programming and using the *bricolage* can be applied to subsequent projects and scores. These structural differences in how the music was produced are I believe pertinent with regard to the compositional intent of the music as heard. This said, such distinctions are not always self-evident after the fact and so for the sake of clarity I will now detail the distinctions relied upon in the following sections.

A principle distinction concerns whether the music is a recording of a performance or a piece assembled in the manner of a tape piece (i.e. from multiple recordings and manipulations/edits of those recordings in post-production). As we have discussed in Chapter 2, ultimately there exists no absolute ontological distinction between the two given that both types are presented as recordings in their own right here. Nevertheless, for our purposes, which approach a form of musical archaeology in the sense that we are seeking to chronicle the evolution and application of the *bricolage* in specific contexts, it remains a relatively useful distinction given that in a recording of a performance, the *bricolage* itself is functioning in real time with the performer and there therefore exists a feedback loop between the *bricolage*, the instrumental performer and myself (as controller of the *bricolage*). By contrast, when the *bricolage* is used in a post-production scenario, this feedback loop does not exist except in the case that the recording is of the *bricolage* performing with itself. In this case, there exists a virtual feedback loop within the *bricolage*, where one instance of the *bricolage* is ‘listening’ to another instance of the *bricolage* (this is particularly relevant to Ohka, but is also present elsewhere) and parameters are being set by myself. Here, we open up an ontological category of virtual performance, an affordance of the *bricolage* which straddles the distinctions presented above and presents a particular challenge for the listener. My hope is that drawing attention to such distinctions in the analysis of the works helps elucidate specific compositional intentions (even when these intentions are precisely to confound such distinctions).

Another attribute the musical archaeology this chapter attempts is to elucidate is the function of the corpora used by the *bricolage* as compositional objects in their own right. In this sense there are two facets of the development of the *bricolage*, the first being the technical evolution of the *bricolage* in Max/MSP and the second being the evolution of recordings for use by the *bricolage*. Over the years that the *bricolage* itself has been in development and in use, the corpus of recordings available to the *bricolage* has grown. As it stands, almost 17GB of data in 271 separate recordings (encoded at a resolution of 44.1Khz, 16Bit) are currently available to the *bricolage*[1], equivalent to almost 28 hours of audio. Any user of the *bricolage* is therefore presented with a vast amount of data for use in the *bricolage* that is for the most part obscured by the nomenclature of a file name. Familiarity and human memory therefore play a large role in the selection of a corpus of sounds for use in the *bricolage*. Moreover, the fallibility of human memory also plays a particular role in performance situations, where a user selecting recordings for use in the *bricolage* may desire a particular file, but end up with another in error. A file might equally be selected at random in the knowledge that there is an equal sense in which the performative ability of the *bricolage* is at least as pertinent as the relevance/appropriateness of the corpus. Nevertheless, within the system of nomenclature, distinctions exist that in part represent not only the origin of the file, but also structural differences in the provenance of those files. For the purposes of aiding our analysis below I include documentation (Appendix B) that gives an overview of all of the files available to the *bricolage* at the time of writing.

I will now analyse the various musical works of the thesis in consideration of their respective categories.

6.1 Collaborative Composition

The description 'collaborative composition' relates to the embodiment in these works of the specific musicality and skills of instrumental performers and their role in the progressive evolution of the *bricolage* as a partner in the process of music creation. The implication is that the instrumentalist and the digital system (with myself as composer, performer and designer) are engaged in a structural dialogue (often over multiple iterations of the *bricolage*), with the result that the compositions articulate the possibilities of a combined assemblage.

6.1.1 with Lothar Ohlmeier

Lothar Ohlmeier is an improvising musician and composer who performs on both saxophones and clarinets. The recordings documented here represent some of the earliest iterations of the *bricolage* and these collaborations with Lothar have been instrumental in defining the early evolution of the *bricolage* and many methodologies for its use.

'Haze (excerpt)' from the album 'Nowhere' (2007)

Haze is the first work which utilises the particular qualities of real time concatenative synthesis proposed by the design of the *bricolage*. In terms of its composition, Haze is part real time performance and part tape piece. Specifically, the excerpt presented here is the section of the piece that is constructed using concatenative synthesis, which, despite the fact that it was sequenced by the *bricolage* in real time, was edited in post-production. The excerpt is

[1] Appendix B documents these files in full.

constructed of three parallel performances by the *bricolage* wherein it attempts to match the instrumental bass clarinet performance by Lothar to a corpus of improvised recordings also made by Lothar. Here, the compositional aim was to interrogate the potential of the *bricolage* to produce a form of 'counter-movement', where the continuous improvised instrumental line played by Lothar is juxtaposed and mirrored by facets of his own playing selected from previous performances.

In this realisation, the *bricolage* is configured to match segments from the corpus using a two dimensional vector representing fundamental frequency and loudness (selected from a pool of different descriptors); the pitch and volume of the instrumental performance is analysed in real time over a designated window length and this value is then matched to the euclidean nearest neighbour in the corpus of recordings which are also segmented over the same window size. As the vector presented for matching is two dimensional, the corpus segments themselves can also be represented as a map, whereby each point identifies the vector values for each segment (see figure 6.2).

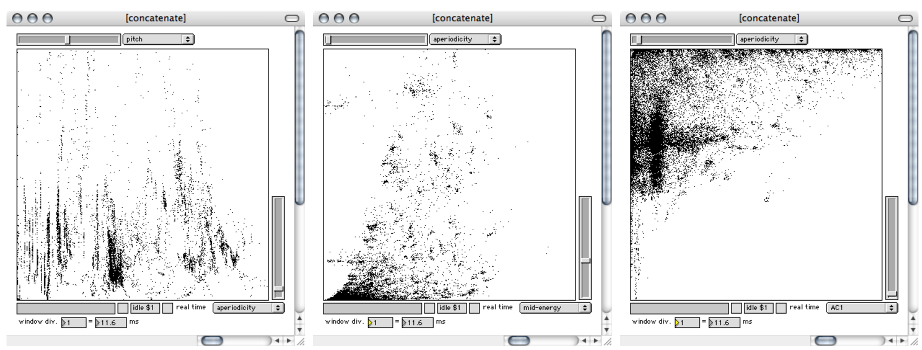

Figure 6.2: Examples of different two dimensional descriptor mappings from the same corpus. On the left, the corpus is mapped using pitch on the x-axis and aperiodicity on the y-axis. In the centre, the corpus is mapped using aperiodicity on the x-axis and mid-energy on the y-axis. On the right, the corpus is mapped using aperiodicity on the x-axis and AC1 (spectral tilt) on the y-axis.

Within this framework of matching the instrumental performance using frequency and loudness, the size of the windowing becomes a critical parameter that influences the selection of particular segments as a result of the fact that the map of possible selections is redrawn to take account of the window size (see figure 6.3). Aurally, the effect of increasing the window size introduces the possibility for progressively more artefacts of the musical gestures the specific pitch and loudness segments are being identified within. Beyond a certain window size threshold of around 250ms very few single unaffected notes remain at all, with the result that the averaging over the window length performed by the *bricolage* meant that segments containing multiple notes were mapped and selected using this average. This has a direct result on the engineering efficacy of the concatenative synthesis which goes from being an accurate reproduction of the source constituted from the corpus to a concatenation in which divergences and convergences from the source are presented as a result of the structure of the recordings present in the corpus.

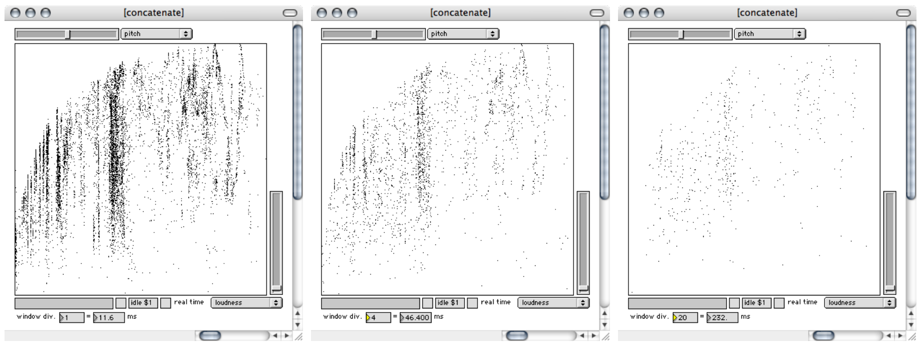

Figure 6.3: Examples of frequency and loudness mappings from the same corpus given varying window sizes of 11.6ms, 46.4ms and 232ms.

In this excerpt, it is precisely these divergences and convergences that are used to structure an emerging ‘counter-movement’ to the primary instrumental line. In this process, there is no score; moreover, this counter-movement is edited from 3 different performances by the *bricolage* with window sizes of roughly 150ms, 300ms and 450ms. In many cases, the divergences presented by the selected segments are so extreme that they effectively constitute another melodic line, something that has been reinforced by the editing of the piece in post-production.

Analysing the excerpt more closely, it becomes possible to discern a compositional logic to this editing (see figure 6.4)[2]. From the beginning up until 1:15, there are a series of five bass clarinet principle statements (p1, p2, p3, p4, and p5) which elicit reactions from the *bricolage* and forms a kind of opening orchestration. In addition to this, the grey rectangle in the spectrogram highlights the introduction of spectral re-synthesis which serves to route this introduction harmonically around the partials present in the instrumental performance. At around 1:00 we hear a first proposition by the *bricolage* (c1) that diverges significantly from the principle statements made in the instrumental performance. There follows a stretch of 20-30 seconds where statements by the *bricolage* and the instrumental performance combine to form a series of call and answer statements which appear to be traded liberally until 1:45 where the instrumental performance settles into a mode of playing longer phrases and notes to which the *bricolage* provides a distinctive counter-movement to in the form of several

[2]For the purposes of analysing the recorded works of this thesis I have settled on a methodology that involves annotating a spectrogram analysis of each recording. The recording itself is depicted via the spectrogram in such a way that it forms a guide for the listener, allowing for a correlation between the time-line of the recording, its notation as frequency banded energy in the spectrogram and an analysis of the processes used in the *bricolage* at that point in the recording.

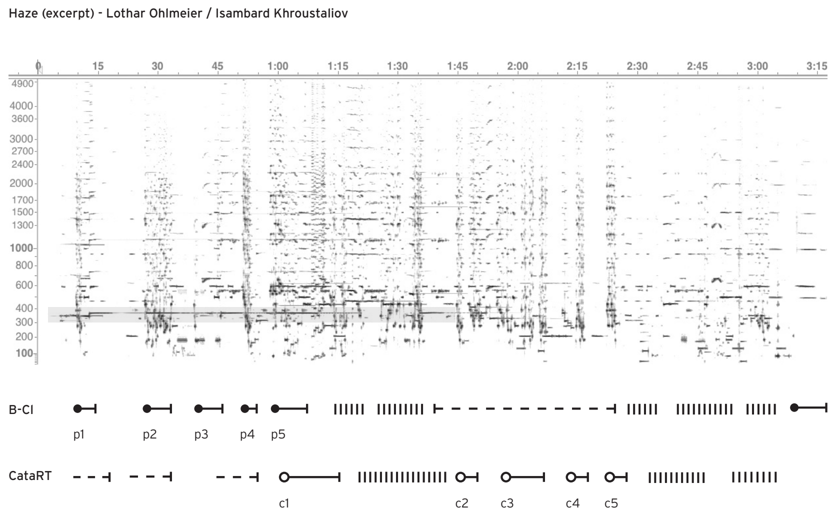

Figure 6.4: Analysis diagram of 'Haze (excerpt)', see Appendix C for a key and full size reproduction.

segmented phrases that are concatenated into a new melodic line (c2, c3, c4 and c5). The final section of the piece from around 2:30 until the end recapitulates the mood of the introduction albeit in a more fragmented sense where the continued simple phrases and notes of the instrumental part are orchestrated by smaller phrases and notes in the absence of any spectral re-synthesis to reinforce the harmonic sensibility of this section.

This excerpt of Haze, in demonstrating the varied compositional possibilities for the concatenative synthesis engine implemented as part of the *bricolage* affirmed to me, in the manner of a proof of concept, that these tools, through harnessing audio analysis as a methodology for composition had enormous potential that warranted significant further familiarisation and exploration. Furthermore, this example, albeit realised in the studio and not live, also affirmed to me the idea that such techniques could functionally be used to construct highly structured, detailed collaborative pieces of music where the way in which the feedback loop between the *bricolage* and the performer functions and can be modified becomes the material structure of the composition.

'Scratch' from the compilation 'An Introduction to Not Applicable' (2008)

Following the sustained period of recording and editing that resulted in the album of work from which 'Haze' is an excerpt[3], 'Scratch' documents an early improvised live performance. The situation of live improvised electro-acoustic performance presents many unique challenges both in terms of the software design and the performance methodology adopted by the electronic musician and is an area which continues to be dominated by idiosyncratic approaches as opposed to standard practices. In this sense it differs markedly both from pure electronic music performance and the tradition of electro-acoustic musical performance where there is either no interface with instrumental musicians[4]or where that interface is either well-structured (for example where the instrumentalist follows the electronics or vice-versa) or based around a pre-defined score (instrumental or electronic) or other fixed musical elements (tempo, key, melodic motifs).[5]. By contrast improvised electro-acoustic performance is generally concerned with keeping as many elements of musical expression in flux as is possible, meaning that the totality of techniques known to either the instrumentalist or electronic music performer are able to be called upon, ordered, contextualised and juxtaposed at will. Moreover, there is no assumption that this type of performance be maximal in its scope, it is equally valid to traverse a large territory of techniques and types of musical structure as it is to interrogate one particular structure in detail. This poses a significant challenge both for the design of the software and the person performing with that software, wherein the software has to present a significantly wide range of possibilities in an accessible manner to the performer and equally provide refined control over these processes without encumbering the performer's ability to listen and react to the performance scenario at hand.

As we have seen from the previous section, the solution here has been to develop a modular system where audio analysis becomes a partner in not only generating sound (synthesis) and ordering previously recorded material (concatenation and sequencing) but also in the control of the parametrisation of these processes. The details of this model were arrived at by trial and error with many elements fluctuating and evolving according to both instrumental context and compositional prerogatives, nevertheless, at its core the principle of having numerous different processes and generators controlled and parametrised by audio analysis remains a constant.

'Scratch' is a significant defining moment in the development of the *bricolage* itself and performing with it, in that it starts to articulate a number of different possible structural relationships between the instrumentalist and the *bricolage*, and also presents the evolution of those relationships as a broader narrative

[3]The album; 'Nowhere' by Lothar Ohlmeier and Isambard Khroustaliov contains 5 tracks and was publicly released in 2008 on Not Applicable Recordings (see Appendix F for details)

[4]Examples of such works include Stockhausen's *Kontakte* and *Hymnen for Instrumentalists*, Luigi Nono's *...Sofferte onde serene...* and Luc Ferrari's *Tautologos 3*.

[5]for a detailed overview of electro-acoustic music theory and practice see 'The Language of Electro-acoustic Music', Simon Emmerson (ed.), London: Macmillan, 1986.

that exemplifies the musical potential of the *bricolage* as a kind of augmented instrument.

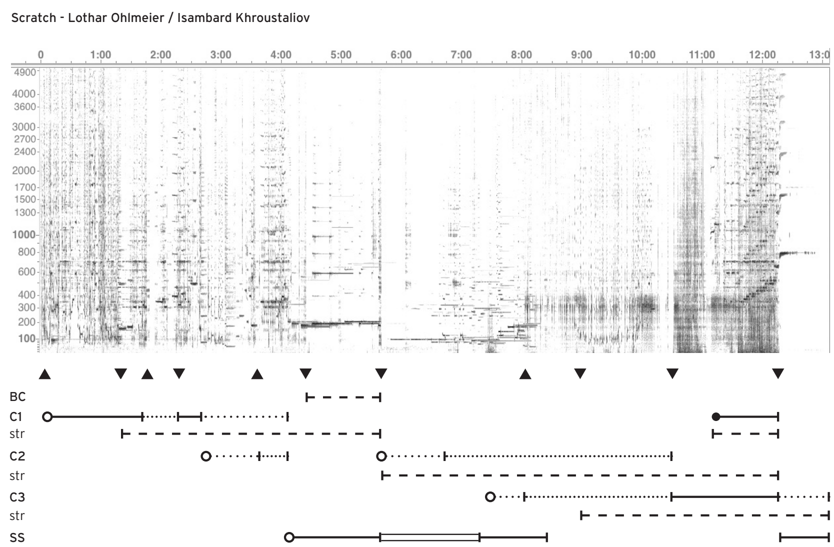

Figure 6.5: Analysis diagram of 'Scratch', see Appendix C for a key and full size reproduction.

Analysing the piece as a macrocosm (see figure 6.5), it becomes possible to discern the different sections of the electronics in the piece, how they are being modified and the points at which they prompt structural changes for Lothar and vice-versa, the points at which Lothar prompts structural changes in the electronics. The piece starts with an initial volley of call and answer phrases, with a corpus of prepared piano[6] being matched by the *bricolage* according to fundamental frequency and volume jostling for position in amongst Lothar's solo line and evolving after about 45 seconds into a kind of gestural orchestration of fleeting voiced notes and scrapes that provides a counter-movement to Lothar's playing. At 1:30 the introduction of timestretching in the piano part elicits a calming change in mood and tempo within the piece. Lothar's brief up-tempo interjections at 2:40 prompts the introduction of percussion elements that serve to shift the emphasis in the electronics away from the piano momentarily until, at 3:45 Lothar changes the mode of his playing again, which is followed in the electronics by a descent into an extended section of time-stretched percussion and spectral synthesis. The introduction of further percussion and elements

[6]The prepared piano was performed by Gareth Humphreys and is an outtake from recordings realised for the assembly of another work; 'Ping' also released on the album 'Ohka' (see Appendix F for details).

of concrete sound at around 8 minutes transforms the interactions into a play of unvoiced noises from the electronics and the clarinet, followed at 9 minutes by the introduction from Lothar of short staccato phrases and stabs that progressively ascend up the register of the clarinet with the electronics becoming more and more dense. The re-introduction of the piano from the first half of the performance in combination with the other elements drives the intensity of Lothar's playing into the upper registers of the instrument until a high G acts as a resolution, dissolving everything into a final episode of spectral synthesis and extreme time-stretched noise.

Whilst we are able to hear in detail the effect of the analyses on the parameters of the processes at hand, perceive changes in the way the *bricolage* is reacting according to Lothar's playing and attribute descriptive criteria to them (sparse, dense, harmonic, noisy, looping, gestural etc.). Without recording the variation in each of these parameters and the origin of this variation during the course of the performance (where this might either be from human interaction or from the *bricolage* of analysis buffering), trying to make further assumptions about the state of the *bricolage* analytically is not only speculative but also in opposition precisely to the compositional intent of creating a software instrument of this nature. Here, in contrast to the principles of scored electro-acoustic music, less significance is placed on the determination of the actual state of the instrument at any one point in time and more emphasis is placed on the capabilities of the instrument to interact or be interacted with. In this sense, the act of performing with the *bricolage* is speculative and relies on intuition rather than determination; one change elicits a reaction and a further change, wherein the chain-reaction effectively constitutes the composition.

'Avenue (excerpt)' from the album 'Lady Fairfax' (2013)

The speculative, non-deterministic nature of the collaborative compositional process evolved with Lothar has also manifested a preference for documenting live performances rather than creating recordings in the studio. We will discuss one such live document entitled 'Long Division' in a later section, where the *bricolage* was configured to act autonomously, however, to conclude the discussion on the collaboration with Lothar I wish to present an excerpt from a more recent live album released in 2013 called 'Lady Fairfax'[7].

'Lady Fairfax' is the documentation of a live performance in its entirety and as such presents a coherent overview of the many types of interaction and collaboration we have developed over several years. The excerpt I choose to present here is pertinent in that it develops a situation arrived at by mistake, wherein I loaded one file into the corpus of the *bricolage* believing it to be another. The mistake transforms this particular performance scenario from a situation of relative knowns in terms of the sound world presented by the corpus, to one of relative unknowns, the result of which plunges both Lothar and I into a kaleidoscopic dialogue that exemplifies the possibilities of improvising in

[7] See Appendix F for more details.

collaboration with the *bricolage*.

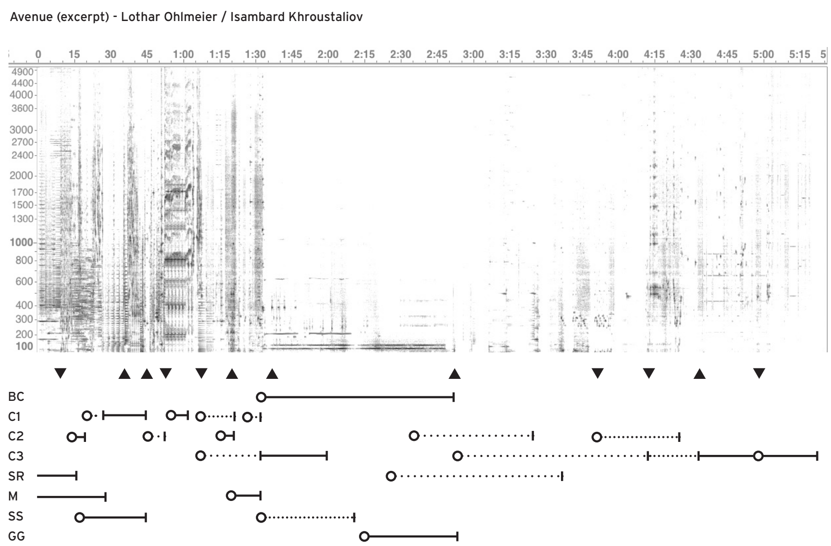

Figure 6.6: Analysis diagram of 'Scratch', see Appendix C for a key and full size reproduction.

If we contrast this excerpt with 'Scratch' two things would seem to be immediately obvious; firstly that this excerpt exhibits as many if not more formal changes and interactions despite the fact that it is less than half the length and secondly that these changes are more extreme in their contrasts, from gestural episodes that are closely tied to Lothar's playing (as can be found at the end of the piece) to the looping rhythmic clusters (which punctuate the first third of the piece) to the single note drone (which occupies the central section of the work) and finally the curious synthesised harmonies that appear as types of 'objets sonore' throughout the piece. The continual re-working of each of these elements and the transformations that are prompted by both the instrumental playing and the propositions made by the *bricolage* for the instrumental playing combine to give a sense that at almost every stage of the piece's development, each episode is simply one of many possible outcomes, crystallising the notion of *hypertextuality* in the mind of the listener, for whom this sense of many parallel pieces from one is perhaps the most cogent means of interpreting the work.

6.1.2 with Maurizio Ravalico

Maurizio Ravalico is a percussionist and improvising musician whose breadth of experience spans from Afro-Cuban music to contemporary and improvised music. My collaboration with Maurizio encompasses some of my first experiments with analysis driven audio modifiers[8] and the recordings documented here focus on the development and articulation of these elements in addition to their entwining with concatenative synthesis in interrogating the way in which compositions are structured and articulated through the act of imprinting (which is seen as a function of audio analysis).

Working with percussion in the context of audio analysis poses unique opportunities, especially where there is a specific focus on the materiality and sonority of the percussive instruments (as is very much the case in my work with Maurizio). Here, the rhythmic motifs and gestures are often arrived at for their ability to induce particular sonorities in the materials being performed with and there is an active sense in which these possibilities for different sonorities within the materials at hand start to articulate a kind of prototypical language of the instrument(s).

This prototyping of an instrumental language by Maurizio is contrasted by its imprinting by the systems of computation through audio analysis and the subsequent interpretation and representation of this prototypical language according to the structured designs of the machine listening and processing of the *bricolage*. This sense in which the choice of parameters for interpreting this type of instrumental language constitutes an active exploration of audio analysis in itself becomes critical, wherein typical features for analysing melodic and harmonic instruments such as fundamental frequency become relatively redundant, with other features such as noisiness and spectral tilt having an elevated roll to play. Functionally therefore, the way in which assumptions inherent in the implementation of audio descriptors in the *bricolage* effect the informational reading of a performance is a key dynamic to our work as a duo. In effect, the fragmentary and provisional nature of machine listening (wherein multiple audio descriptors are often employed in different combinations over different time frames depending on the type of sound being analysed to build up an informational representation of an incoming signal) is presented as a mirror to the act of performance it is attempting to analyse.

Thus, the central focus of our collaborative process surrounds the phenomenology of this 'being imprinted' implied by any form of machine listening and on finding methodologies through which the presentation of the idiosyncrasies of audio analysis can form a dialogue with and ultimately contribute to the prototypical language of percussion being explored by Maurizio.

Here, it is worth bringing to bear the sense in which this approach actively seeks a dialogue with deconstruction, whereby the act of imprinting invoked through audio analysis and re-synthesis opens a perspective on how form is constituted in parallel with signification:

> "In that its passage through form is a passage through the imprint. (...) The (pure) trace is difference. It does not depend on any sensible plentitude, audible or visible, phonic or graphic. It is, on the contrary, the condition of such a plenitude. Although it does

[8]This work is documented on the album 'Five Loose Plans' (Maurizio Ravalico / Isambard Khroustaliov), released in 2006 on Not Applicable Recordings.

> not exist, although it is never a being-present outside of all plenitude, its possibility is by rights anterior to all that one calls sign (signied/signifier, content/expression, etc.), concept or operation, motor or sensory. This differance is therefore not more sensible than intelligible and it permits the articulation of signs, among themselves within the same abstract order - a phonic or graphic text for example - or between two orders of expression. It permits the articulation of speech and writing - in the colloquial sense - as it founds the metaphysical opposition between the sensible and the intelligible, then between signifier and signied, expression and content, etc. If language were not already, in that sense, a writing, no derived notation would be possible; and the classical problem of relationships between speech and writing could not arise. Of course, the positive sciences of signication can only describe the work and the fact of differance, the determined differences and the determined presences that they make possible. There cannot be a science of differance itself in its operation, as it is impossible to have a science of the origin of presence itself, that is to say of a certain non-origin. Differance is therefore the formation of form. But it is on the other hand the being-imprinted of the imprint." Jacques Derrida, *Of Grammatology*, trans. G. Spivak, Johns Hopkins University, 1976, p.62-63.

The articulation Derrida seeks to emphasise here; that there is in effect an anterior to the formulation of the process of imprinting is very much a central concern of my work with Maurizio, made explicit through the formulation and construction of the instruments themselves (both electronic and acoustic) used to compose these prototypical sound worlds. In this sense, the recordings presented here document our emphasis on the function of the provisional in our work; the tension between the inevitable manifestation of a form of structuring implied by the act of imprinting and the simultaneous desire to interrogate the possible deferral of precisely such a structuring. Within the recordings, there is therefore a sense in which structures coalesce and accumulate to the point at which the emphasis and prolonging of the indeterminate formulation of a particular momentary structuring manifests the deferral of precisely the articulations on which it is formed, leading to the deconstruction and eventual evolution of the material relationships that constitute the sound world.

'Fear Of Bees' (excerpt) from the compilation 'An Introduction to Not Applicable' (2008)

This excerpt of 'Fear Of Bees', taken from the final episode of the piece, illustrates this notion of a prolonged formulation, arrived at through a confluence of two particular instrumental elements; the use of a 'cello bow and a series of resonant filters whose pitch and q factor are determined by audio analysis

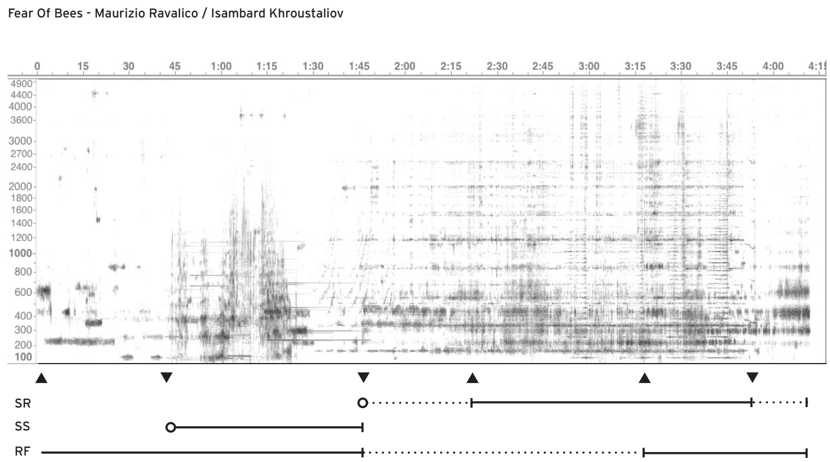

Figure 6.7: Analysis diagram of 'Fear of Bees', see Appendix C for a key and full size reproduction.

within certain parametric constraints[9]. Within the excerpt, there exist many micro shifts in timbre and dynamics that emphasise the particularity of the relationship between the elements whilst investigating the elasticity of the structure it presents. With each investigation, there is an accumulation of both harmonic overtones, but also noise, to the point at which the structure itself appears saturated from the memory of these articulations. Beyond a certain point it is the qualities of this saturation that become the central focus of these interactions, displacing the previous harmonic emphasis in favour of the evolution of these textural qualities. This new emphasis requires a shift in the envelope of the electronics; their deconstruction and re-formulation, something which is only achievable through a transformation in the voicing of the modulator. Here, the inability to achieve this eventually thwarts the evolution of the sound world, leading to the end of the piece.

This excerpt from 'Fear Of Bees' is therefore instructive in that we can clearly perceive the possibility for the evolution of sound worlds through the control of audio analysis parameters in real time modulators such as the one presented here. Nevertheless, it also becomes clear that the specific implementation of these modulators sets out the limits of their practical use. Beyond this point,

[9]This formulation of multiple resonant filters was evolved in later designs of the *bricolage* into additive synthesis with multiple sine waves after the resonant filters proved too prone to violent dynamic outbursts.

where a modulator is stretched to the limits of its engineered functionality, there exists the potential of failure and the sonic possibilities of such a trajectory. For this reason, within each of the designs of subsequent modulators, there is an emphasis both on functionality and failure, wherein how these designs fail (or cease to function in the way they were engineered to) is seen as being in many respects as pertinent as how they operate normally, something we will present more explicitly in the next recording.

'The leisurely exploration of a karstic area; our curiosity leads us along a non-linear path, during the course of which we visit different types of sinkholes, put our safety through some mild risks, and make few unexpected discoveries, among which the decomposing body of a deer, previously signalled by a disturbing smell.' (excerpt) from the album 'The Resurfacing Of An Atavistic Trait' (2011)

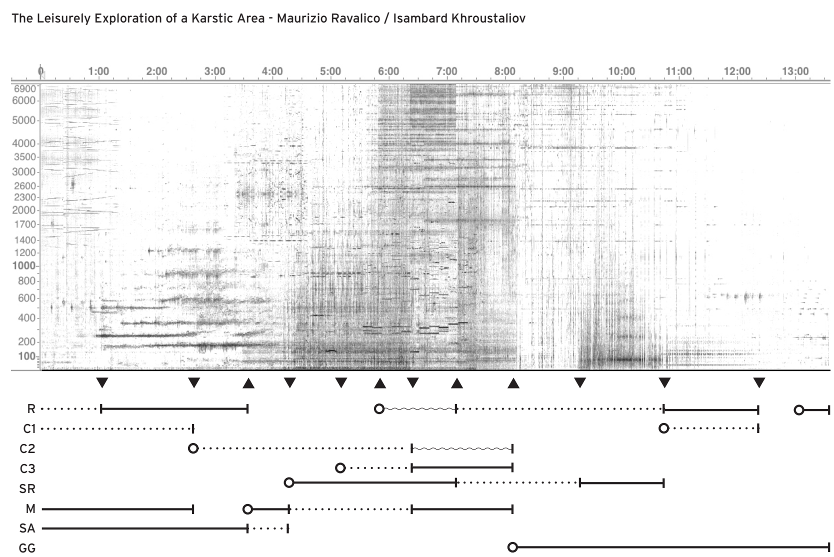

Figure 6.8: Analysis diagram of 'The leisurely exploration of a karstic area ...', see Appendix C for a key and full size reproduction.

This excerpt begins at 15 minutes and lasts until the end of the 29 minute work. Here, we enter the piece at a juncture that is reminiscent of the second half of the previous excerpt of 'Fear Of Bees'; where there is a mixture of harmonic and noisy gestures that are intertwined, coming in and out of focus periodically until the electronics emphasises the lower frequencies of these overtones, at which point the piece begins to evolve to explore the possibilities of this interaction. Already, within this later version of the *bricolage*, it becomes apparent that the possibility to chain modulators via a modular routing system enables a wider range of interactions with the instrumental source material. In addition to this, the introduction of pre-recorded material, selected by the the analysis functions of the concatenative synthesis engine at 3 minutes which itself is subjected to ring modulation via analysis of the instrumental sound begins to open a trajectory onto more percussive gestures at around 4:30. The harmonic saturation of the modulated pre-recorded sound derived from the audio analysis then peaks and evolves into a sequence of harmonic variations triggered by percussive attacks at around 5:30 minutes, followed by further pre-recorded percussive sounds triggered by the instrumental percussion. By 6 minutes these sounds are joined by recorded sections of the live instrumental sound that are spliced and reversed by the *bricolage* and then triggered by percussive attacks in real time. At 6:30 a change in instrumentation from Maurizio to sustained tremolos shifts the focus again to the harmonic drones until a recapitulation of the percussive pre-recorded material presented at 5 minutes seeks to evolve this texture. The disappearance of the pre-recorded harmonic sequencing by 8 minutes leaves only the percussive gestures in the electronics which are put into sharp contrast with the bell tremolos being played by Maurizio through the use of gestural gating and extreme pitch modulation. By 9 minutes this has evolved into a almost call and answer episode where the electronics become increasingly distorted as the modulators are pushed into a dynamic of failure. By 10:30 minutes the tempo has slowed markedly and the electronics have all but disappeared with the exception of some small fragments which interject every so often. This fragmentation is echoed by Maurizio and catalyses the end of the piece where melodic phrases played on Tibetan bowls at 12 minutes are mirrored in reverse.

It has been my intention with these two excerpts to give an overview of the emphasis of my collaboration with Maurizio as well as presenting how this work has not only evolved the design of the *bricolage*, but also the way in which it is able to function. Specifically, the embracing of the dynamic of deconstruction, whereby electronic processes are designed to embrace the inevitability of failure as a part of their functioning opens the conjecture that these disjunctions are as instructive as their constructive counterparts in articulating the form of compositions, something which is explored at length both here and in further collaborations presented below.

6.1.3 with Tolga Tüzün

As a composer, improviser, electronic musician and contemporary of mine from IRCAM, Tolga Tüzün is uniquely versed in systems of computer aided composition and synthesis and their articulation in contemporary music production. The recordings here document a collaborative process that spans a number of years and encompass a studio recording session, subsequent editing and re-composition and the live documentation of a performance some years later following this dialogue.

Within the context of our collaborative work, Tolga performs almost exclusively on the piano[10], which as an instrument, already poses several idiosyncrasies for any analysis using machine listening, most notably that of its polyphony. Until the collaboration with Tolga, the *bricolage* had encountered only monophonic instruments or percussion, where, with monophonic instruments, harmony is either implied through the succession of a series of notes or heard relative to another instrument and with percussion, we are presented with a sliding scale from instruments that exhibit tuning (in that the spectral signature exhibits a clear fundamental frequency even though in most cases the partials/overtones of such instruments are typically inharmonic[11] to instruments whose spectral signature is so dense that it is perceived as a type of coloured noise. In the case of monophonic instruments, fundamental frequency analysis is relatively assured, as are other descriptors such as spectral slope (which gives an indication of the brightness of the sound) and aperiodicity (which gives and indication of the noisiness of the sound). With percussion, the detection of attacks and spectral categorisation using either 'bark' or 'mel' bands (which provide an indication of the timbral makeup of the sound) provide further relevant methods for analysis. However, with a polyphonic instrument such as the piano, where the exploration of harmony is a dominant concern of the instrument, we are presented with the problematic of dense spectral signatures that, while harmonic in their make-up remain problematic for real-time analysis on account that a simple major chord presents us with three discreet notes which must be de-laced from a combined audio spectrum. Whilst there are recent systems capable of efficient real-time harmonic separation of an incoming digital audio signal[12], in 2007, at the time my collaboration with Tolga was begun, the computational load of this type of analysis was such that it severely limited the functioning of the *bricolage* as a system for live performance. Therefore, despite the prospect of more computationally efficient real-time polyphonic transcription[13], my collaboration with Tolga focused on exploring, through improvised performance, whether combinations of timbral and spectral analyses might be used constructively to control to both concatenative synthesis and the parametrisation of audio modulators given the context of harmonic material presented by the piano.

'Until Yet' from the compilation 'An Introduction to Not Applicable' (2008)

'Until Yet' is an early improvised recording with the last minute of the piano performance edited in post production. With this exception it constitutes a

[10] The exception being his introduction of Brian Eno and Peter Chilvers 'Bloom' app, which is used as a musical catalyst in the excerpt of 'From Bloom To Bust - Part 1'.

[11] Idiophones (xylophone, marimba, chimes, cymbals, gongs, etc.) and Membranophones (drums) typically do not produce harmonic overtones, although in many cases attempts are made to tune some overtones to an exact division of the fundamental frequency.

[12] One such system is a real time instantiation of Non-Negative Matrix Factorisation (as discussed in section 5.2.4)

[13] Something that is now a practical possibility using Arshia Cont's transcribe~object for Max/MSP, released as a Beta version on the IRCAM Forum website in November 2014.

kind of stream of consciousness reckoning of approaches to Tolga's playing using the *bricolage*, where concatenative synthesis, re-recording and re-sequencing of the instrumental performance, partial re-synthesis, spectral re-synthesis and ring/frequency modulation are combined and re-combined to form different structures and modes of interaction. If we compare this piece with 'Scratch'; a similar recording of an improvised performance with Lothar Ohlmeier presented earlier in this chapter that dates from a similar period, we can see that there exist a number of similarities in how the improvisations progress; notably, both begin with an initial statement of the concatenative synthesis engine and after an initial crescendo progress to a sparser episode of spectral re-synthesis, however, even within this similarity, there exist marked differences that deserve more detailed discussion.

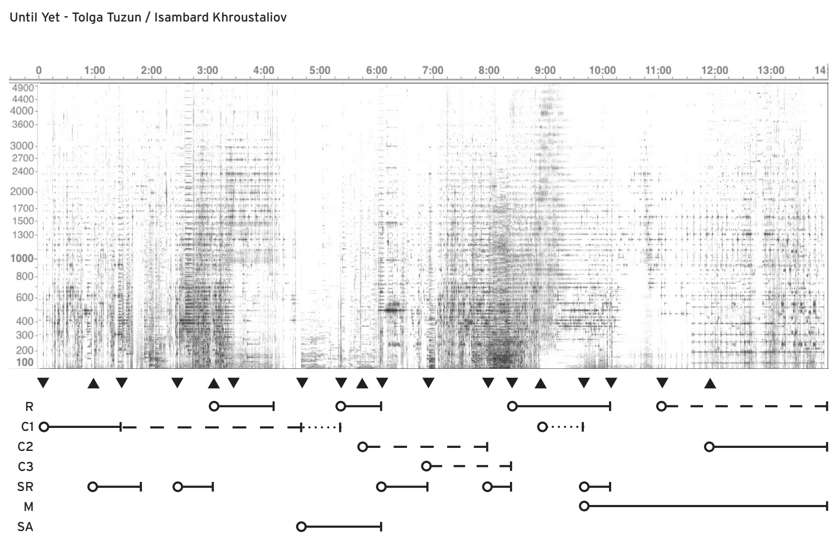

Figure 6.9: Analysis diagram of 'Until Yet', see Appendix C for a key and full size reproduction.

Firstly, from the outset, there is a critical difference in the choice of prerecorded material used for concatenation; in 'Scratch' this consists of a prepared piano performance[14] whereas on 'Until Yet', the pre-recorded material is an editing together of various un-voiced (or noisy) sounds created using a violin and viola. Within both selections of pre-recorded material there is an emphasis on gesture and timbre, however in the material used for 'Until Yet', this emphasis is far more extreme, with tonal sounds appearing as an exception and where

[14]The prepared piano was performed by Gareth Humphreys and is an outtake from recordings realised for the assembly of another work; 'Ping' also released on the album 'Ohka' (see Appendix F for details).

they do, with no sense in which they need express any form of melodic or harmonic content, or even for that matter temperament. In 'Until Yet', the nature of the material being used for concatenation has a specific implication on our perception of the interplay between this material and the piano performance. In contrast to 'Scratch' where the aim of the concatenation is to form a kind of emerging counter-movement/orchestration to the instrumental line by principally matching the fundamental frequency of the clarinet line to that of the pre-recorded material, with 'Until Yet' the concatenative synthesis manifests a kind of parallel arrangement of these more of less concrete sounds (influenced by the phrases of the piano) in a more abstract sense, owing in part to the fact that the main descriptor used for concatenation is spectral centroid rather than fundamental frequency. Spectral centroid is a calculation of the 'centre of mass' of an audio spectrum and is generally considered relative to the fundamental frequency to give an indication of the brightness of a sound[15]. Here, the spectral centroid is used on its own for its ability to generalise the polyphony of the piano performance into a single value which is used as the principle component to drive the concatenation. This rational enables a direct correlation between relative perceptual centres of each spectrum, a correlation that manifests itself audibly in the form of a kind of parallel motion that is not based specifically on tempered pitch. Two prominent examples of this occur, firstly at 0:38, where a gesture from Tolga that shifts an octave lower than his playing previously elicits a reaction from the *bricolage* which contains a voiced note in this range which in turn is picked up by Tolga and used as a refrain in his next series of phrases. Additionally at 1:42 a shift by Tolga up two octaves completely shifts the concatenated sound world from a series of rhythmic gestures whose focus on the lower-middle range of the spectrum complements that of the piano to a series of scrapes and squeals whose focus echos this focus around a higher frequency range. Accompanying this concatenation from 1:00 onwards as a direct modulation of the piano using partial re-synthesis can also be heard. Here, the spread of the partials of the additive synthesis is also controlled by the spectral centroid, meaning the lower the piano performance, the more dense the spectrum and vice-versa. The effect of the partial re-synthesis also serves to shift our perception of the central attributes at play in the musical dialogue taking place from the harmonic and melodic expectations engendered by the tradition of the piano in western classical music to a more amorphous zone of relations, where gesture, concrete sounds and the un-tempered dynamics of audio spectra all coincide, influencing and confounding each other through various evolving relationships throughout the course of the piece from here on.

Towards the end of the piece the sonorities developed by applying modulators to both concatenation and re-sequencing of the performance produces a sound world that takes aspects of the instrumental performance and allows for the composition of musical statements that manifest their own time structure, gesture and harmonic content abstracted from the instrumental performance,

[15]This is achieved by calculating the difference between the fundamental frequency and the spectral centroid frequency, where the greater the number, the brighter the sound should appear perceptually.

exemplifying the possibilities for such an approach.

'From Bloom To Bust - Part 1' (excerpt) from the album 'From Bloom To Bust' (2013)

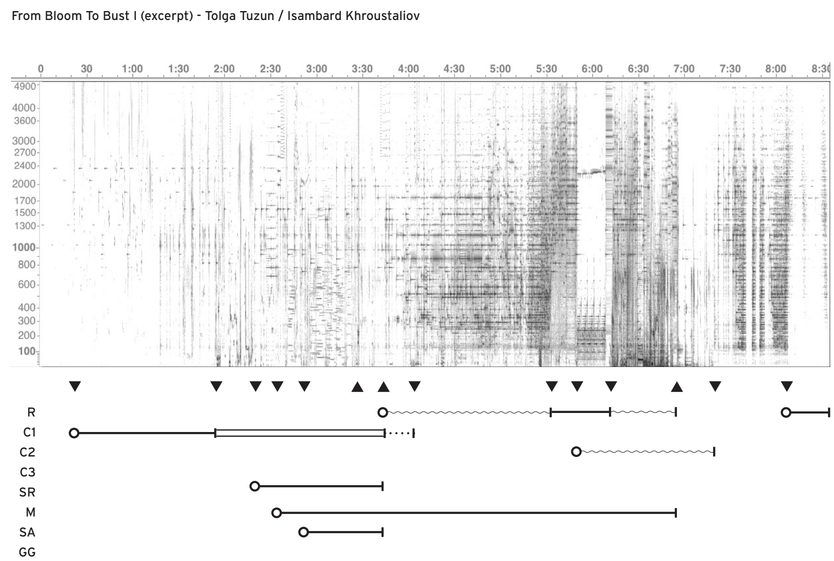

Figure 6.10: Analysis diagram of 'From Bloom To Bust - Part 1', see Appendix C for a key and full size reproduction.

This excerpt of a recording from 5 years later is perhaps the most overt encapsulation of how far the various methods of automatic control developed in the *bricolage* over this period have come from the seeds of processes glimpsed in 'Until Yet'. Of particular note from the point of view of the functioning of the *bricolage* are the opening interplay between the *bricolage* and the Bloom app and the last third of the excerpt from 5:30 onwards, where multiple parallel ideas are almost jump cut, with the many different dimensions the piece has explored up until that point being bought together to evoke the sense of a kind of musical montage.

As a whole, the collaborative work with Tolga introduces us to some of the limitations of the functionality of machine listening given the density of information the piano is capable of generating. In doing so it also affirms the need for creative interpretation of the potentialities of the *bricolage* by the performer and equally the compositional relevance of designed autonomy within the *bricolage* itself; where the reactions of the *bricolage*, whilst potentially triggered in some way by an incoming audio signal, nevertheless exhibit their own dynamics and structural paradigm. This concept of the *bricolage* functioning not only as an agent both in reaction to the instrumental input but also to its own outputs via a chain of potential feedback possibilities and processes begins to establish a secondary type of procedural composition of elements, constituting a distinct vernacular idiom of expression by the *bricolage* in the form of a parallel structure which unfolds relative to the real time instrumental events.

6.1.4 with Philippe Pannier

Echoing my collaboration with Tolga Tüzün, my collaboration with Philippe Pannier began at IRCAM, where I wrote a piece for banjo and electronics based around the possibilities for the instrument arrived at via Philippe's playing[16]. The works detailed here build on this work begun at IRCAM in the sense that they seek to dissolve the absolute determination of the score, which characterises the vast majority of electro-acoustic works emerging from the Western European Art Music tradition, through an engagement with improvisation whist nevertheless seeking to retain the detail and fastidiousness manifested by such works.

'Aporia' from the album 'Ohka' (2009)

Although 'Aporia' was published in 2009, along with 'Haze' (from the album 'Nowhere' with Lothar Ohlmeier) it is in fact one of the first pieces composed within the context of this thesis, dating from 2007. However, unlike 'Haze', where only the concatenative synthesis was realised in post production, with all of the other electronic elements being performed live at the same time as the clarinet recording, all of the electronics present in 'Aporia' were realised in post-production and moreover, the performance itself was catalysed by a graphic score (the full score can be found in Appendix D).

In contrast to the recordings with Lothar, where the instrumental performances are improvised by Lothar and our mode of dialogue is in the moment of performance, 'Aporia' seeks an overt engagement with the act of composition in that it presents a kind of preface for the instrumentalist in the form of a notated body of thought whose intention is to locate the musical discussion in some kind of shared space of intention. In this sense, 'Aporia' also opens a dialogue with previous 'scored' work I have created, most notably the piece 'Ping' [17]. Both 'Aporia' and 'Ping' share an opening with respect to the formulation of their graphic notation to two principle sources; composer Cornelius Cardew's 'Treatise' and the architect Bernard Tschumi's 'Manhattan Transcripts' (figures 6.11 and 6.12 respectively).

For me, both Cardew and Tschumi's drawings investigate whether a system of notation might be evolved to describe its own process of inscription and in effect deconstruct the phenomena they were designed to structure. In this

[16]This piece; 'Junkspace' is documented on the album 'Ohka' released in 2009 on Not Applicable Recordings, see Appendix F for more details.

[17]'Ping' is also documented on the album 'Ohka', see Appendix F for more details.

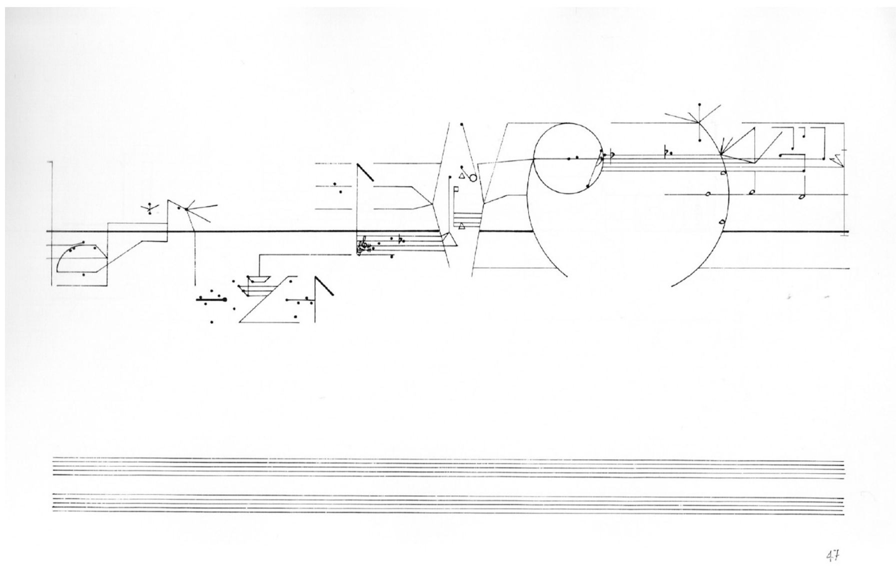

Figure 6.11: Page 47 from Cornelius Cardew's 'Treatise' (1961).

sense they negotiate a similar opening to that which we have seen Derrida describe above (in section 6.1.2) via a language of graphic statements that relate in both cases to well prescribed languages of notation; one the one hand musical notation and on the other architectural orthogonal projection. Concerning 'Treatise', Cardew has stated that he believes no description or analysis of the work is required and that it should be interpreted without such an encumbrance, something he affirms in the 'Treatise Handbook', published some years after the initial publication of 'Treatise' at the request of his publisher:

> "I wrote Treatise with the definite intention that it should stand on its own, without any form of introduction or instruction to mislead prospective performers into the slavish practice of 'doing what they are told'." Cornelius Cardew, *Treatise Handbook*, 1971.

and

> "... it is my contention that an instrumentalist who reads through 200 pages of such material will inevitably find himself forming musical associations, and these will form the basis of his interpretation." Cornelius Cardew, *Treatise Handbook*, 1971.

Hence, if there is a logic to the interpretation of 'Treatise' it lies in the way in which each instrumentalist is forced to reckon with the concept of notation itself and by implication, through engaging with this act of re-imagining a hitherto familiar landscape of signs into new relations and propositions, might also be engaged in the imagining of a sound world they might describe.

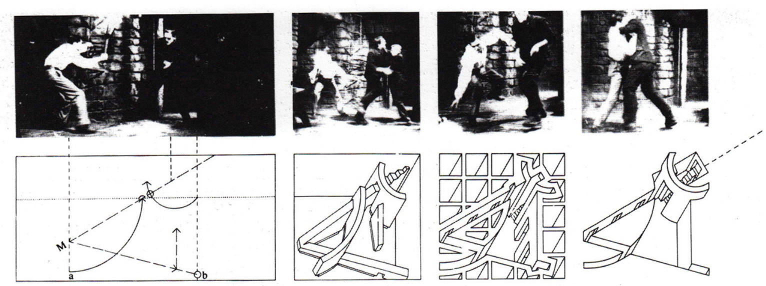

Figure 6.12: A detail from Bernard Tschumi's 'Manhattan Transcripts' (1976 - 1981).

Tschumi also acknowledges this intention in the Manhattan Transcripts, noting that:

> "The work on notation undertaken in The Manhattan Transcripts was an attempt to deconstruct the components of architecture. The different modes of notation employed were aimed at grasping domains that, though normally excluded from most architectural theory, are indispensable to work at the margins, or limits, of architecture. Although no mode of notation, whether mathematical or logical, can transcribe the full complexity of the architectural phenomenon, the progress of architectural notation is linked to the renewal of both architecture and its accompanying concepts of culture. Once the traditional components have been dismantled, reassembly is an extended process, above all, what is ultimately a transgression of classical and modern canons should not be permitted to regress toward formal empiricism. Hence the disjunctive strategy used both in the Transcripts and at La Villette, in which facts never quite connect, and relations of conflict are carefully maintained, rejecting synthesis or totality. The project is never achieved, nor are the boundaries ever definite." Bernard Tschumi, *Architecture and Disjunction*, MIT Press, 1996, p.211.

Whereas Cardew leaves indeterminate the functionality of his "Treatise", Tschumi goes further in his description of how the process of reassembly should proceed, with the result that a clear picture begins to emerge of how he seeks to portray this deconstructive discourse in his work; through disjunction.

Here, it is worth returning to Derrida, in that the disjunctive strategy Tschumi elucidates would seem to present an imperative form of what Derrida refers to as a rupture:

> "The event I called a rupture, the disruption l alluded to at the

> beginning of this paper, presumably would have come about when the structurality of structure had to begin to be thought, that is to say. repeated. and this is why I said that this disruption was repetition in every sense of the word. Henceforth. it became necessary to think both the law which somehow governed the desire for a centre in the constitution of structure, and the process of signication which orders the displacements and substitutions for this law ..." Jacques Derrida, *Structure Sign and Play in the discourse of the Human Sciences*, from Writing and Difference, Routledge, p.353.

In that we might *perceive* this constant act of deferral; of the repetition of this thinking of the structurality of structure as disjunction, Tschumi begins to set out a reading of deconstruction as not only a form of literary criticism, but moreover a type of formal criticism, where the structural foundations behind any ordering process becomes a viable subject for deconstruction and where the ruptures bought about through this deconstruction in a critical sense, manifest themselves as disjunctions in an imperative sense.

'Aporia' draws on this disjunctive imperative in the way in which it seeks to combine the instrumental performance with the electronic orchestration. Here, while there is a clear sense in which the realisation uses concatenative synthesis to posit immediate relationships between the instrumental performance and the pre-recorded sounds, there is also an overt emphasis on the disjunctions this creates both temporally and contextually (in terms of shifts in orchestration) and a desire to explore these fissures as the material of the composition itself.

To this end, the score attempts to create an environment for the interpreter where the continuity of structural relationships (in this case between a series of volumetric objects) can never be fully ascertained. This suspension of our ability to 'read' these shapes as legitimate orthogonal projections and furthermore their intertwining throughout the course of the score effectively forces a consideration of certain gestalt qualities of the compositions. This is further encouraged by both the exaggeration and diminution of different lines and points, along with the framing of the composition on a set of sequential pages. The result is a provocation which catalyses an interpretation that is then the subject of a kind of deconstruction through the subsequent digital orchestration and contextualisation.

This pattern of using a score as a catalyst for a recording which is itself provides the subject of a further deconstruction, as opposed to the intention of the realisation of the score becoming a definitive statement of its own is a critical juncture in this work with instrumentalists which also opens the possibility for traditionally notated works in the knowledge that these works would in turn form subjects for a deconstructive reading via the digital systems described in the previous sections.

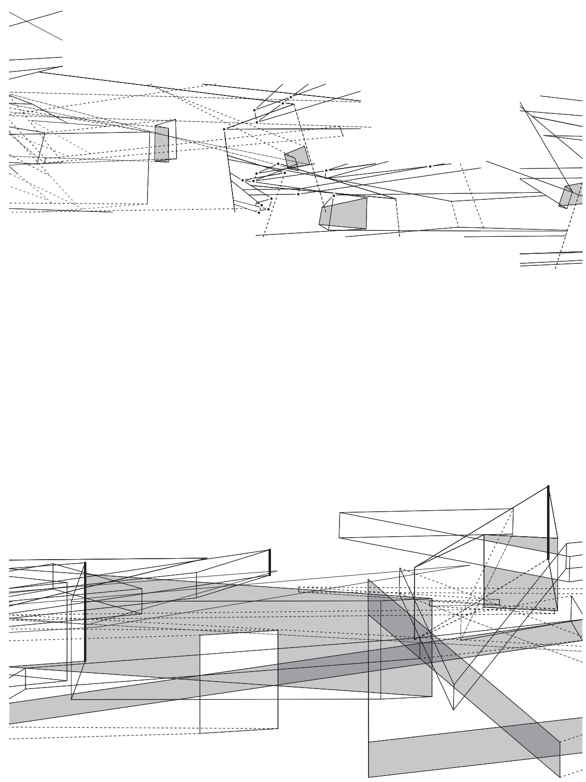

Figure 6.13: Pages 3 and 11 from the score 'Aporia', see Appendix D for a complete reproduction.

'Entre Des ...' from the album 'CHALEUR' (2011)

'Entre Des ...' is taken from an album of material recorded with Philippe during a rehearsal and concert performance on the 18th and 19th November 2010[18]. The album curates these recordings into a series of episodic pieces via a process of editing and re-arranging in much the same way as 'Aporia', although here, the various episodes are combined improvised performances. Here it is worth noting that this process of taking performed improvisations and re-working them into a composite work is very much seen as part of the intentionality of our process of working. In this sense, the album diverges from the notion of a 'document' in the sense of a live recording, to which other pieces presented here are a testament

[18]This album, entitled CHALEUR was released in 2010 on Not Applicable Recordings, see Appendix F for more details.

to[19]. By contrast, the opening to the idea of the performance as a speculative realisation of a discreet intentionality as proposed by the intermediate process of the score in 'Aporia' is seen as a function of the shifting reality proposed by the hypertextual context outlined earlier, where any emphasis on the documentation of definitive structures is eroded in favour of the exploration of the structuring of these structures via an investigation of chains of relativity across the intersection of the instrumental/digital musical divide.

'Entre Des ...' can therefore to all extents and purposes be considered as an excerpt from the larger work which is 'CHALEUR'. The intention in presenting it here is to illustrate the almost fractal like quality our line of enquiry leads to. In its brief one and a half minute duration, 'Entre Des ...' both exhibits a rhetorical exploration of the pre-recorded material used to construct 'Aporia' whilst also functioning as an illustration of one possible structuring of this material amongst a set of linked variables that constitute the larger work of 'CHALEUR'.

These links between 'Aporia', 'Entre Des ...', and 'CHALEUR' begin a trajectory that seeks to dissolve any perceived divide between the structures of performance, pre-production and post-production by exploring their very incompleteness, something which is also affirmed via a quotation on the artwork to 'CHALEUR':

> "I do not yet know, and in the end it really does not matter, if I will be able to make it clear why I must leave these thoughts fragmentary, or why I value them for their incompleteness even more than for their fragmentation, more for their pronounced incompleteness, for their punctuated yet open interruption, without even the authoritative edge of an aphorism. These little stones, thoughtfully placed, only one each time on the edge of a name as the promise of return." Jacques Derrida, *The work of mourning*, University of Chicago Press, 2003.

6.1.5 with Tom Arthurs

Having performed alongside Tom Arthurs on a number of occasions in ensembles led by other musicians, our first duo collaboration was in fact developing an autonomous system designed to improvise with Tom without any input from me[20]. The recording documented here takes a step back from this autonomy to explore the diversity possible given a period of experimentation prefigured by a series of concert performances.

[19] Notably the pieces 'Scratch' and 'Avenue' with Lothar Ohlmeier, 'Fear Of Bees' and 'The leisurely exploration of a karstic area; our curiosity leads us along a non-linear path, during the course of which we visit different types of sinkholes, put our safety through some mild risks, and make few unexpected discoveries, among which the decomposing body of a deer, previously signalled by a disturbing smell.' with Maurizio Ravalico and 'Until Yet' (with the exception of the last minute which is edited) and 'From Bloom To Bust I' with Tolga Tüzün.

[20] This work, entitled 'Long Division' is documented in section 6.4.1. Details of the recording, released on Not Applicable Recordings in 2011 can be found in Appendix F.

'Irina Peperin' from the album 'Vaucanson's Muse' (2015)

The pieces that constitute the album 'Vaucanson's Muse' were recorded over a period of two days in November 2013 following a series of concerts dedicated to the realisation of Graphic scores as an ensemble with 3 other musicians; Joanna McGregor (piano), Oliver Coates ('cello) and Elaine Mitchiner (voice)[21]. Notably, in the context of this ensemble, Tom and I interpreted Cardew's 'Treatise' both with Oliver Coates as a trio and then with the full ensemble. It was with reference to this that I chose to write about my experience of 'Treatise' for the Wire Magazine[22], contextualising this experience in relation to the architectural movement of Deconstructivism:

> "Engaging once more with Cardew's 'Treatise' as I have had the pleasure of doing in preparation for some forthcoming performances, what remains striking for me is the level of critical attention and analysis Cardew manifests for music in honour of philosophy ('Treatise' derives its name from Ludwig Wittgenstein's 'Tractatus Logico-Philosophicus'). I find a similar affirmation in these drawings by Libeskind especially given that while the palaces of 'Deconstructivism' (Libeskind's *Jewish Museum* in Berlin, Frank Gehry's *Guggenheim* in Bilbao and Bernard Tschumi's *Parc de la Villette* in Paris) made optimal use of the contemporaneous digital revolution in computer aided design to facilitate their prototyping and construction, by contrast their genesis remains in returning to the question of how a language of architecture is manifested. For me, as an electronic musician and composer, inevitably wrapped up in the negotiation and creation of software and hardware to realise projects, architectural 'Deconstructivism' as a movement is a poignant reminder that the digital language which has transformed architecture as well as music making (and increasingly our lives in general) necessitates an equally radical appraisal of our engagement with philosophy." *The Inner Sleeve* for the Wire Magazine, October 2013.

Interestingly, in performing 'Treatise' alongside other graphic scores, although I found that it was one of the scores that I identified with the most, it was nevertheless perhaps the most problematic to perform, in part from the perspective that it was envisaged as an ensemble piece. The nature of ensemble playing in the context of a score such as 'Treatise' and the desire to in some way render the pages through musical interpretation as decisively as the graphics led to a number of crises, (accentuated by the small amount of time available for

[21] This ensemble toured the UK, performing 6 dates in total in October 2013, interpreting the following scores: Cathy Berberian Stripsody, John Cage Water Music, Cornelius Cardew Treatise (excerpts), George Crumb Crucifixus (Capricorn), Spiral Galaxy (Aquarius), Fred Frith Bricks for Six and Zurich, Wadada Leo Smith Luminous Axis, Tom Phillips Golden Flower, Lesbia Waltz, Ornamentik and Jennifer Walshe THIS IS WHY PEOPLE O.D. ON PILLS.

[22] The full article can be found in Appendix E

rehearsal with the whole ensemble). This ultimately seemed to thwart Cardew's stated desire for the score to catalyse a critical reading of musical associations the graphic language suggested to the musicians (something which requires a complimentary amount of time to realise) in favour of the decision being taken to interpret a particular excerpt of the score in an idiomatic manner wherein each of the performers related to this construct first and tailored this towards the forms of the score. Thus, while we could all identify with the motivations for a work such as 'Treatise', there was a sense that it also precluded its own intentionality as a result of its 'completeness', something that ultimately manifested a kind of dogmatic constraint on the act of performance.

This experience was contrasted vividly by the experience of interpreting with Tom as a duo, Wadada Leo Smith's 'Luminous Axis'[23]. Wadada Leo Smith says of the 'Luminous Axis' scores:

> "All the pieces of Luminous Axis are language scores, I don't call my Ankhrasmation scores 'graphic scores', because they must be performed and not read as one might do a painting or picture. I will send you a document in another email or a link to it, which can help the musicians to understand how to perform my Ankhrasmation score. But please do not publish this document in any form. And I ask the musicians not to give that document to other musicians."
> From instructions provided by Wadada Leo Smith to *Luminous Axis*

In accordance with his desires, I will not go into any discussion of the guidance provided for interpreters by Wadada Leo Smith, nevertheless, this aspect that he emphasises in the quotation above of both an emerging language and of the scores themselves as being both incomplete and emblems for a process that is yet to be finalised until the moment of performance I found particularly pertinent.

Within our duo performances of 'Luminous Axis', my impression was that our interpretation of the scores was formed from fragments; moments where the score functioned as a point of departure for a string of gestures and interactions but equally as a structure from which to hang motifs with an acknowledgement of their incompleteness (given their relationship to the incompleteness of score).

When Tom and I came to record 'Vaucanson's Muse' a month after our last performances as a duo of 'Luminous Axis', it was with a conscious intent to document our work as a duo, despite the fact that the language of playing we had developed together was born out of an association with 'Luminous Axis'. At the beginning of recording, we made the conscious decision not to return to 'Luminous Axis', but to press on in interrogating this emerging language of our duo.

The recordings themselves were made in long takes of as much as half an hour each and cumulatively over 3 hours of music was recorded, a significant

[23]Ishmael Wadada Leo Smith is a trumpeter and multi-instrumentalist, composer and improviser and has been active in creative contemporary music for over forty years. His systemic music language 'Ankhrasmation' is significant in his development as an artist and educator.

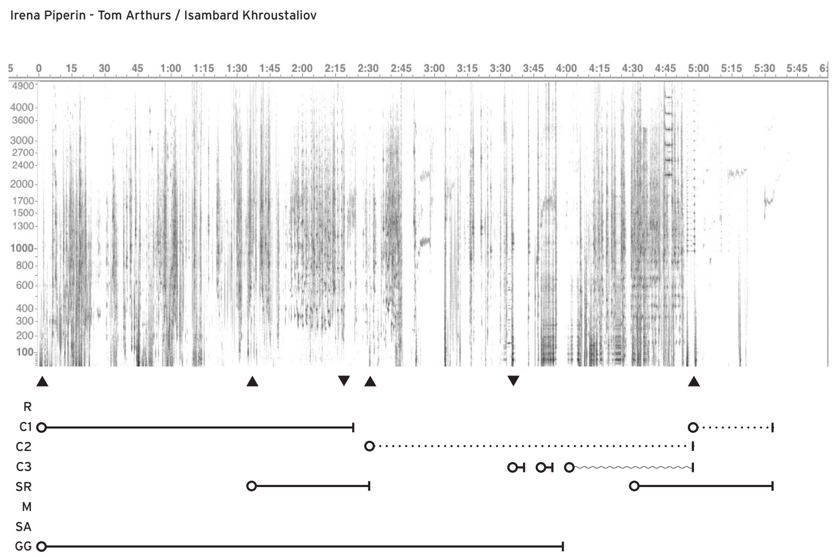

Figure 6.14: Analysis diagram of 'Irina Peperin', see Appendix C for a key and full size reproduction.

expansion on the two ten minute interpretations we had worked on for 'Luminous Axis'. Within the recording sessions, I felt that the cumulative experiences of working on 'Luminous Axis' and also the autonomous suite 'Long Division' with Tom meant that we had amassed a combined set of parallel experiences, which although influential were clearly separate from the way in which the music was formed over the course of the recording. I also had the impression that it was precisely a desire to interrogate these fragmentary associations born out of these previous tangential experiences that became a central focus of the music itself.

Thus, 'Vaucanson's Muse' inherits a legacy of previous interactions as a basis for its musical statements, but critically, from my perspective, does not attempt to try and find a unity in this inheritance, but rather interrogate it for its disjunctions, both in the manner in which it unfolded as an act of recording, whereby the a priori *selective* and *subjective* memory of these interactions was called upon at length to form a document whose subject was this discontinuity and furthermore present this narrative as a discontinuous exposition in its final published form (in the sense of editing from this document in post-production of 'episodes' to form the actual record itself).

As such, the recordings that constitute 'Vaucanson's Muse' constitute for me a determined exposition of a set of enquiries that span all levels of the process of musical production, from the experiences of autonomous performances and interpreting graphic scores to sustained studio interaction and finally the processing and presentation of this work as a public document.

6.2 Multiply-Directed Composition

I propose to call the music of this section 'Multiply-Directed Composition' to make explicit the sense in which these works investigate the multiple lines of enquiry proposed through 'Collaborative Composition' and employ any or all of those processes to create works that investigate the panorama of musical forms resulting from those encounters. In this sense, Multiply-Directed Composition prototypes on the one hand, a methodology through which the *bricolage* might act as a generative/semi-autonomous musical agent, whilst also opening a trajectory wherein algorithms and processes researched with relation to the control of the *bricolage* might also investigated in a space of symbolic intervention; that of the musical score. This parallel investigation into the correlation/disjunction between the algorithmic determination of events and their manifestation as sound through both recorded works and as performances (via a score) also draws an analogy with Bernard Tschumi's exegesis of his own working process as set out with regard to Parc de la Villette:

> "A fundamental distinction separates these two strategies. In the first case, the design is the result of the transformations, While in the second it becomes the origin. Rather than the outcome of a thinking process, the design, in the latter instance, provides the starting point for a long series of transformations that slowly lead to the built reality. In this sense, it is a mutually implicating structure, both hypotext and hypertext." Bernard Tschumi, *Architecture and Disjunction*, p.188, MIT Press, 1996.

Here, Tschumi articulates the way in which the scale of his working practice spans the manipulation and transformation of existing forms (in the sense of extant spaces and the fabric of the built environment) to the genesis of new ones (from an expansion of theoretical 'first principles'), highlighting the sense in which he considers the subject matter to remain analogous from a conceptual viewpoint between both. This is pertinent for us here in that Multiply-Directed Composition, is equally concerned with this sense in which our enquiry might proceed from diametrically opposed scales; on the one hand from the fabric of the corpora themselves via a process of feedback and self organisation within the *bricolage* and on the other, by using the medium of a score and the performance interactions observed via musicians interpreting that score as a way to prototype a methodology for longer form episodic control of the *bricolage*.

This section therefore presents these two opposing ends of the spectrum of composition; from the building of a large scale recorded work using the *bricolage* as an organiser, manipulator and ultimately generator of sonic events which are then structured and layered together into episodes manually in the manner of 'Musique concréte', to the prototyping and design, via the medium of the score, of a system of automatic episodic control of the *bricolage*, wherein autonomous macro-structuring of material generated by the *bricolage* becomes possible.

6.2.1 'Ohka' from the album 'Ohka' (2009)

'Ohka' is the first long form composition that attempts a sustained interrogation of the musical forms and interactions evolved through 'Collaborative Composition' as produced by the *bricolage* alone. In the absence of an instrumentalist as an input for the *bricolage*, the *bricolage* is used in a feedback loop with itself to generate material, whereby the output of one concatenative sequencer in the *bricolage* is fed to the input of another and vice-versa, thereby setting up a loop in which the two sequencers act as semi-autonomous musical agents; selecting and sequencing segments of recordings in response to one another according to certain parameters. These purely digital 'performances' are recorded and subsequently edited and arranged to form the final composition.

In this sense, by turning to instrumental music as the primary source material for its composition, Ohka invokes the dimensionality of musique concréte as a method for interrogating the recorded form of instrumental music. From a material perspective, Ohka can be interpreted as taking its cue from Helmut Lachenman's description of his music as "Musique Concréte Instrumental"[24], speculating on the question of what an inverse formulation of Lachenman's foregrounding of the concreteness of action and material in the digital system developed here might sound like. In this sense Ohka also alludes specifically to Luc Ferrari's formulation of what he describes as 'anecdotal music', re-purposing Ferrari's methodology as a means of deconstructing recordings of instrumental music in light of the digital technologies through which they are disseminated.

> "They are anecdotal both because they are formed of anecdotes from the flow of the cultures in which the original recordings are made, yet also because they combine to form new anecdotes. The sounds of a piece of Ferraris *musique anecdotique* are open conduits in which meaning flows between the worlds from which they were taken and the world they create. This meaning is pointedly Derridean, a product of differential friction and the trace of alterity, a meaning constituted by what it is not." Seth Kim-Cohen, *In the Blink of an Ear: Toward a Non-Cochlear Sonic Art*, A&C Black, 2009.

[24]Lachenmann has referred to his compositions as "musique concréte instrumentale." Here, Lachenmann implies a musical language that embraces the entire sound-world made accessible through unconventional playing techniques. According to the composer, this is music "in which the sound events are chosen and organised so that the manner in which they are generated is at least as important as the resultant acoustic qualities themselves. Consequently those qualities, such as timbre, volume, etc., do not produce sounds for their own sake, but describe or denote the concrete situation: listening, you hear the conditions under which a sound- or noise-action is carried out, you hear what materials and energies are involved and what resistance is encountered." from *Musique Concréte Instrumentale. A conversation and concert with Helmut Lachenmann about the composition, musical languages, and unconventional playing techniques*, (slought.org

Figure 6.15: Accompanying artwork to the physical release of 'Ohka' on CD.

Specifically, Ohka takes the perspective that instrumental music increasingly inhabits a world where the boundaries of where performance can be said to end and dissemination begins is increasingly unclear. Thus, Ohka adopts the perspective that the front line of sound and music is a multifarious, increasingly digital space where narrative is often the product of hypertextual and algorithmic suggestion[25] whose fleeting juxtapositions and unintentional counter-movement have begun to define our contemporary relationship to recorded music. In acknowledging this space and its underlying character, Ohka is perhaps best seen as a kind of fictional field recording that documents an automated, digital habitat where recorded music is subject to the parametrised impulses of algorithmic operations. Thus, Ohka documents as a hypertextual journey through a corpus of digital audio, the 'procedural dance' of this fictional habitat; an exploration of its landscape through the events of digital agents that seek to uncover informational relationships that exist within it[26].

[25] Examples of software and websites that employ either algorithmically driven systems of recommendation or which generate playlists of music algorithmically are numerous and include Apple Music, Spotify and Last FM.

[26] This aspect of the work is also explicitly implied by the artwork for the release (as illustrated), which, in its adaption of the typographic language of David Carson and its use of the '1337' alternative alphabet to render information about the recording attempts to create a kind of topography through which the music is contextualised.

6.2.2 'Axiom' and the Prototyping of Autonomous Episodic Control for the *Bricolage*.

Beginning at the opposite end of the spectrum articulated by our definition above of 'Multiply-Directed Composition', 'Axiom' uses the medium of the musical score and instrumental performance to prototype and test a methodology for structuring musical material into non-deterministic larger scale structures. This research then forms the basis for the subsequent design of an algorithmic agent able to effect episodic control of the *bricolage*.

The score for 'Axiom' consists of two parts; a sheet of graphic notation divided and articulated by numerous markers and indicators, and a set of instructions as to how this material may be structured by a conductor or 'prompter'.[27] As a score, 'Axiom' is framed through its references to three works that are already well represented in our discourse here, namely; John Zorn's 'Cobra', Karlheinz Stockhausen's 'Plus Minus' and Cornelius Cardew's 'Treatise'. In effect, Axiom 'samples' ideas from each of these works to produce a hybrid, wherein each element is treated as if it were an algorithmic process. In 'Axiom', the prompting techniques are adapted from Zorn, the notation from Cardew and the articulation from Stockhausen. Added to this is the use of prime numbers as an ordering process for the graphics.

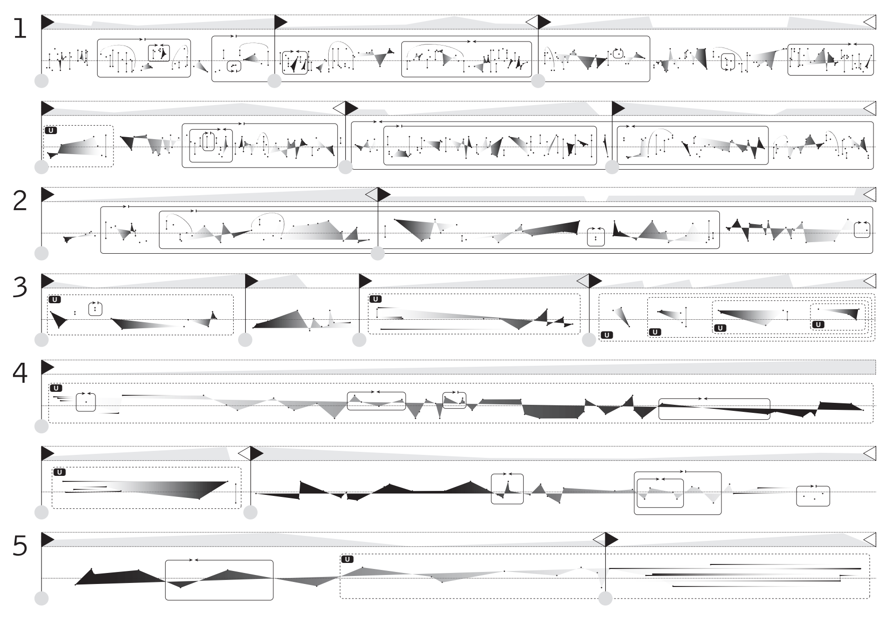

Figure 6.16: The graphic score for 'Axiom', see Appendix D for a full reproduction.

[27]The score for 'Axiom' is included in Appendix D

'Axiom' has had various performances[28] and has also been used as guide for realising recordings with instrumentalists[29], some of which have subsequently then been used as source material for improvisations using the *bricolage*.

The experiences of prompting 'Axiom' and of recording instrumentalists interpreting the score was in effect a method for me to experiment with questions of control over musical autonomy and how this might ultimately inform a sense in which I could begin to formalise the digital system used in the framework of 'collaborative composition' for the purposes of autonomous composition. In this sense, the structure of 'Axiom' partly mirrored the processes of editing I had evolved when composing 'Ohka' in a DAW[30] time-line, whereby I began to organise material based on the density and types of events, subsequently auditioning various combinations and identifying within these combinations unique events and loops of interest that might begin to constitute a structure of sorts. This process was iterated until the material finds a representative form that constitutes the published recording. In principle, then, 'Axiom' sought to interrogate the significant variables that effect such a formulation, the most critical of which, in my analysis ultimately concerned the functioning of time with relation to the density of the sonic material. Here, my observations concerning relationships between time and density were informed both by my own experience and through studies in auditory perception analysis, where human subjects are given a number of auditory examples containing varying types of groupings of sonic elements and the length of time taken to distinguish these elements (or not) is recorded, with the intention of better understanding how we parse sonic events from a stream of sound:

> "Temporal or perceptual units play an important role in auditory recognition. These units are held in a pre-perceptual auditory store for perceptual processing. If a second auditory pattern can be integrated with a first, they can form a single unit. If not, the second can interfere with the pre-perceptual image of the first. Perceptual processing refers to an analysis of information in the perceptual unit. This analysis requires an examination of the physical features of the stored sequential pattern in order to identify the input. The temporal course of perceptual processing depends on the complexity of the identification task. The more difficult the discrimination, the longer the time needed for reading out the necessary information." Dominic W. Massaro, *Pre-perceptual images, processing time, and perceptual units in auditory perception*, Psychological Review.

With the in mind I began by building an automated prompter for 'Axiom' where the length of time before a new episode was prompted was in inverse

[28]'Axiom' was work-shopped by members of the London Contemporary Orchestra at Brunel University in March 2010 and subsequently performed by the Berlin Improvisers Orchestra at Wendel, Berlin in September 2010 and Jazzwerkstatt Wein in Vienna, November 2011.

[29]Recordings of the entire graphic score to Axiom were made during the course of 2010 with numerous improvising instrumentalists including Dominic Lash, Anna Kaluza, Tom Arthurs, Frank-Paul Schubert, Lucy Railton and Zac Gvi.

[30]Digital Audio Workstation.

proportion to the density of change in the auditory scene. Here, the working hypothesis is made that the complexity of the auditory scene has an implication on the time it takes the listener to analyse and parse events from this stream of sound; the more varied this stream of information is, the more challenging it is for the task of auditory perception. Thus, in the context of creating a system concerned with the longer term structuring of events it would seem necessary to be able to measure the density of change in a stream of audio in order to mitigate against the situation where the listener's ability to process the audio scene is overloaded.

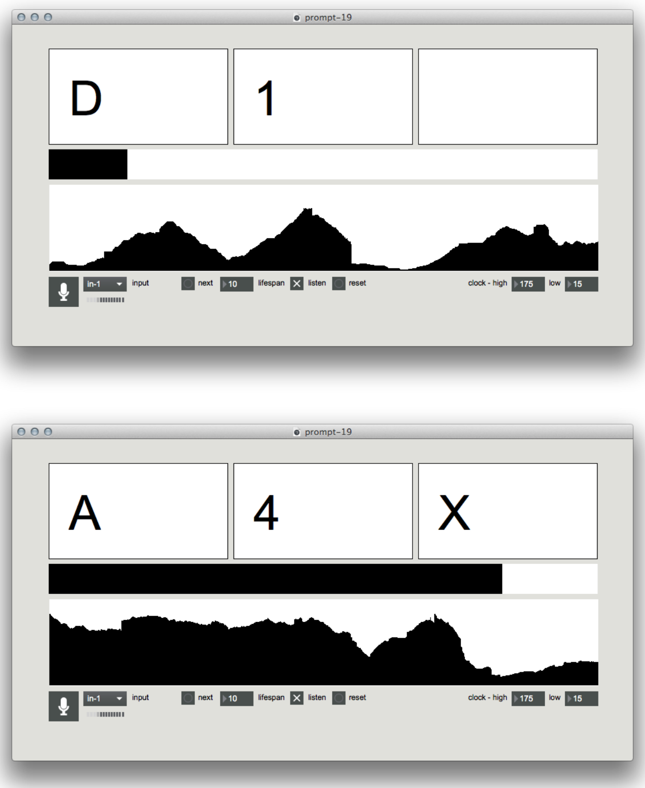

Figure 6.17: The automated prompter for 'Axiom' as realised in MaxMSP. The letters and number at the top of the patch indicate regions in the graphic score to be interpreted by the performer. Below is a progress bar giving the performer an indication of how much time remains before the next instruction is given. The lower graph shows the spectral flux analysis of the performance taken from a microphone input to the computer. The spectral flux is mapped to the relative tempo of the progress bar.

In the automated prompter developed for 'Axiom', the density of change in an audio stream was calculated by evaluating the spectral flux (the difference of energy between consecutive FFT frames) of the incoming signal, where large

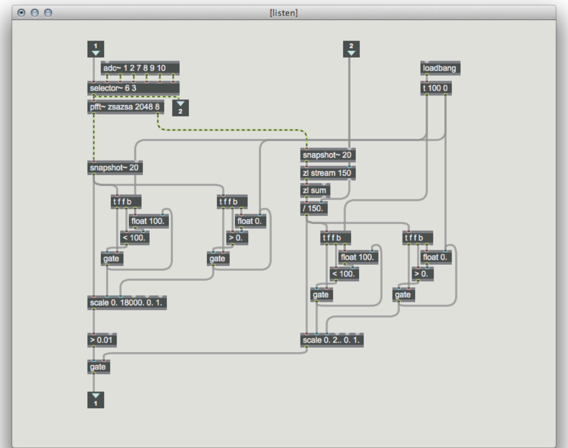

Figure 6.18: Schematic of the for listening module from the automated prompter for 'Axiom' as realised in MaxMSP. The spectral flux analysis is computed at the top left of the patch and parametrised in the remainder of the patch.

differences in either the volume or pitch of the signal elicits a high value of spectral flux and vice-versa. The average of this value over a variable window (initially set at 150 samples at 20ms intervals) was then used as an elementary indication of how spectrally different an incoming signal was from its previous state.

This measure of spectral flux is then used as a variable for the tempo at which events unfold within the prompting system; when the measure of spectral flux is high, the demands made of our auditory perception are also assumed to be high and tempo is accordingly sped up in order that a change in the state of the composition will occur sooner. The opposite is true when the spectral flux is low. Within the prompter, the extremes of low and high tempo are also parametrised, as is the window size of the averaging of the variable of spectral flux, meaning the system can be tuned in order to manifest more or less extreme behaviour, whereby the highs and lows of intensity in long term structure are correspondingly dilated and expanded.

Having designed and implemented the timing of events within the prompter, the question of how the composition should unfold in time also needed to be modelled. Here, I was aware that I might draw on any number of well documented methods through which to encode the decision making process within the prompter given the relatively small but not insubstantial number of combinatorial options offered by the system of cards. My intention was to inform the choice of cards using transition probabilities recorded in a Markov chain[31],

[31] A Markov chain is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.

whereby I could compose a number of model sequences for the cards, analyse the transition probabilities of these sequences and implement them in the Markov chain, such that it would base its output on these models. The Markov chain was implemented in the prompter and I initially experimented with various sequences of cards as models, however, I found that the situation of precomposing strings of model progressions for the system bore little resemblance to the method of decision making I had experienced whilst prompting 'Axiom' myself.

In my experience of prompting 'Axiom', the sense through which longer term episodes of a piece form an identity seemed less contingent on the cards themselves and more on both the degree of autonomy given to the musicians in interpreting the score and the points at which structural changes were effected in time. Accordingly, the performances I felt were most satisfactory from my own subjective viewpoint were those with musicians who were used to improvising (who effectively modified their own musical vocabulary in light of the score) and where large structural changes were bought about that amplified the sense in which the act of prompting effectively disrupted any unfolding formal or musical patterning.

> "I have formal concerns. I don't set myself any aesthetic restrictions, which means I don't abstain from thinking about it. How can a form emerge from random elements? How does chance produce events? (...) Is the philosophy in the determination or the play of chance? (...) Chance is channelled through the rules of the game. Chance can propose margins of determination that will make the project work. (...) One could say that a preoccupation with chance has to do with form, and with deconstruction." Luc Ferrari, interviewed by Jacqueline Caux in *Almost Nothing with Luc Ferrari*, p77-78. Errant Bodies, 2002.

Thus, the training of the Markov chain by example was, in the experience of 'Axiom', abandoned at an early stage in preference for a system based purely on chance. This 'random' automated prompted version of 'Axiom', where the emphasis was placed on the timing of these random events and on autonomy, received only one performance[32] before being integrated into autonomous manifestations of the *bricolage* as documented in the chapter 'Contingently Autonomous Agents for Composition'.

6.3 Algorithmic and Parametric Composition

This section details contexts in which techniques and compositional methodologies derived from the various approaches to collaborative composition and multiply-directed composition detailed above have informed the composition of

[32]With the clarinettist Brigid Burke in 2010.

works that reside almost exclusively in the digital domain and in which the algorithmic and parametric possibilities of the computer are explored in depth as a basis for structuring musical output.

6.3.1 with Oliver Bown, as 'Icarus'

Presented here are two recordings which on the one hand adopt some of the methodologies pursued through the framework of 'collaborative composition' and on the other unfolds them into a virtual space of synthesised performance, where digital systems for creating musical gestures are combined with systems designed to control them, constituting an experiment in 'designed variation', whereby the composition of the musical work is extended to encompass the design of multiple unique instances of the work.

At this juncture, in order to contextualise the approach to composition adopted by Ollie and I as 'Icarus', it is useful to discuss the problems of analysis with regard to combined electronic music production. In the previous chapter; 'Collaborative Composition', all of the musicians I collaborate with play acoustic instruments and as such, there is a clear delineation between their contributions and mine as a result of this acoustic/electronic divide. While this divide is conflated both by the methods through which the acoustic sound is processed by the software and the fact that these collaborations are presented as recordings (on which both acoustic and electronic sound are represented by the same medium of digital audio), it is never fully erased, in part owing to a general understanding of the parameters of acoustic instruments themselves through familiarity. However, in the context of my collaboration with Oliver Bown as 'Icarus', the distinction between our roles in the production of the music does not exist a priori in any definitive physical/structural sense, but has evolved through the various tools we have used and techniques we have developed over the numerous years we have been producing music. Moreover, in the case of two individuals producing a combined piece of electronic music, it is perhaps fair to say that no definitive account can be made concerning their individual contributions for the simple reason that the vast majority of the decisions made in the course of composing such works exhibit a complex hybrid causality that is only ever tangentially documented in the final medium of the recording. In the case of my collaboration with Ollie, the roles we have assumed in the process of composing works have changed markedly in response to both the tools used to realise them and the situations in which they were composed. Therefore, the only generalisation that can reliably be made concerning our individual contributions to these combined works concerns this changeability. Nevertheless, when analysing single works and particularly those performed rather than produced in the studio, it is possible to elucidate distinctions with more certainty and 'Sparkly Bear' is one such case. By contrast, 'Colour Field' personifies precisely this ambiguity.

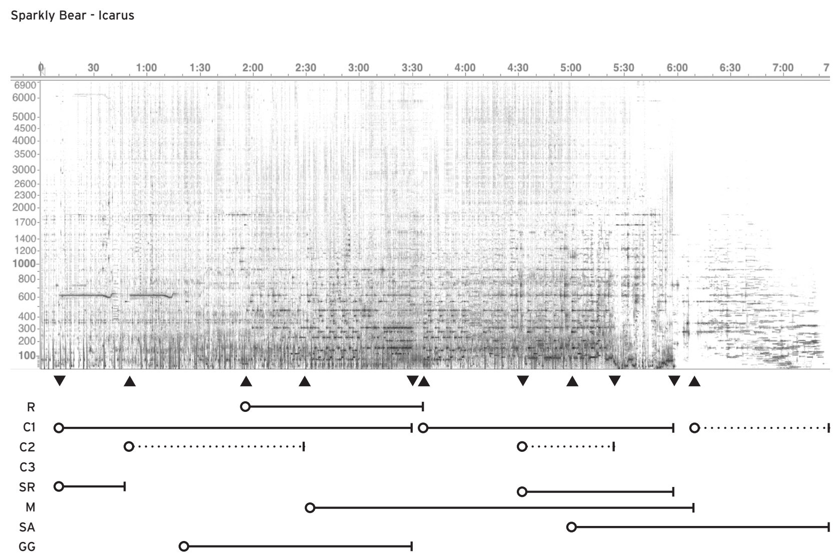

Figure 6.19: Analysis diagram of 'Sparkly Bear', see Appendix C for a key and full size reproduction.

'Sparkly Bear' from the EP 'Flensburg' (2011)

'Sparkly Bear' documents part of a live performance recorded during a series of concerts given in Australia in March 2010. This concert series followed on from a preceding series of concerts in July 2009, which resulted in the release of an album documenting this evolution of our work as a performing electronic duo entitled 'All Is For The Best In The Best Of All Possible Worlds'[33].

'All Is For The Best In The Best Of All Possible Worlds' consolidated a shift in our modus operandi from predominantly studio based productions to the documentation of improvised live performances, drawing on the performative possibilities of software we had designed and built since around 2003 as part of the process of producing music in the studio[34]. Although the album 'Sylt' (2007) features two recordings of excerpts of live performances, these performances were contextualised by five studio productions that framed them and emphasised the nature of the live performances as derivations from studio references. For this

[33]The album was released on March 25th 2010 through Not Applicable Recordings (see Appendix F for more details) but is not documented here as a result of the fact that no one excerpt was able to be cut from the album to sufficiently represent the breadth of its structure. For reasons of brevity, we therefore limit our discussion to the single composition 'Sparkly Bear' which is nevertheless realised in the same manner.

[34]Music featuring various incarnations of such software (used in the sequencing synthesising and processing sounds) is documented on the albums 'I Tweet The Birdy Electric' (The Leaf Label, 2004), 'Carnivalesque' (Not Applicable, 2005) and 'Sylt' (Rump Recordings, 2007)

reason, the live performances were also titled 'First Inf(e)rænce' and 'Second Inf(e)rænce', emphasising this notion of 'inference' from an archetype that had already been separately realised as a studio production[35]. By contrast, with 'All Is For The Best In The Best Of All Possible Worlds', the explicit aim was to develop a completely new palette of material that we would structure and form into compositions through the process of live performance, thereby cutting the association in live performance to any previous structural reference of that material. The process of making the album was therefore one of continual documentation and aggregation over the course of some eight live performances during July and August 2009, with each performance being recorded. 'All Is For The Best In The Best Of All Possible Worlds' documents the last of these performances in its entirety.

'Sparkly Bear' is a direct descendent of this methodology, but limits the scope to a single composition. Here, as detailed above, the performance material used to compose it was put together before the concerts and the piece was structured directly through improvisation during a live performance. In improvised live performances of this nature, Ollie and I have evolved a division of musical material with which to improvise that can is broadly split between melodic/harmonic material, which has become my central concern and percussive/rhythmic material, which has become Ollie's primary domain. In spite of this, there are numerous instances where these divisions are blurred, notably in the case of more traditional tuned percussion such as piano, prepared piano, vibraphone, glockenspiel etc. but equally in the case of percussion that is tuned through software manipulations and sequencing to exhibit melodic patterns and motifs. Such divisions are also speculative with regard to synthesised sounds an textures, which on the one hand may be both tuned and percussive and on the other may be both harmonic and rhythmic. In addition to this, I am also able to take the output from Ollie's software and use it as an input for my system, meaning this division can further be blurred by fact that I can both process Ollie's output and also trigger and sequence material using an analysis of his output in my system. Therefore, whilst this division of material exists a priori and to a certain extent governs both the design of the software made by each of us (which is markedly different), in practice it is often the case that the liminal exceptions (which to varying degrees confound this schematic and once again put into question the structuring function of sounds) become a large part of the compositional enquiry.

As has been documented in the chapter 'Collaborative Composition', improvised encounters using software benefit from a degree of automated control whereby algorithms are implemented to control various lower level functions of the *bricolage*. Control over these algorithms and the corpus of material being manipulated by them then constitutes the form of a performance in a concrete sense. As noted in my commentary on the piece Ohka, there is a therefore a sense in which recordings of performances of this nature are as much concerned

[35] In the case of these pieces, the majority of the material used as structures for the improvisations derive from the albums 'I Tweet The Birdy Electric' (2004) and 'Carnivalesque' (2005).

with what I have called the 'procedural dance' of the algorithms as with the longer term control of those algorithms by the human performer. In effect, then, the implied goal of these improvised performances, wherein there exists no pre-defined archetype for how this material should be structured or arranged is to a large degree a question of anticipating potentially interesting confluences between the material being manipulated and the algorithmic processes. In the case where much of this control is exercised through parametrisation, one can begin to think of the act of performance as describing a path between different pertinent state spaces.

This is very much the form exhibited by 'Sparkly Bear'. From my perspective, the track takes as its central material two composed sets of variations derived from a source recording of a Fender Rhodes improvisation by myself and electronic musician Oliver Duckert. I composed these sets of variations and manipulations using a standard DAW in the manner of a tape piece. These recordings are manipulated and sequenced in performance by the *bricolage* as one half of the combined performance that makes up 'Sparkly Bear', wherein the piece itself is formed by a series of episodes resulting from the different parametrisations of the *bricolage* with regard to the source material (See figure 6.20)

From my perspective, both 'All Is For The Best In The Best Of All Possible Worlds' and 'Sparkly Bear' consolidate part of the approach hypothesised in 'Ohka', in the sense that both the algorithmic and analytical processes proposed by the *bricolage* itself start to become explicit structural generators of the musical episodes within the piece (as opposed to the sense in which they are orchestrators and catalysts in 'Collaborative Composition'). In this sense, both 'All Is For The Best In The Best Of All Possible Worlds' and 'Sparkly Bear' also constitute explicitly limited explorations of the proposed larger fictional framework intoned by 'Ohka', whereby the deconstructive reading of a corpus of recorded instrumental music through the articulation of the algorithms and processes used as operators in the *bricolage* are bought to bear within the more tractable musical habitat that constitutes our project 'Icarus'.

'Colour Field' from the album 'Fake Fish Distribution' (2012)

The process of transformation engendered by embracing algorithmic processes as a structuring paradigm for improvised performance within 'Icarus' also led us to consider more critically the question of variation within the context of the music we were engaged in producing outside of a live performance context. Here, the opening we have discussed of 'virtual performance', manifested by the 'procedural dance' encountered in 'Ohka', is bought to bear in the context of the more standardised tools of electronic music production as encapsulated by the DAW. This idea; to try and construct a production framework through which we could compose with variation, thereby disrupting the sense in which electronic music composition using a DAW was necessarily a process resulting in a fixed singular product, was the stimulus for embarking in 2011 on the production of 'Fake Fish Distribution', an album in 1,000 variations:

"Our idea of producing an album in 1,000 variations was motivated by the desire to seek a balance between various forces: to produce music in the standard distribution medium - the digitally distributed album - as opposed to producing custom generative software, but with mechanical variation as a key element; to work with code and algorithms as key production elements, but still to compose creatively in time-lines with audio and MIDI and virtual studio elements; to act as creative authors, while handing over part of the production process to an automated system; and to provide a listening experience that is familiar - in that it is repeatable - and that can be experienced as any other album, but can also be perceived as a vast multi-faceted entity with musical qualities that are noticeably the product of a process of automated variation. We chose 1,000 variations in order to take on a quantity of music (1,000 times 45 minutes equals almost exactly 1 months worth of audio) with which we could conceivably engage, but not in any practical way. This quantity of music could be considered out of reach, but only just."
Oliver Bown and Sam Britton, *An Album in 1,000 Variations: Notes on the Composition and Distribution of a Parametric Musical Work*, Leonardo, Vol. 47, No. 5, pp. 437-441.

Thus we set about constructing a modular production system (as opposed to a performance system) that could fulfil these aims[36]. In doing so, we made numerous observations concerning the relationship between the algorithms used to create variation in the material being composed with[37]. Here, I wish to examine one such example (amongst the many used to create the album) which was used to structure the composition 'Colour Field'.

'Colour Field' is perhaps one of the more extreme examples of how far our process strayed away from a path where algorithms are chosen based on research into their ability to produce behaviour that has the potential to conform to recognised musical traits[38].

"What weve been doing in 'Icarus' and further afield, through our work with improvising musicians and soloists, perhaps amounts to our own skewed take on a musical Turing Test, in that if, what we are designing our computers to produce, can be deemed sufficiently musical - not only to us, but the other musicians involved as well - then it must have some merit.

Thats not to say that the work necessarily has any allusion to a musical humanism, but that it exhibits traits that humans nonetheless find interesting in a musical context.

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[36] for a complete description of the system see Appendix E

[37] Again, see Appendix E for a more complete overview.

[38] One such example would be the *Euclidean* algorithm, whose ability to generate "a large family of rhythms used as time-lines (ostinatos), in sub-Saharan African music in particular, and world music in general" is documented in Godfried Toussaint's paper "The Euclidean Algorithm Generates Traditional Musical Rhythms"

> (...)
>
> In this respect, one of the most interesting things about using generative and algorithmic processes in musical composition is how you end up contextualising them. What's curious is that quite often in our musical contexts, the idea that the more rigorously researched and well-implemented processes yield more musical results, is often a fallacy.
>
> Weve often found that cruder processes; those that play on context, forcing musical situations and allusions, that you could never have conceived of when programming them at the outset, are incredibly valuable." Interview with the author by Marsha Vdovin, published on www.cycling74.com

Thus, we acknowledged the role of *framing* in such an exercise, whereby the expectations of the listener and indeed the composer are mediated by the sense in which the musical output seeks, on the one hand, to simulate a recognised model, or on the other hand create a divergence into an unknown relationship between musical elements. In saying this, it is essential to acknowledge the role of musical 'aesthetics' in such matters, whereby different formal expectations are implied given that a piece assumes the conventions of an established musical style. Here we should also acknowledge that 'Icarus' as a musical project has its roots in the dance music culture of the 1990s and as such there persists, at its core, a formal sensibility derived from that musical language.

In the context of the many different approaches taken on the album, 'Colour Field' epitomises the sense in which a disjunct between the musical sensibility of the material at hand and the algorithm used to structure that material foregrounds the idiosyncrasies of the algorithm through the sense in which it produces 'inappropriate' results given the logic of the musical material it is structuring. In 'Colour Field' the compositional logic of the elements that structure the work would appear to be that of a gradual crescendo, with various percussive elements being progressively layered in various different configurations while an ensemble of mallet instruments appears to build a harmonic progression to compliment it. Thus, on the face of it, what might be described as a kind of 'vernacular' dance music structure is presented, only for its potentially familiar logic to be serially confounded by the algorithm used to structure the progression of the piece, wherein the timing of each change in elements becomes the basis for a deconstruction of this assumed model. The compositional detail of such an approach therefore rests in the way in which such assumptions are interrogated and pulled apart. Here, 'Colour Field' plays on comparisons of dance music as a kind of economical musical practice that somehow echo's the concerns of minimalism:

> "... electronic dance music particularly foregrounds the strategies pioneered in the work of so-called Minimalist composers like Steve Reich and Philip Glass. Indeed, while it's possible to say that most electronic dance music would be impossible without an emphasis on

repetition, beat-oriented electronic music's most avant-garde productions explore the very nature of repetition itself, carrying on the mantle of classical Minimalism as a movement delving deep into the heart of form" Philip Sherburne, *Digital Discipline: Minimalism in House and Techno*, Audio Culture: Readings In Modern Music, 2004.

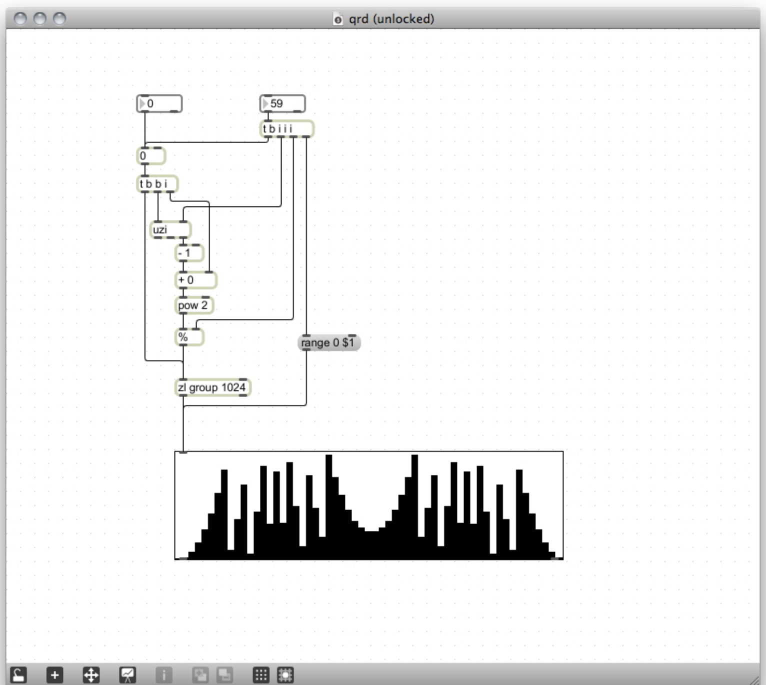

Figure 6.20: Implementation of a quadratic residue algorithm in MaxMSP, used for the creation of timing variables for a step sequencer in the composition 'Colour Field'.

The sporadic ebbs and flows of the progressions in 'Colour Field' combined with the resolutely intractable intonations of a harmonic progression, both articulated by a looping framework that is traversed by time steps calculated via a quadratic residue algorithm explodes this sense of minimalist intent into a magma of phased progressions that push the formal concerns of the work to a almost Schoenbergian sensibility whose focus nevertheless remains on the specific characteristics of a simple algorithmically generated number sequence. In this sense, my compositional intent with 'Colour Field' was to interrogate this disjunction between algorithm and musical framing and furthermore to articulate the sense in which the way in which these elements might not cooperate as a legitimate subject musical exploration.

My work with Oliver Bown personifies the sense in which digital audio as both the primary input (as source material for compositions) and primary output (as finished works) creates an open field of articulation, whose homogeneity by definition begins to not only question the tradition of musical distinctions and structure inherited from instrumental music, but also the non-performative ontology of tape music. Within this work, there is a clear sense that digital audio combined with the computer as an algorithmic agent for its analysis, categorisation, transformation and ordering both confounds such distinctions at the same time as proposing new territories for artistic exploration in the composition and production of music.

6.4 Contingently Autonomous Composition

The possibility of computer agents acting autonomously in a musical setting is currently the subject of much research discourse[39]. My attention was first drawn to the subject through the 'Live Algorithms for Music' network, formed in 2004 by Tim Blackwell and Michael Young[40]. In this forum, I contributed through performances using the *bricolage* described here (which was then in its infancy) on several occasions: In December 2006 I improvised with the *bricolage* in collaboration with Evan Parker and also presented an experimental collaboration with Diemo Schwartz; 'Rien de Tout'. In August 2009 I created a prototypical autonomous system that improvised with Eddie Prevost and Finn Peters and in 2014, as part of the Musical Metacreation event[41], I presented an experimental autonomous system entitled 'Anything In Any Order By Anything At Any Time For Any Reason'.

In addition to the above, in 2010, Oliver Bown, Tom Arthurs and Lothar Ohlmeier and I were commissioned to present a suite of autonomous compositions for the North Sea Jazz Festival entitled 'Long Division'[42].

The motivation for engaging with the possibilities of autonomous performance scenarios in part stems from a logical expansion of the methods of control for the *bricolage*; the more complex the system, the more intractable it becomes to individually control each parameter, a problem which is potentially solved by a higher degree of automation. This embracing of automation leads to the

[39]As documented by the wealth of papers and recordings emanating from the Musical Metacreation network: musicalmetacreation.org

[40]An report summarising the activities and objectives of the Live Algorithms for Music Network may be found on the Goldsmiths website: 'Live Algorithms for Music research network - Final Report March 2007 '

[41]The Musical Metacreation concert event was recorded by Cafe OTO, and received funding from the Design Lab at the University of Sydney. It was further supported by NIME 2014 (Goldsmiths) as a satellite event, which fed into a musical metacreation workshop presented at NIME 2014. The pieces presented were published in Computer Music Journals 2014 Sound and Video Anthology, entitled 'Distributed Composition and Musical Metacreation', compiled by Doug Van Nort.

[42]The suite of compositions was subsequently performed in Berlin in 2011 and recordings from both events were combined and published as 'Long Division' in 2012 on Not Applicable Recordings.

question of what the rules are that should govern it. Here, we engage with a paradoxical problem, in that the right type of automation might reasonably be said to be that which 'sounds good', however the subjectivity of what 'sounds good' makes the formulation of concrete rules about desirable versus undesirable automation virtually impossible. This is something that is hinted at in the programme notes written for 'Long Division':

> "Programming computers with dynamic behaviours that respond to sound invites us to engage with the emergent qualities of cause and effect that take us from one split-second frame of experience to the next. Our crude agents are not virtual musicians, but they are still participants. We have no precise goal, no blueprint, for the machines we have built; they do what we tell them and we try to tell them to do things on their own, without us knowing exactly what it is they should really be doing. In trying to capture it, we embrace the deceit; the meaning of autonomy slips between our fingers and all we can do is try to catch a glimpse of it in a certain light." Sam Britton, Oliver Bown and Tom Arthurs, *Long Division*, Sleeve Notes, 2011.

This sense of not having a blueprint or indeed a manifesto other than to 'make sonic events' affirms a sense in which this is not a scientific endeavour, but rather draws on scientific and engineering knowledge and puts it to use with an ad-hoc methodology to find workable solutions to controlling complex systems in particular scenarios and contexts.

> "In some sense, what our computational systems generate is our music, and as artists were entitled and obliged to judge it by ourselves. But in another sense, we find the music is not ours, its the result of an experiment. Perhaps we find it musically lacking in some way, but it represents an intermediate result. Perhaps we find it musically interesting and engaging, but still embryonic.
>
> Papers in which authors conclude that they liked the music generated by their system drive scientists crazy. But I think we have to come to terms with the fact that, in a fundamental way, music meta-creation is (mostly) not a scientific field. A conclusion of I like it is vacuous in itself, but it doesnt follow that a paper concluding thus is vacuous. This area of research may be invested with irreducible subjectivity, but its still a technical field, in which mathematical, algorithmic, conceptual, and formal design advances and innovations may take place. And therefore it is this level, our process level, at which our discourse is valuable." Musical Meta-Creation: The Discourse of Process, Andie Sigler, Papers from the 2013 AIIDE Workshop.

Here, Andie Sigler voices what could be described as a kind of pragmatic acceptance of the notion that the field of Musical Metacreation is in essence barely scientific. Her conclusion is that the legitimate focus of Musical Metacreation is in underscoring a process driven analysis of how the various systems are in fact *not* autonomous[43] asserts the role of analysis both from the point of view of technics (the nuts and bolts of why something happened) but also from the point of view of theory (the why these various structures were bought together in the first place). Whilst it is uncontroversial to acknowledge that even in the most complex of systems, technical analysis is almost certainly assured, on the other hand the role of theory, wherein an understanding of what contributed to the outcome in a broader sense remains not only problematic but, outside of specific incredibly constrained environments, practically unachievable. Here, we return to the NP-complete problem, wherein the more factors that we acknowledge might have contributed to a 'synergy' in a combined performance between an instrumentalist and an autonomous system, the less likely we are to be able to compute the variables that manifested it. We are left with the dichotomy of either trying to construct laboratory conditions for the testing of such systems, whereby strict rules of engagement and evaluation effectively turn proceedings into a type of game-play, or alternatively acknowledging this ocean of possible interactions and attempting a different type of architecture that embraces this complexity. It is the second of these alternatives that concerns me here and one I would also identify as part of the central concern of my approach to building autonomous agents for composition; that such systems are best considered in the absence of concepts of musical legitimacy that might seek to unnecessarily restrict chains of signification set in play by these encounters. Moreover, the potentially disjunctive, de-structuring sense in which such digital systems can act, unconfined by questions of musical legitimacy or otherwise is seen as one of their great virtues, whereby the act of designing and putting such a system into practice constitutes in its own specific way an affirmation of the deconstructive possibilities of digital audio in a larger framework of musical actions.

6.4.1 'Arthurs/Ohlmeier/Khroustaliov' from the album 'Long Division' (2011)

'Long Division' represents my most critical and sustained interrogation into the possibilities for autonomous performance and as such is the only work relating to autonomous performance discussed here (other works either being prototypes of the *bricolage* implemented here or subsequent variations on it). 'Long Division' encapsulates the quest to both automate the long term/episodic organisation of musical material as prototyped through the automated prompter designed for 'Axiom' whilst at the same time harnessing the generative possibilities of the concatenative digital system developed in the context of 'Collaborative Composition' and 'Multiply-Directed Composition'. For 'Long Division', a series of reactive states for the *bricolage* were composed (both in the sense of selecting and creating new source material for the corpus and in terms of parameterising the *bricolage* itself) which were then trialled and refined with Lothar Ohlmeier

[43] "Computer programs are not currently capable of truly autonomous behaviour. All decisions are made deterministically or randomly (within constraints). So let us ask of a system, 'what are all of the ways in which it is not au- tonomous?' "

and Tom Arthurs (both as individual episodes and as sequences). The automatic prompter designed for ‘Axiom’ was then adapted to sequence these states in response to the unfolding of the improvisations live.

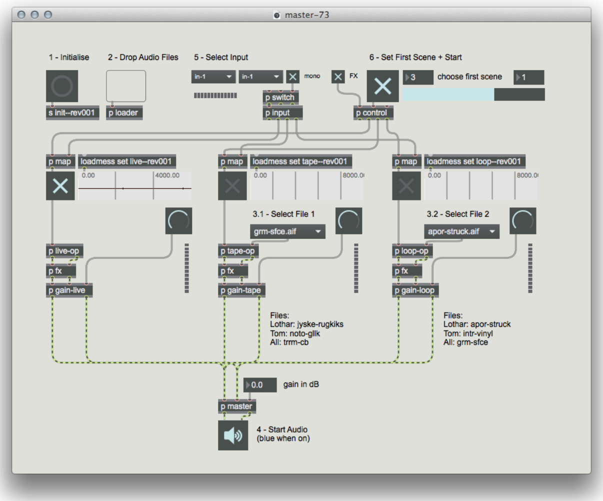

Figure 6.21: The master patch for ‘Long Division’ as realised in MaxMSP. At the top right of the patch a modified version of the ‘Axiom’ prompter can be seen. The prompter directs the three sequencing engines. Parameters in the sequencing engines and modulators are in turn controlled through buffered audio analysis mappings.

The entire suite of ‘Long Division’ received a total of three performances[44], with this recording documenting the final piece in the suite as played at NK in Berlin. The suite itself forms a kind of palindrome with the opening and closing improvisations mirroring each other in that they are both trio improvisations between the *bricolage*, Tom Arthurs and Lothar Ohlmeier[45].

Whilst analysis diagrams of one of the trio pieces from ‘Long Division’ can be found in Appendix C, in lieu of providing my own written analysis of this work as I have done previously, I would like to instead discuss this recording from the suite in light of two reviews which singles it out with relation to the rest of the suite:

> “The balance between the two live musicians and the computer generated sounds constantly shifts, at times bringing out the organic interactions between Arthurs and Ohlmeier, at others leaning heavily on the side of the machines, but it is when all these elements are combined fairly equally that things appear to take on a different dimension altogether. This is perhaps best demonstrated

[44]At The North Sea Jazz Festival, Rotterdam (July 2010), NK, Berlin (August 2010) and Kings Place, London (January 2012).
[45]See Appendix F for more details of the recording

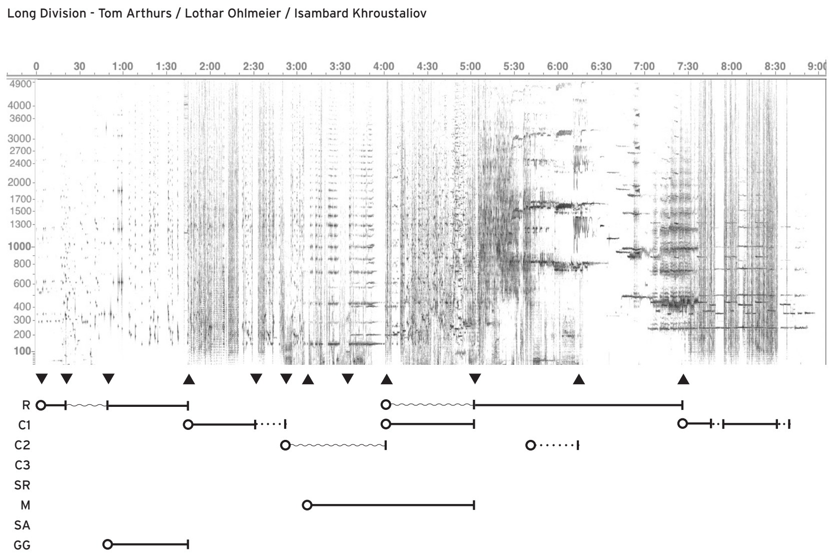

Figure 6.22: Analysis diagram of 'Ohlmeier/Arthurs/Khroustaliov' from the suite 'Long Division', see Appendix C for a key and full size reproduction.

> in the closing piece, its first half especially, Arthurs and Ohlmeier combining forces to fight off relentless assaults of glitches and noise distortion. Before that, (...) the album's opening piece is resolutely geared towards textures and noises, which take on various forms here, some extremely electronic and distorted, some sourced from the instruments, but Arthurs and Ohlmeier steer clear of any remotely musical components to instead work from silent blows and breathings as they attempt to emulate the fragmented patterns generated by Brittons software." As reviewed by themilkfactory.co.uk, 19th January 2012.
>
> "What sound like distorted field recordings become an otherworldly imitation of an organic environment, while Arthurs and Ohlmeier evoke strangled, glottal spasms from their instruments. This is where, to me, the beauty lies in this set of recordings when preconceived ideas of what roles certain instruments should play are challenged to the extent that youre not even sure what instrument is what. It feels as though they are revealing in the lack of limitations improvisation presents to them as a musician." As reviewed by thefourohfive.com, 25th January 2012.

Both reviews draw our attention to the fact that the *bricolage* and instrumentalists navigate a path that is as full of aspects of symbiosis (moments where instruments and electronics mesh together) as it is of disjunction (moments of juxtaposition and adversariality), and that the breadth of these swings creates enormous challenges for the instrumentalists and listener alike, challenges that, with a sincerity of engagement, nevertheless reward in equal measure.

In turn, this highlights for me the value of the approach I took to designing the autonomous electronic agent for 'Long Division', as being an experiment not in simulation, but in what I would term 'extended synthesis'. Here, I proffer the term 'extended synthesis' as a way of addressing the sense in which the *bricolage* focuses on extracting the most from an economy of means; stochastic processes which are framed and contextualised by audio analysis. In this respect 'extended synthesis' seeks to acknowledge both the history of pioneers of the techniques of electric and electronic music[46], who have deployed such techniques in the service of expanding the horizons of music. 'Extended synthesis' also acknowledges my desire to frame such experiments for their potential to subvert and derail preconceptions about what might or might not be considered musical.

[46]For an incomplete but expansive list see: 'History of Electronic/Electro-acoustic Music (1937-2001)' from www.ubu.com

Chapter 7

Final Remarks

It has been my intention through the work presented in this thesis to explore the implications of digital audio on the creation and production of music, wherein the logic of digital audio as an information technology (that necessitates an engagement with computational processes at a fundamental level) is explored through the possibilities it affords for the deconstruction and reformulation of musical composition and performance.

In identifying what I have found to be both theoretically pertinent and functionally useful ways of investigating the implications and possibilities of digital audio (and its associated technologies for music production, in particular the FFT) in the form of *hypertextuality*, I hope that the discussion presented here articulates a sense in which digital technologies are perhaps most useful in their ability to offer us a new viewpoint on the familiar, allowing users to not only question received knowledge and the structures they derive from but also articulate and construct new realities using digital tools that explore this emerging digital ontology.

As I have sought to demonstrate through the construction and use of the *bricolage*, my contention is that the prospect of *hypertextuality* as a potential articulation manifested through the affordances of digital audio for music offers music creators, technologists and theorists a method through which specific types of articulations associated with the techniques of audio analysis can be effectively put to use in the production of music. Moreover, and perhaps more importantly, *hypertextuality's* instantiation of deconstruction as a technical act, whereby the interrogation of the 'galaxy of signifiers' proposed by computer analysis and categorisation of digital audio and their articulation via the process of algorithmic composition and control allows for the formulation of what Derrida calls 'undecidables' in a musical setting; propositions that confound elemental binary oppositions.

> "I have called undecidables, that is, unities of simulacrum, "false" verbal properties (nominal or semantic) that can no longer be included within philosophical (binary) opposition, but which, how-

> ever, inhabit philosophical oppositions, resisting and disorganising it, without ever constituting a third term, without ever leaving room for a solution in the form of speculative dialectics." Jacques Derrida, Interview with Jean-Louis Houdebine and Guy Scarpetta published in *Positions*, Continuum, 1972.

It has been my intention to demonstrate through the music of this thesis that what I have described as a *hypertextual* system for creating ad hoc networks and articulations between sounds in digital audio corpora, when used in the context of composition or performance to form a linear narrative, presents one possible structure amongst many, *without* dispelling the possibility of others in the mind of the listener. This is the result of a system whose choice is not catalysed by aesthetics or a language of interaction but by technics and as such the articulations it presents, while explicable technically, always remain speculative aesthetically, or to put it another way; their 'what if' is never exhausted[1].

> "once the limits (...) can no longer be controlled or fixed by (...) simple opposition (...) *another* approach to differences must structure ("conceptually" and "really") the field that has thus been reopened. Far from effacing differences and analytic determination, this other logic calls for other concepts. One may hope it will allow for a more refined and more rigorous restructuration. It alone in any case can call for this constant restructuration, as elsewhere for the very progress of the critique." Jacques Derrida, *Specters of Marx*, Routledge, 1993.

Thus, in this research, I have attempted to use the *bricolage* not only as a system/tool/instrument through which to explore a non-linear topology constituted by a corpus of digital audio, but also, through collaborations with instrumental musicians, as a way of interrogating and 'hacking' the possible interactions and relationships that constitute a musical narrative. The *hypertextuality* presented by the *bricolage* is made navigable for an instrumentalist through machine listening and whilst this interactivity contributes to their performance decisions, as an actor, the system remains relatively musically inert; a manifestation of its mechanics but not of a theorised and applied musical language of interaction as is the case with an expert system. As I believe the work presented here in both 'Collaborative Composition' and 'Contingently Autonomous Composition' attests, the *bricolage* attempts to amplify the ad hoc nature of instrumental improvisation not by trying to mimic human interactions and musical structures, but, by turning to the principle affordances of digital audio, in the form of non-linearity and audio analysis, and presenting their functioning and mechanics as viable dimensions for the structuring of musical narratives.

As Derrida implies above, that we as music practitioners and creators must seek and call for the continuous restructuring of music is incontrovertible and

[1] We have demonstrated in the music of this thesis the possible expansion of one linear narrative to 1000 and that in theory there is no need to stop there.

a priori instantiates the many dialectics variously articulated by the history of music. It is in this light that we must frame the role of digital technologies such as digital audio, machine listening and computation, such that their capacities are the subject of critical discourse in the domain of music creation. In doing so it is also important to acknowledge the role the *artist-programmer* will have to play in such a discourse, in that navigating this emerging digital ontology of music will necessitate a functional understanding of both the domain of music as a written and performance tradition and its possible articulation through code and computation.

> "We share the infosphere with digital technologies. These are ordinary artefacts that outperform us in ever more tasks, despite being no cleverer than a toaster. Their abilities are humbling and make us re-evaluate human exceptionality and our special role in the Universe, which remains unique. We thought we were smart because we could play chess. Now a phone plays better than a Grandmaster. (...) The success of our technologies depends largely on the fact that, (...) we increasingly enveloped the world in so many devices, sensors, applications and data that it became an IT-friendly environment, where technologies can replace us without having any understanding, mental states, intentions, interpretations, emotional states, semantic skills, consciousness, self-awareness or flexible intelligence. Memory (as in algorithms and immense datasets) outperforms intelligence when landing an aircraft, finding the fastest route from home to the office, or discovering the best price for your next fridge." Luciano Floridi, *Should we be afraid of AI?*, Aeon (2016).

As Floridi points out, the creation of machines that can act in the domain of human culture is not conditional on their attainment with relation to logocentric definitions of intelligence and music is no exception. Moreover, such functional technologies are beginning to effectively restructure our cultural sphere irrespective of our ability to fully comprehend their implications, despite these being vast and far reaching[2]. To acknowledge this is to acknowledge the need not only for critical discourse that seeks an ontological understanding of the role of these technologies for music but equally a music practice that foregrounds the mechanics of such systems as potential tools for musical creation without being inhibited by received definitions of musicality.

Composers and music creators of the 20th century sought precisely such a dialogue with the emerging technology of analogue sound recording and in doing so they created an inspired legacy, a legacy which has in turn helped foster the music of this thesis. Moreover, this climate of experimentation and investigation into the sonic and structural possibilities afforded by such technologies fed back into concert music and other instrumental music practices throughout

[2] As discussion in this thesis and as referenced herein via Eisenberg's *The recording angel: Explorations in phonography*, Roads' *Microsound*, Kramer's *The Time Of Music* and Floridi's *Philosophy and computing: An introduction* amongst others would attest.

this period, creating a multiplicity of new musical forms and practices. As John Cage noted in 1992:

> "We live in a time I think not of mainstream, but of many streams, or even, if you insist upon a river of time, that we have come to a delta, maybe even beyond delta to an ocean which is going back to the skies. John Cage, KPFA radio interview, 1992.

The legacy of this restless optimism and intrepid sense of exploration, combined with the possibilities digital audio proposes for music creators, scientists and researchers in the 21st century, encourages us to consider the open question as to what contemporary structures and processes might exert as bold an influence on what may come to be called music. It is my contention that the combination of machine listening and algorithmic and generative computational processes, whose ubiquity grows by the day with the proliferation of information and communications technologies and whose possibilities for music creation is the central concern of the music of this thesis, have precisely this potentiality.

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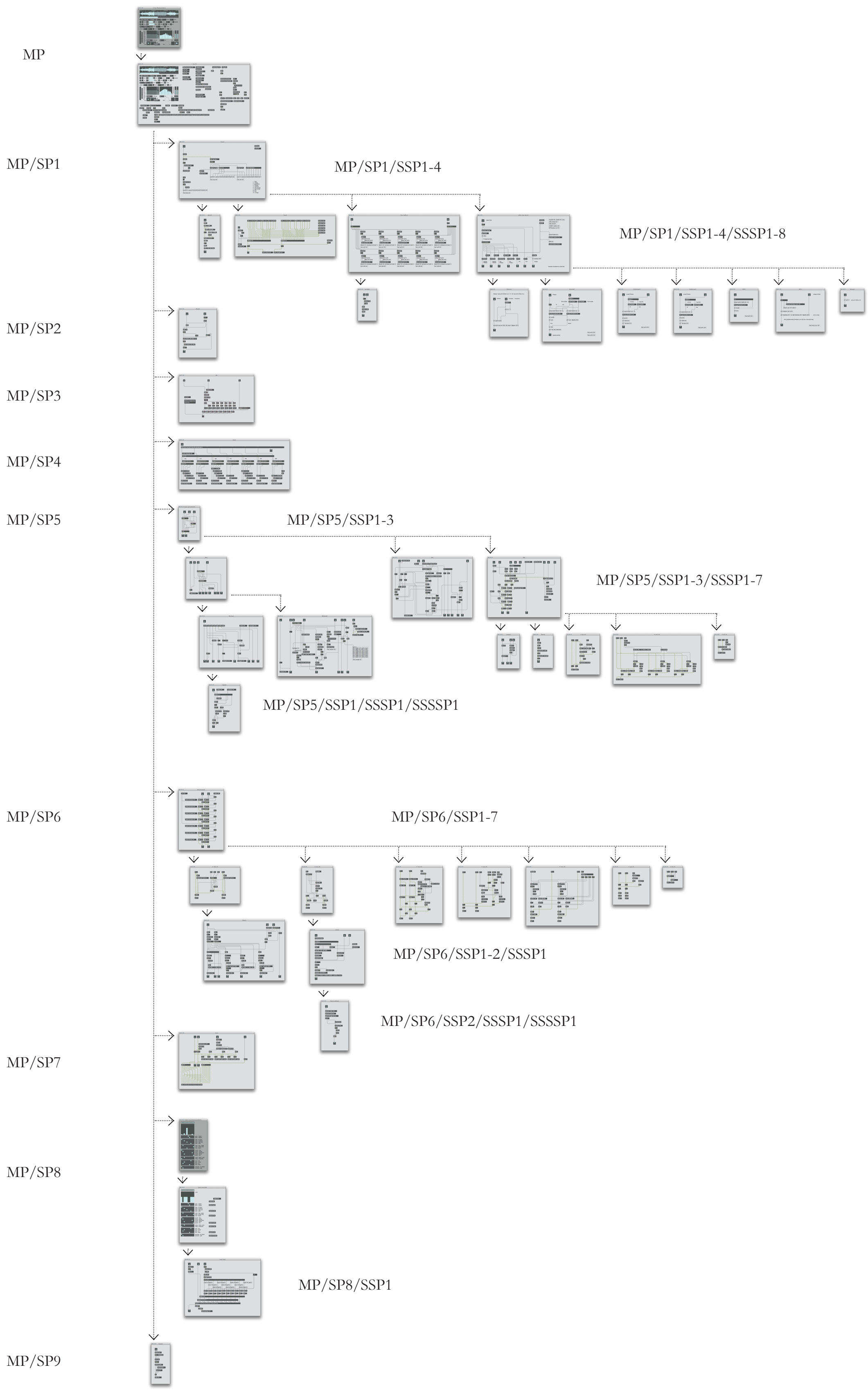
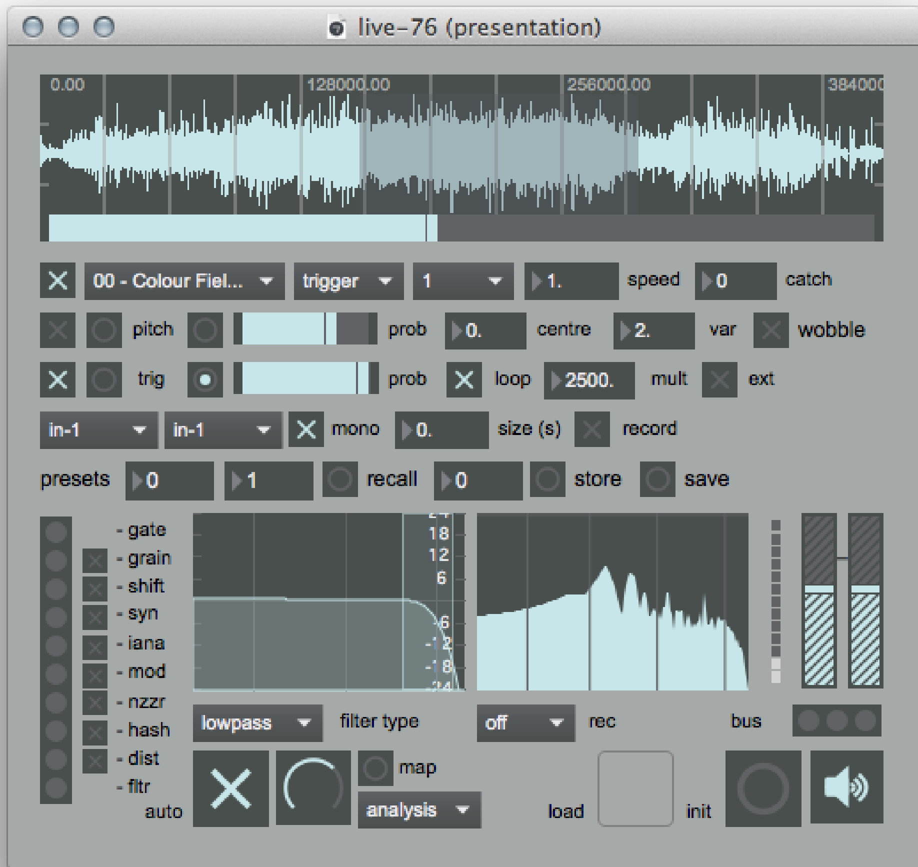
Appendix A

Bricolage Schematic

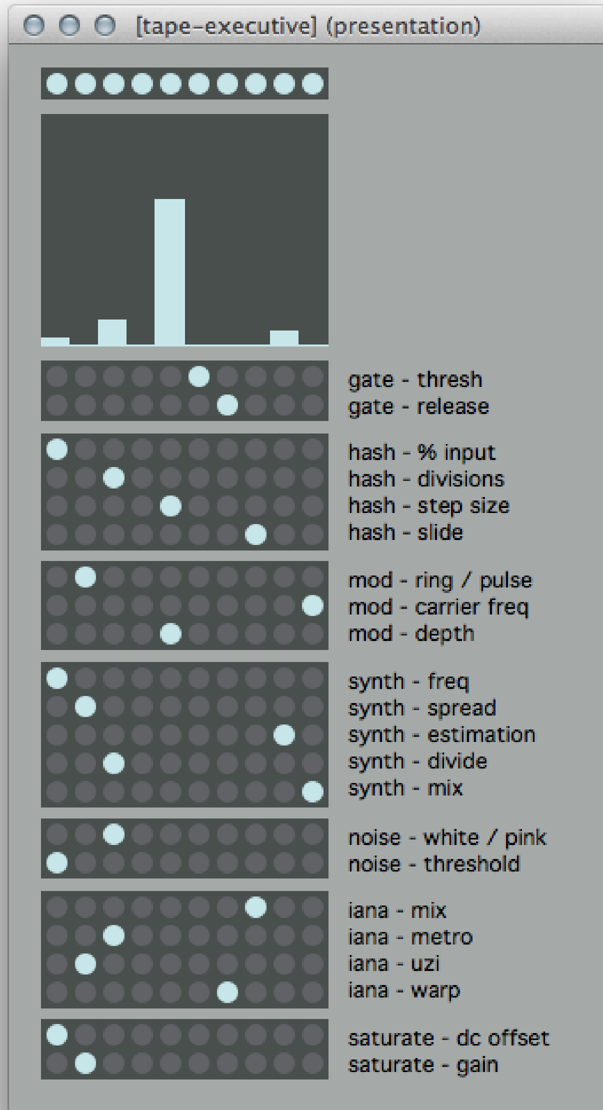
Hierarchical Structure of the System



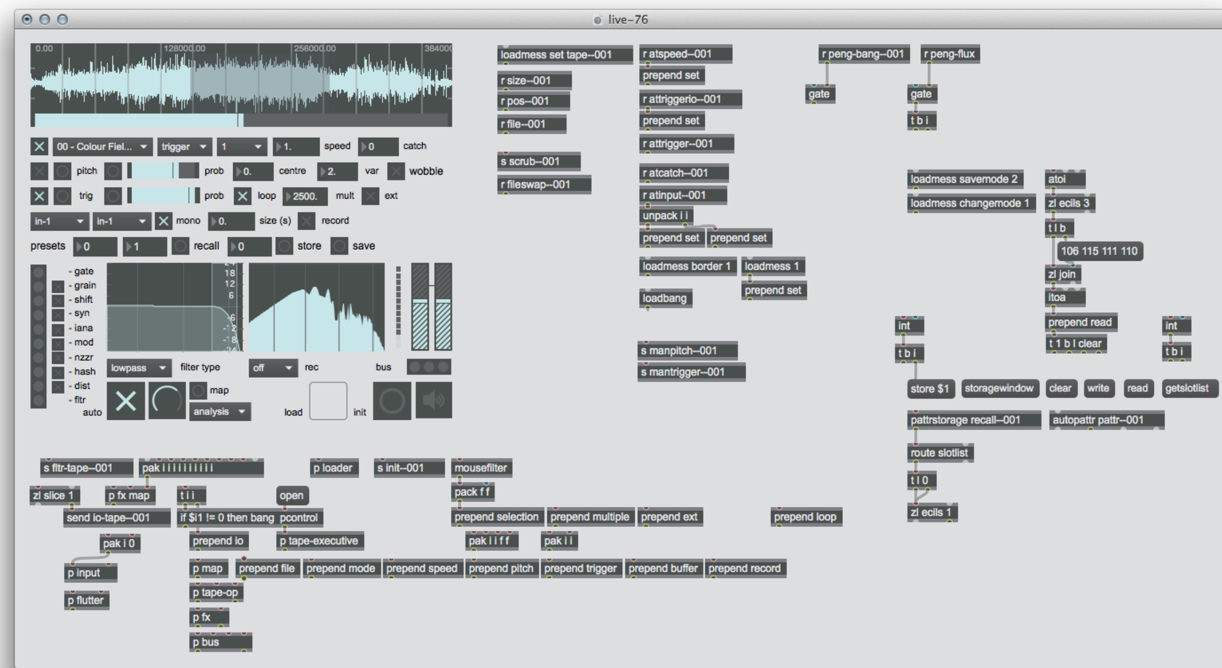
Individual Patch Schematics



MP (Master Patcher) GUI



MP/SP8 (Tape Executive) GUI



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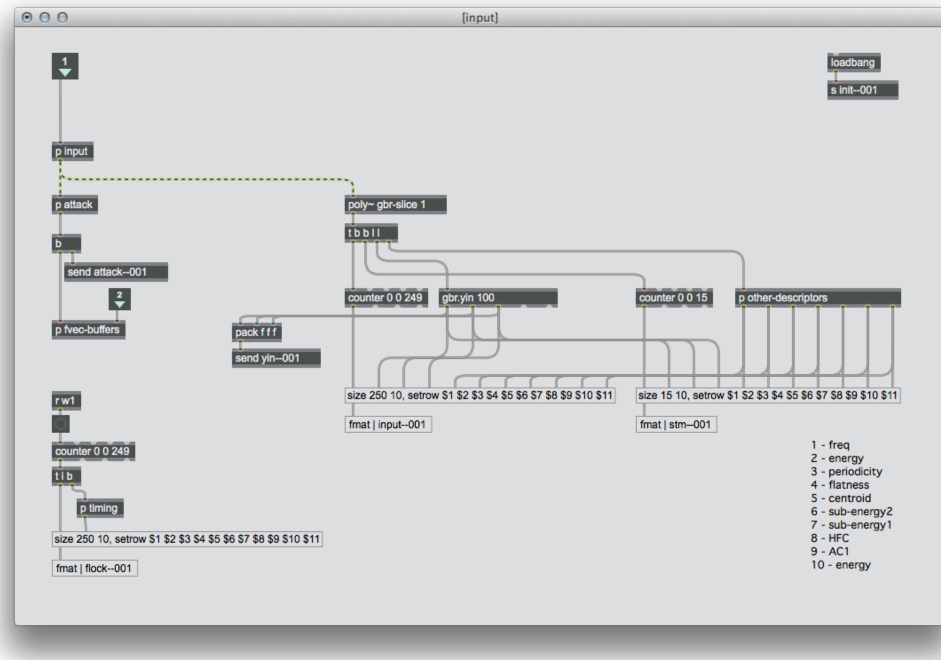
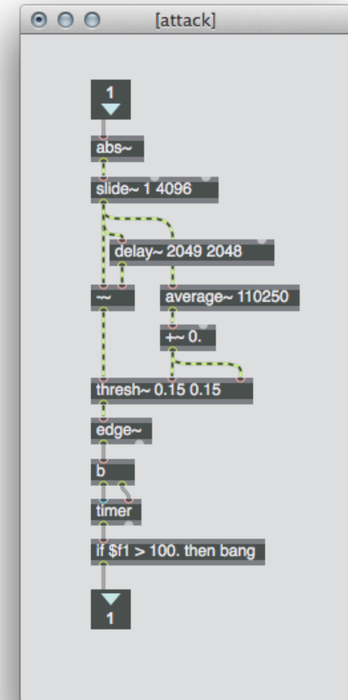
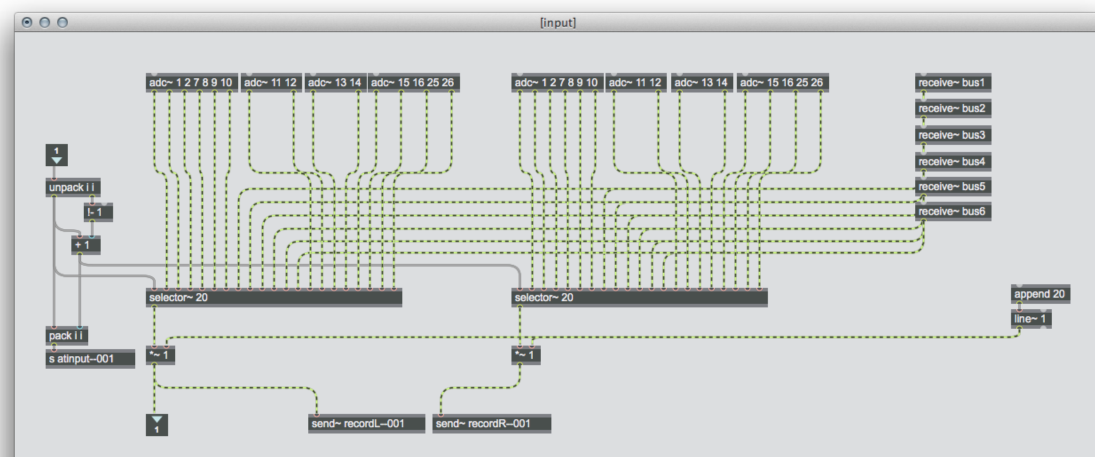

[input]
loadbang
s init--001
p input
p attack
poly~ gbr-slice 1
t b b l l
b
send attack--001
counter 0 0 249
gbr.yin 100
counter 0 0 15
p other-descriptors
p fvec-buffers
pack f f f
send yin--001
size 250 10, setrow $1 $2 $3 $4 $5 $6 $7 $8 $9 $10 $11
size 15 10, setrow $1 $2 $3 $4 $5 $6 $7 $8 $9 $10 $11
fmat | input--001
fmat | stm--001
r w1
counter 0 0 249
t i b
p timing
size 250 10, setrow $1 $2 $3 $4 $5 $6 $7 $8 $9 $10 $11
fmat | flock--001
1 - freq
2 - energy
3 - periodicity
4 - flatness
5 - centroid
6 - sub-energy2
7 - sub-energy1
8 - HFC
9 - AC1
10 - energy

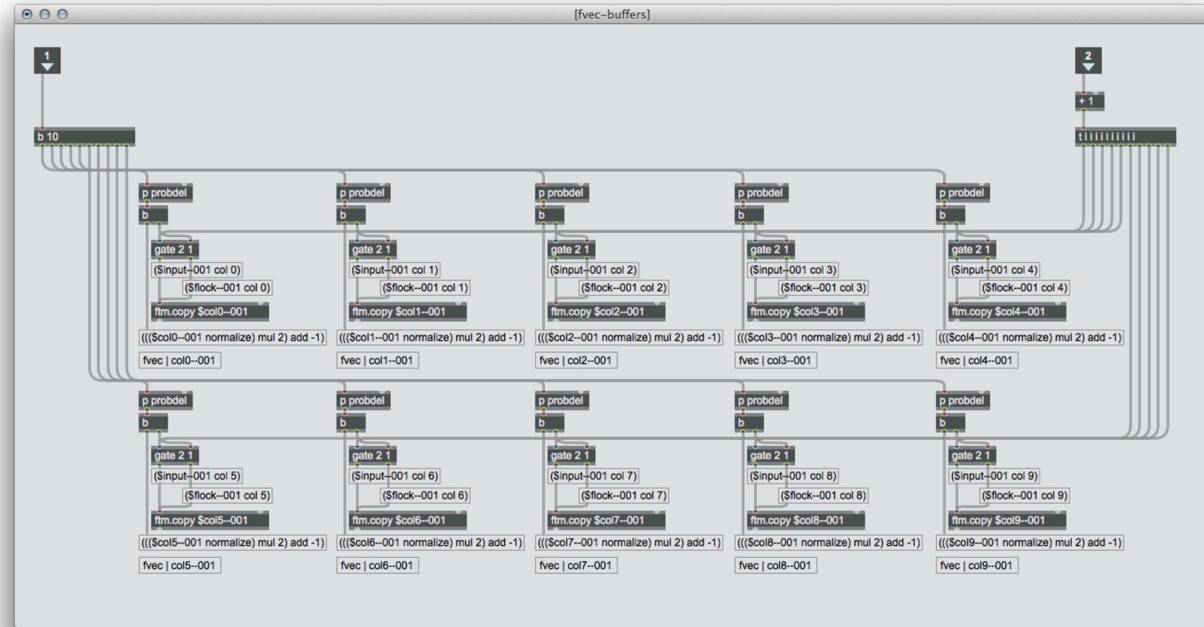
MP/SP1 (Input)



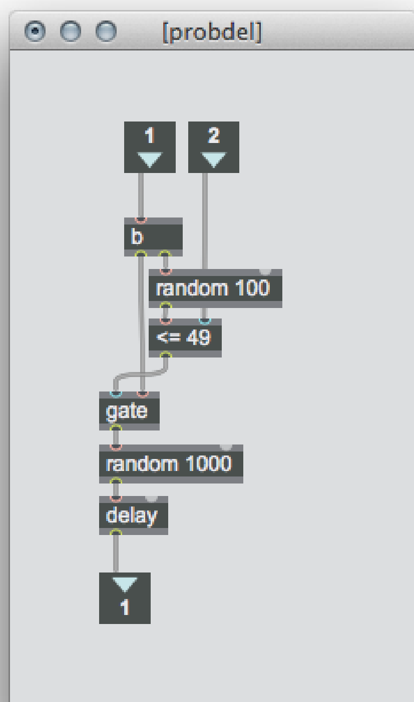
MP/SP1/SSP1 (Attack)



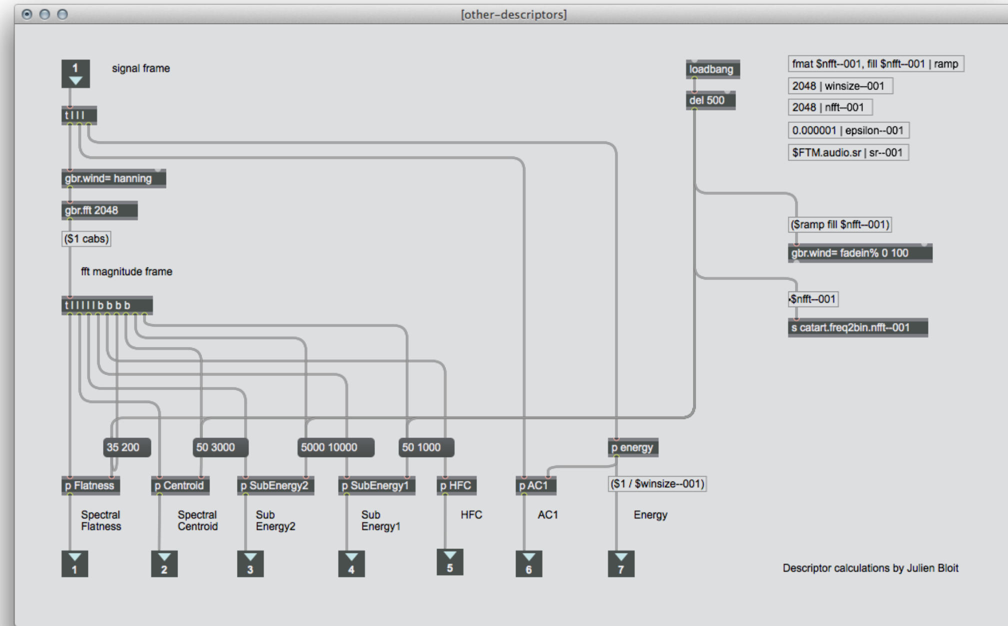
MP/SP1/SSP2 (Input)



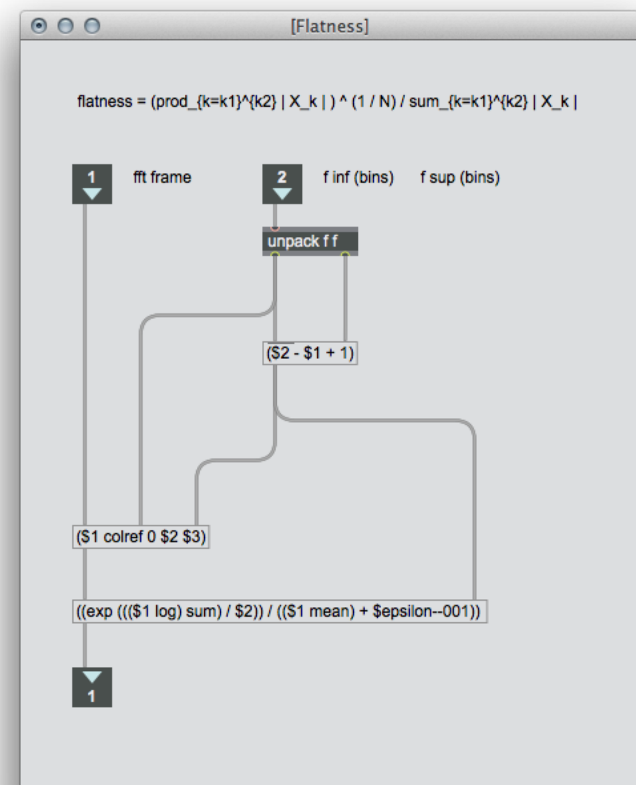
MP/SP1/SSP3 (FVEC Buffers)



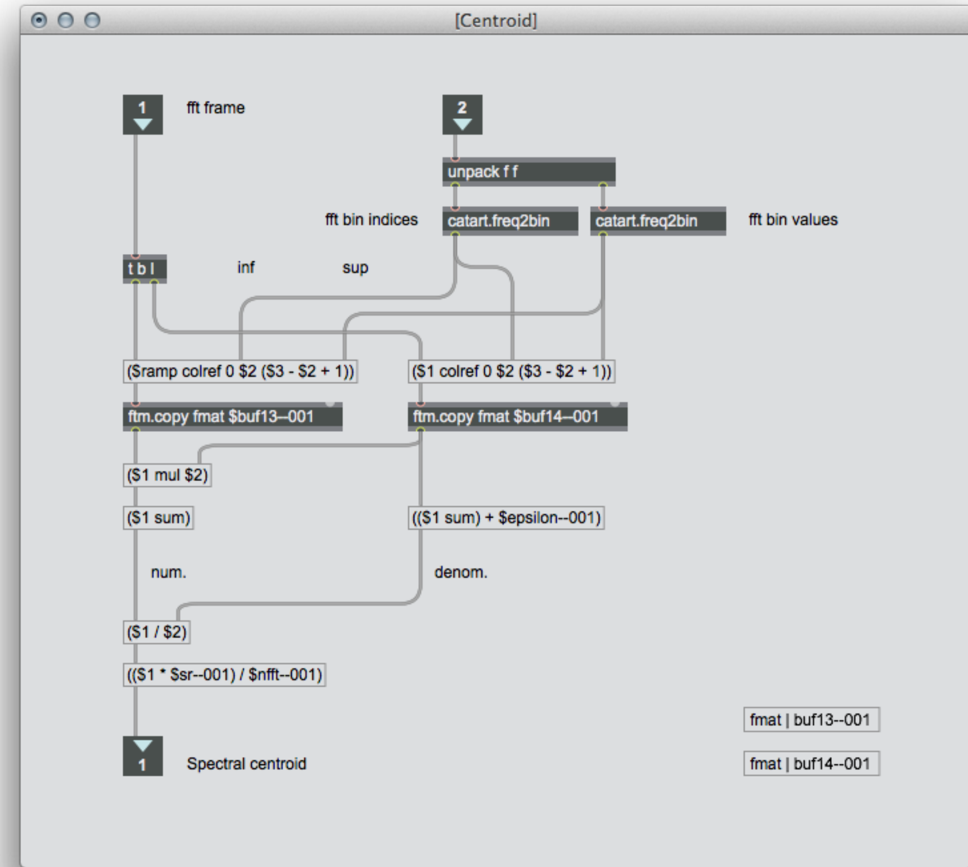
MP/SP1/SSP3/SSSP1 (Probdel)



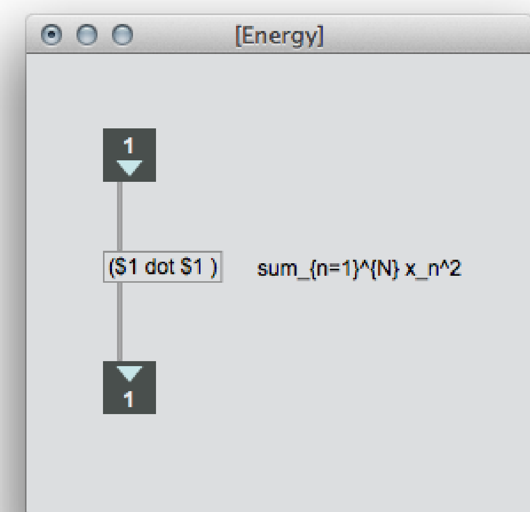
MP/SP1/SSP4 (Other Descriptors)



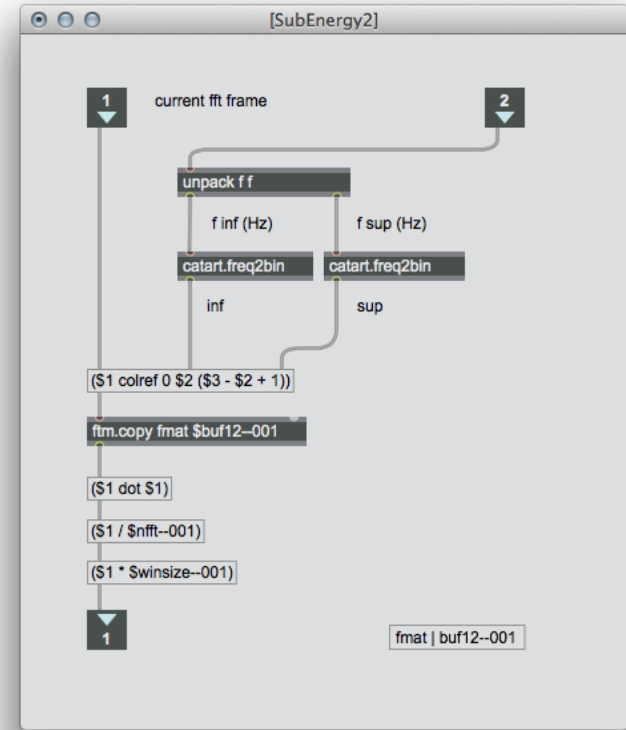
MP/SP1/SSP4/SSSP2 (Flatness)



MP/SP1/SSP4/SSSP3 (Centroid)



MP/SP1/SSP4/SSSP8 (Energy)



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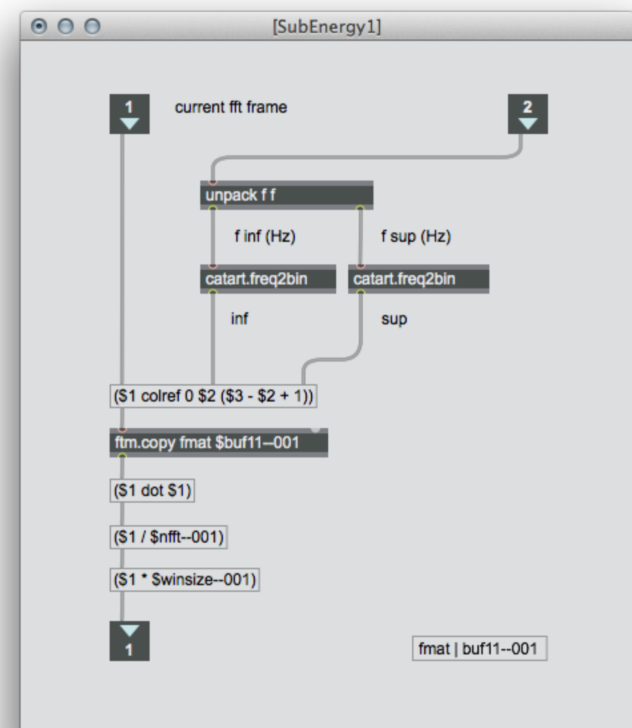

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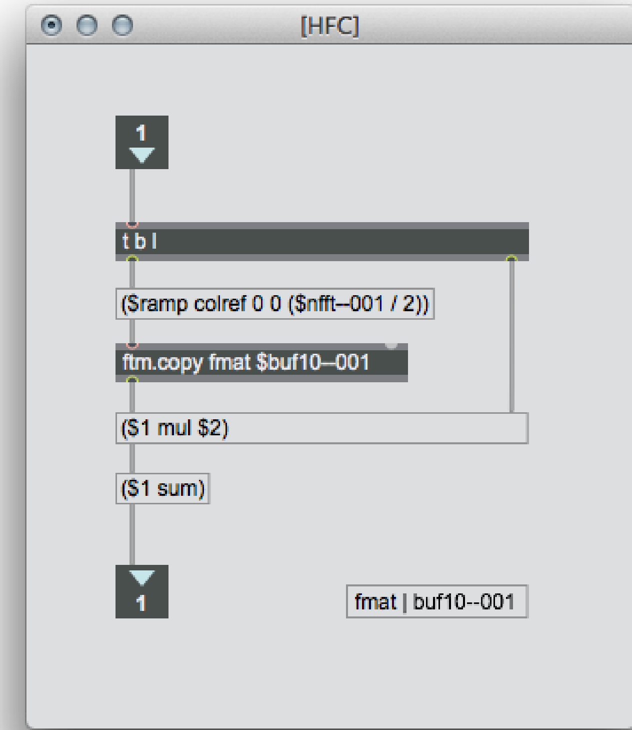
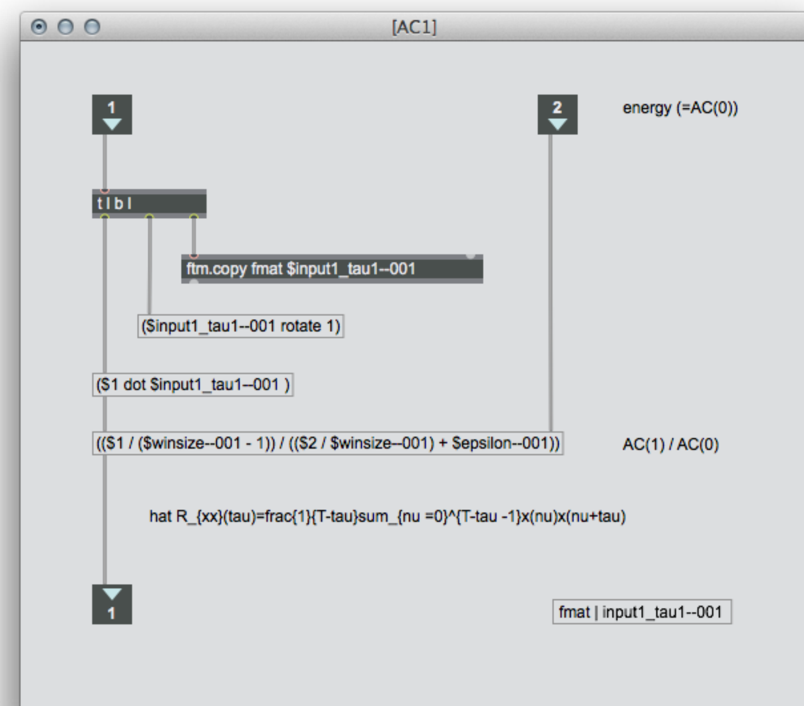
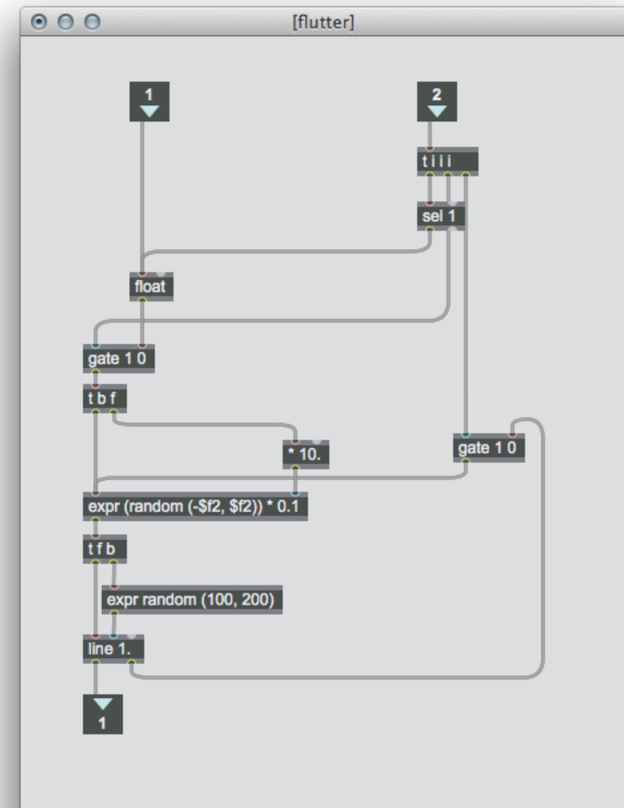


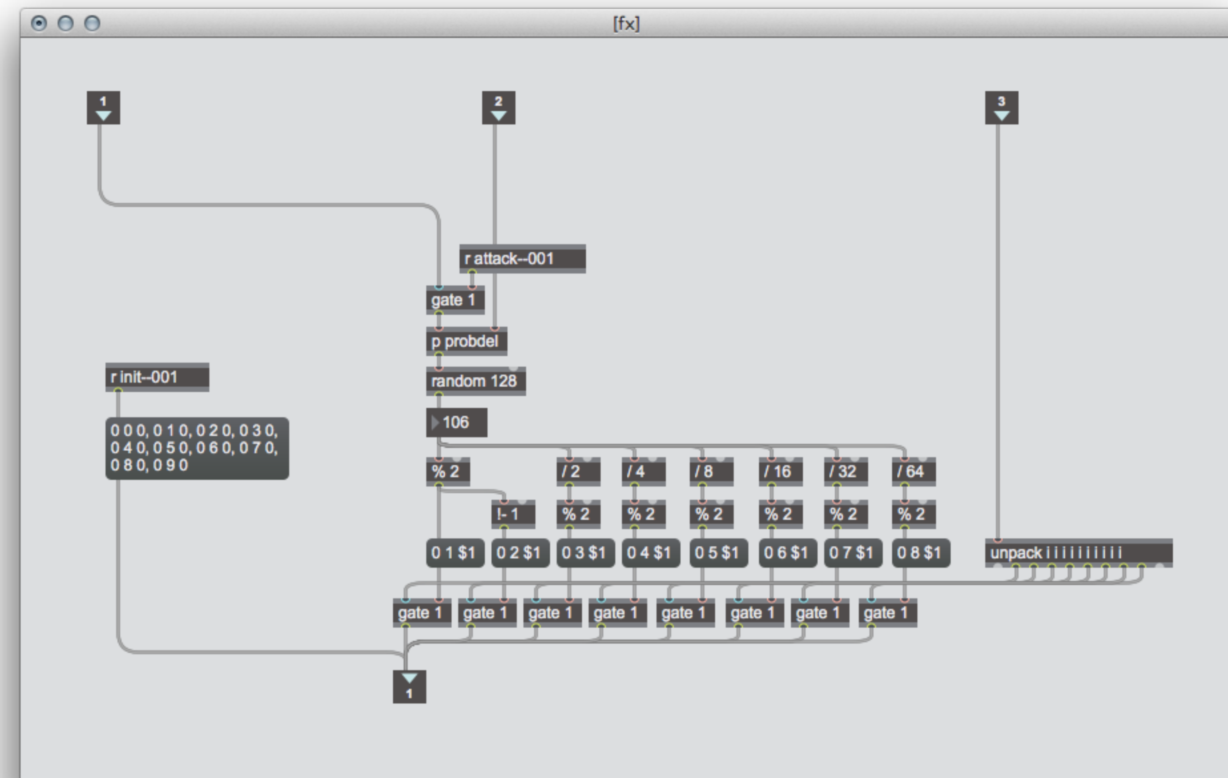
MP/SP1/SSP4/SSSP6 (HFC)



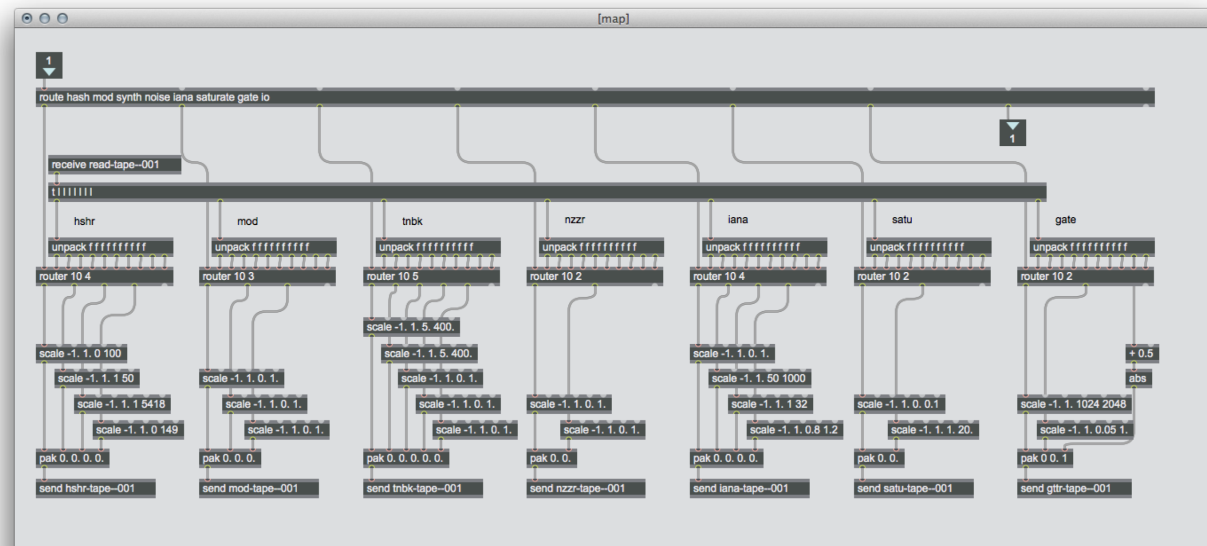
MP/SP1/SSP4/SSSP7 (AC1)



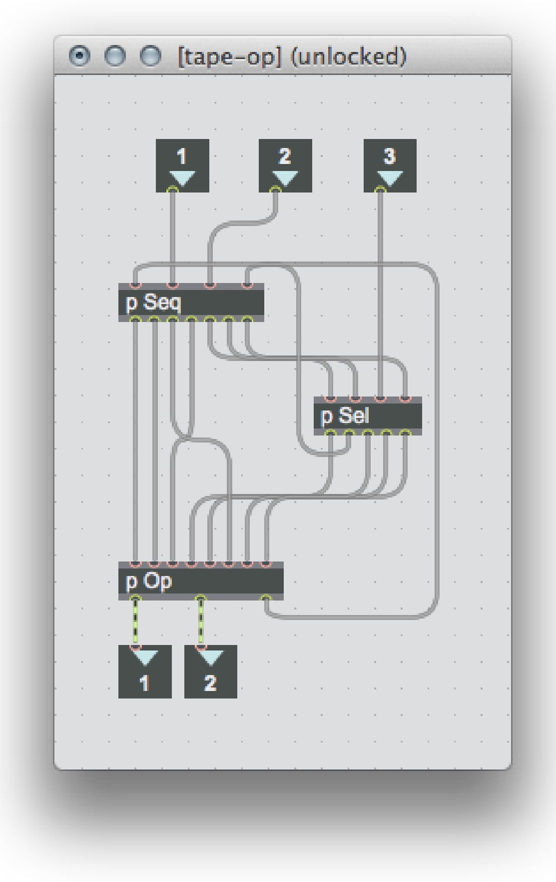
MP/SP2 (Flutter)


[fx]
1
2
3
r attack--001
gate 1
p probdel
random 128
106
r init--001
0 0 0, 0 1 0, 0 2 0, 0 3 0,
0 4 0, 0 5 0, 0 6 0, 0 7 0,
0 8 0, 0 9 0
% 2
/ 2
/ 4
/ 8
/ 16
/ 32
/ 64
!- 1
% 2
% 2
% 2
% 2
% 2
% 2
0 1 $1
0 2 $1
0 3 $1
0 4 $1
0 5 $1
0 6 $1
0 7 $1
0 8 $1
unpack i i i i i i i i i
gate 1
gate 1
gate 1
gate 1
gate 1
gate 1
gate 1
gate 1
1

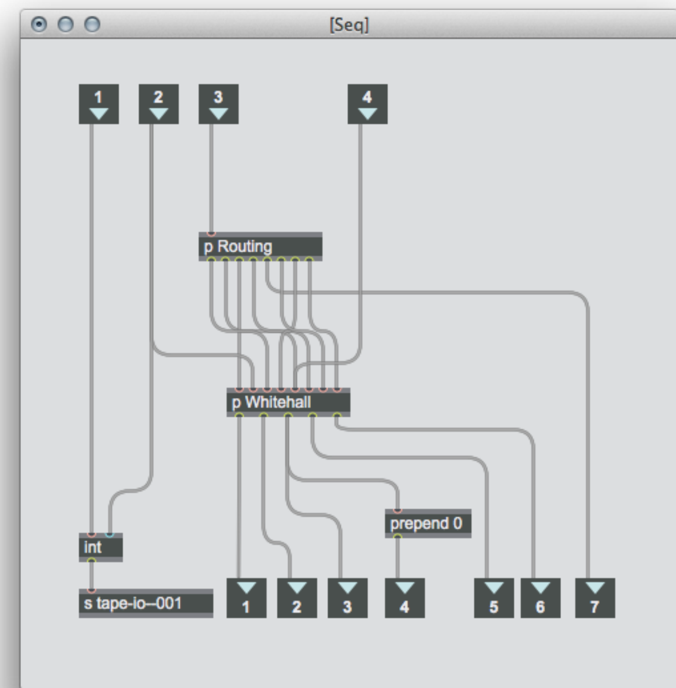
MP/SP3 (FX)


[map]
route hash mod synth noise iana saturate gate io
receive read-tape--001
hshr
mod
tnbk
nzzr
iana
satu
gate
unpack f f f f f f f f f f
router 10 4
router 10 3
router 10 5
router 10 2
router 10 4
router 10 2
router 10 2
scale -1. 1. 5. 400.
scale -1. 1. 0 100
scale -1. 1. 1 50
scale -1. 1. 1 5418
scale -1. 1. 0 149
scale -1. 1. 0. 1.
scale -1. 1. 5. 400.
scale -1. 1. 50 1000
scale -1. 1. 1 32
scale -1. 1. 0.8 1.2
scale -1. 1. 0. 0.1
scale -1. 1. 1. 20.
+ 0.5
abs
scale -1. 1. 1024 2048
scale -1. 1. 0.05 1.
pak 0. 0. 0. 0.
pak 0. 0. 0.
pak 0. 0. 0. 0. 0.
pak 0. 0.
pak 0 0. 1
send hshr-tape--001
send mod-tape--001
send tnbk-tape--001
send nzzr-tape--001
send iana-tape--001
send satu-tape--001
send gttr-tape--001

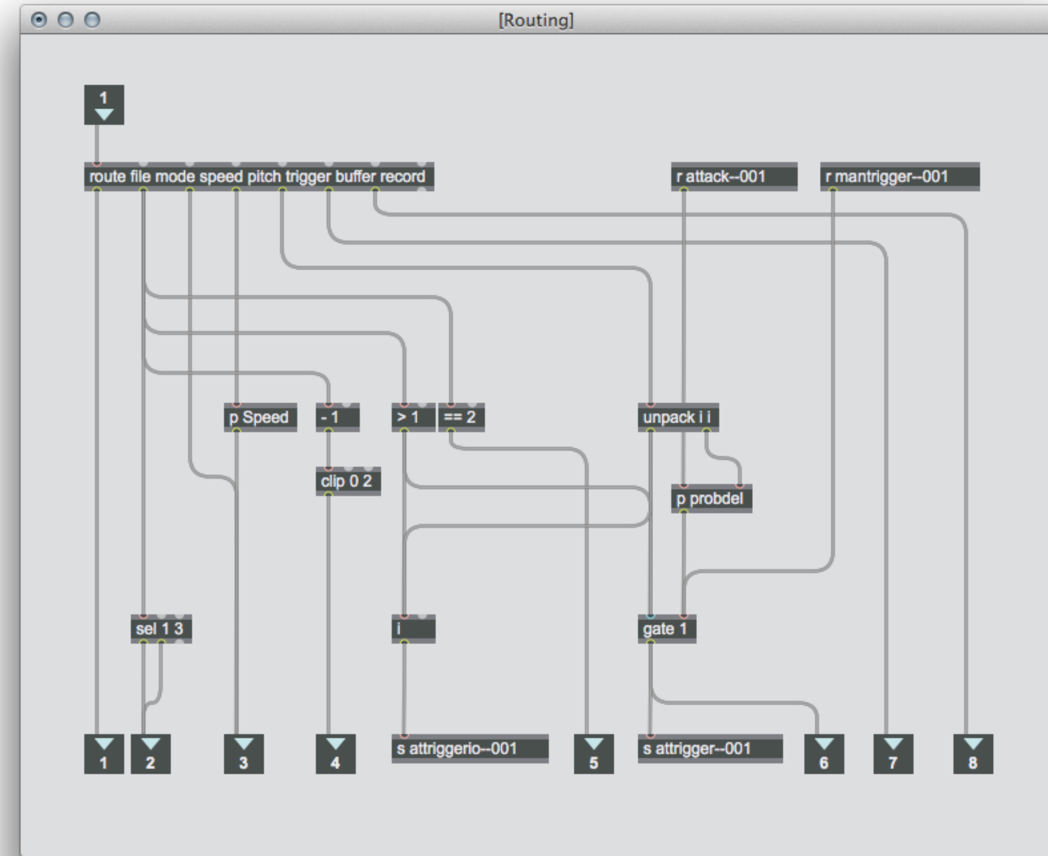
MP/SP4 (Map)



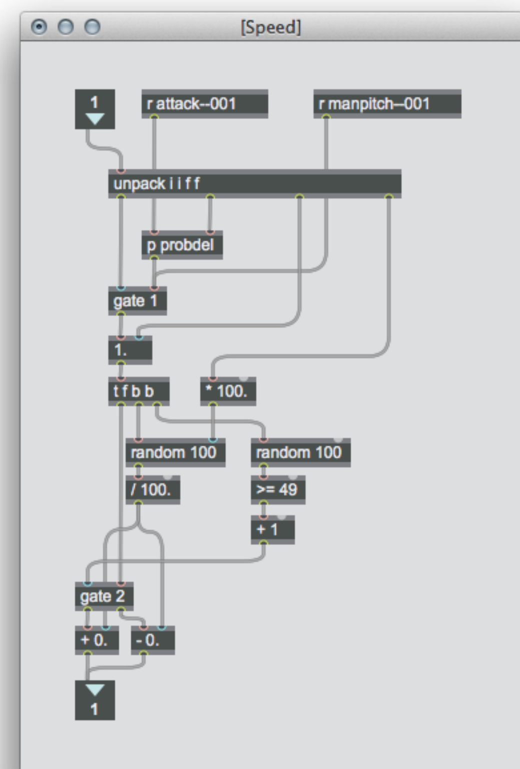
MP/SP5 (Tape Op)



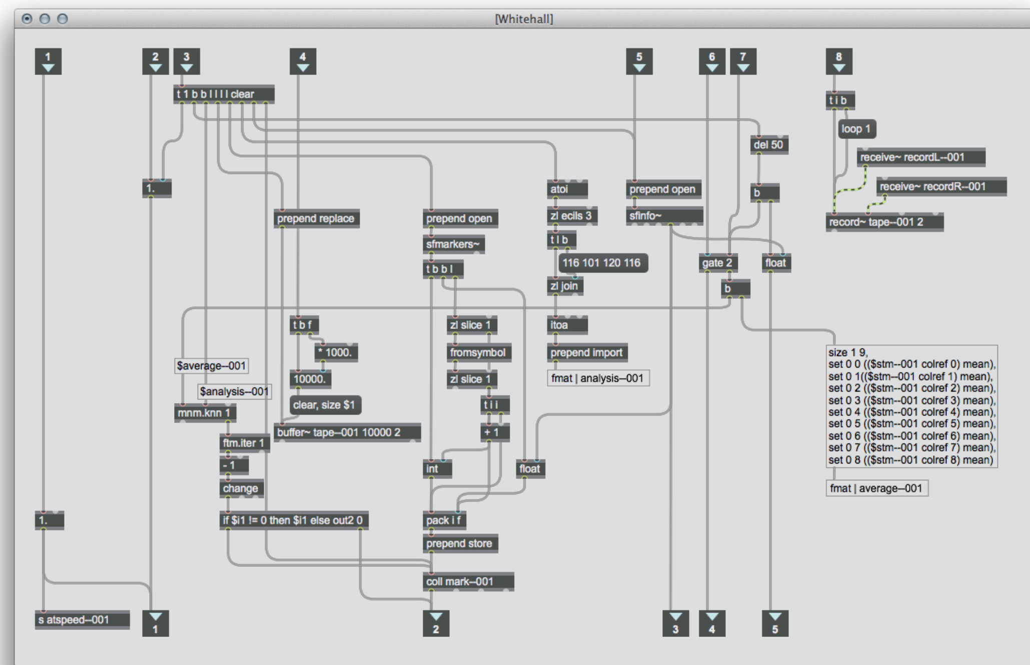
MP/SP5/SSP1 (Seq)



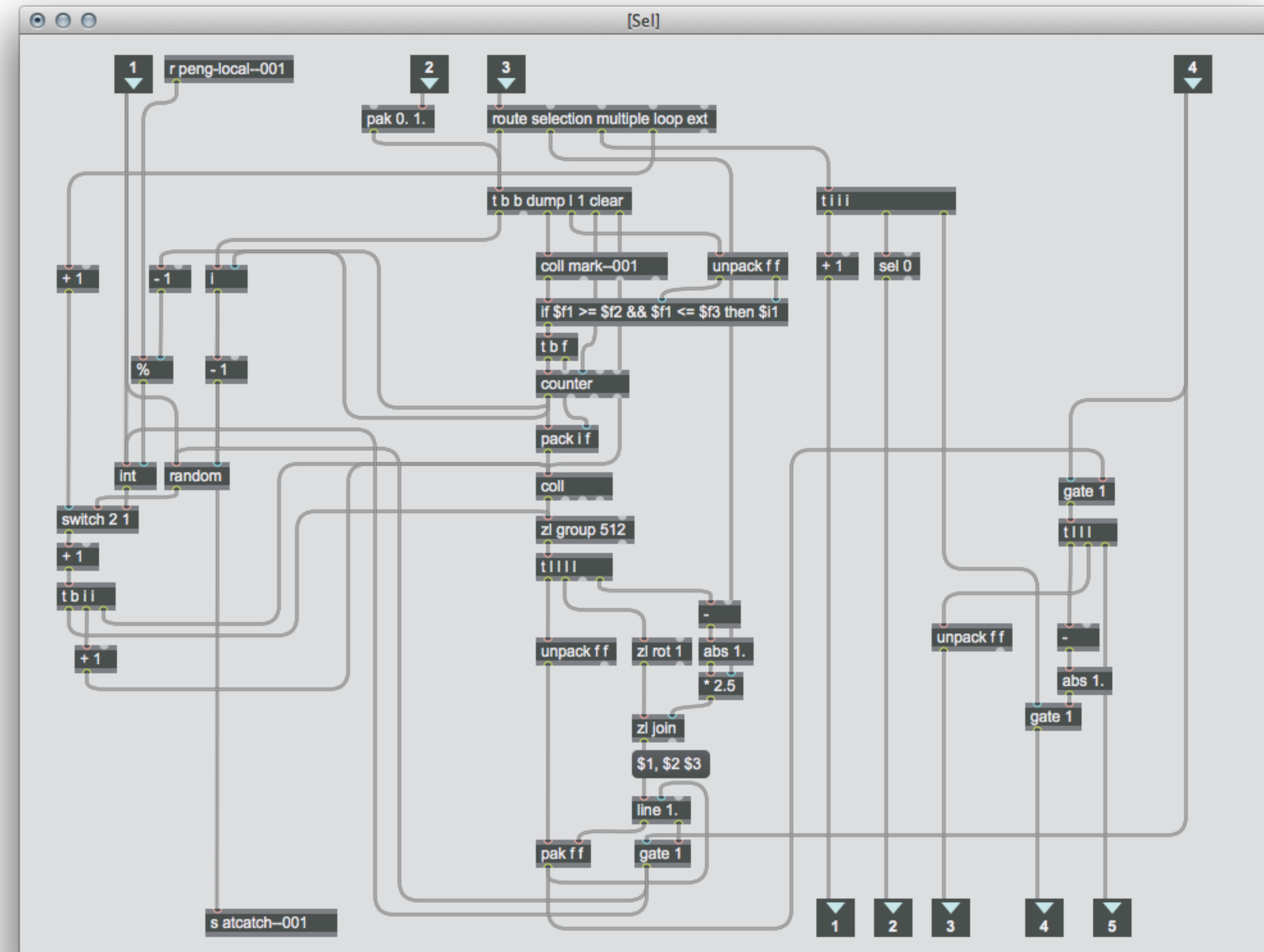
MP/SP5/SSP1/SSSP1 (Routing)



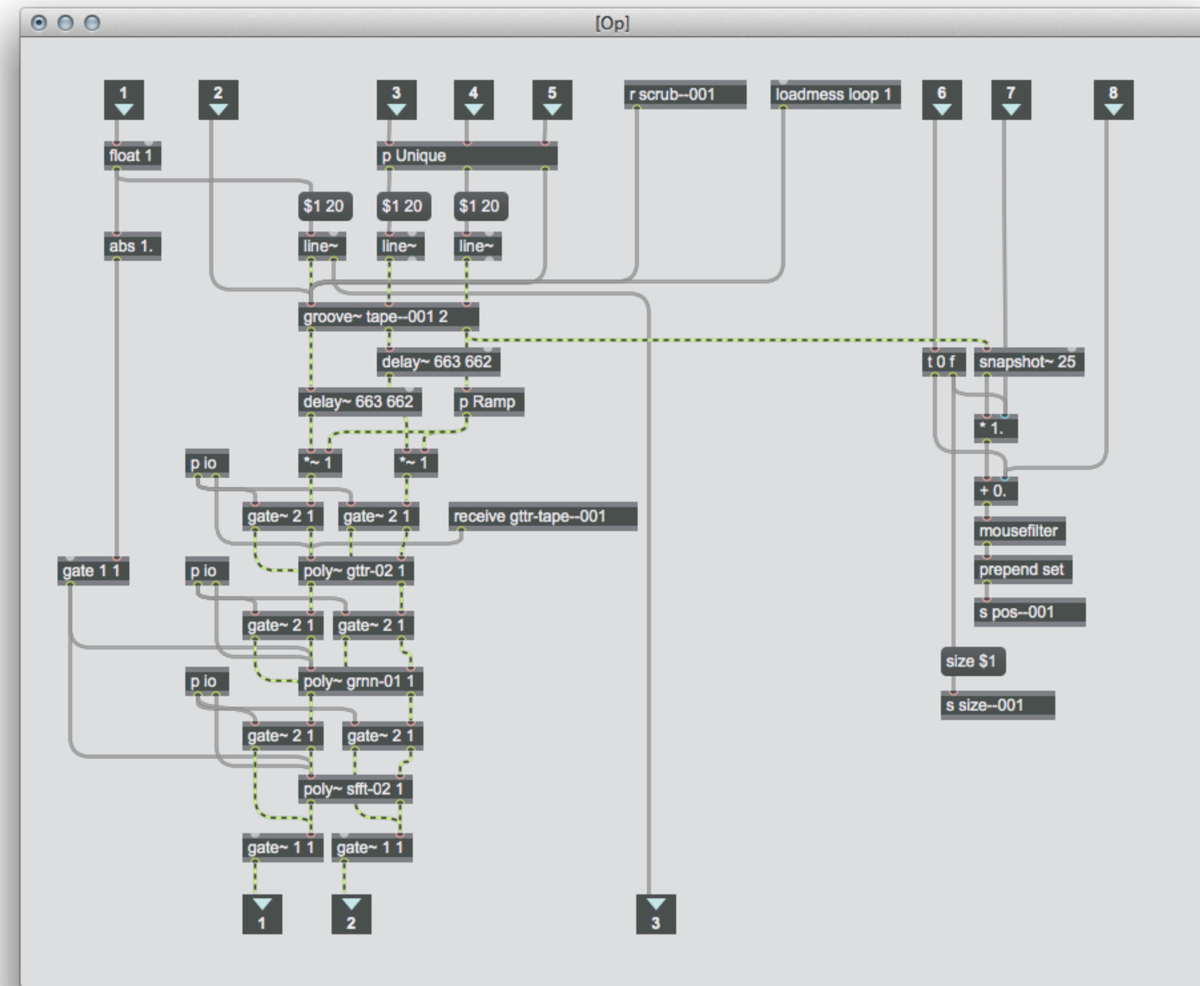
MP/SP5/SSP1/SSSP1/SSSSP1 (Speed)



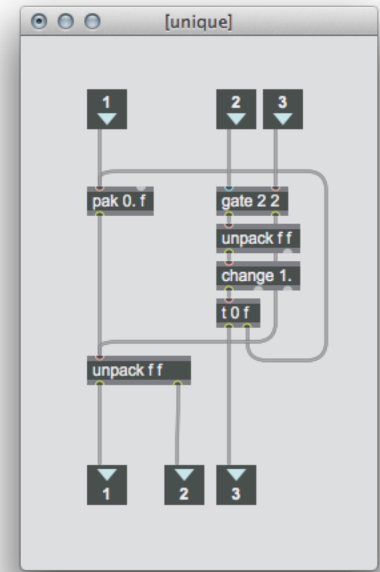
MP/SP5/SSP1/SSSP2 (Whitehall)



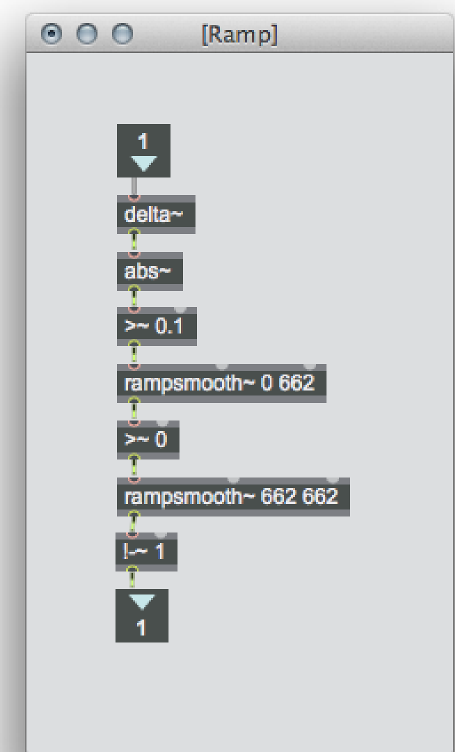
MP/SP5/SSP2 (Sel)



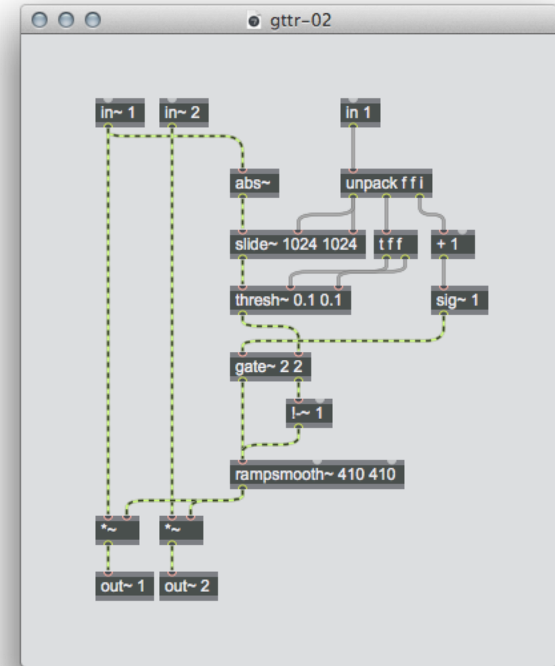
MP/SP5/SSP3 (Op)



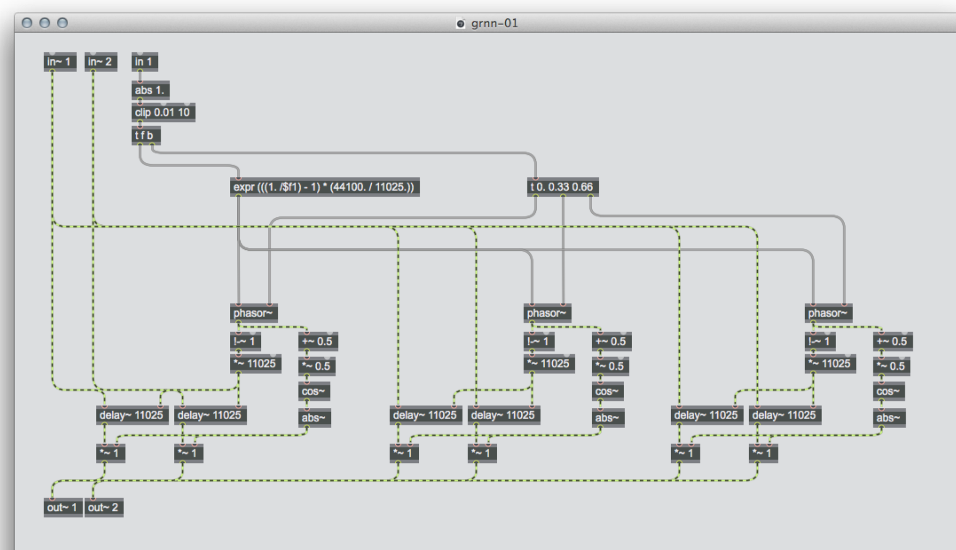
MP/SP5/SSP3/SSSP1 (Unique)



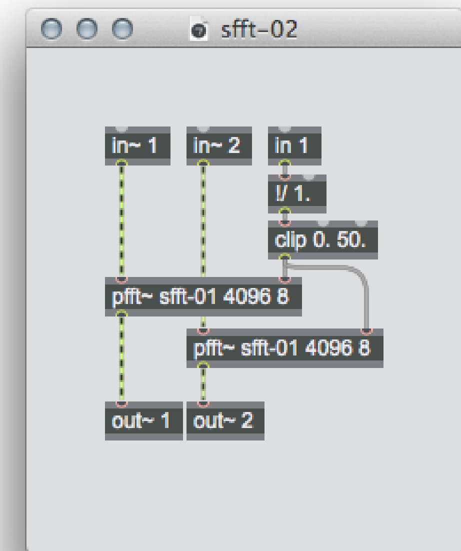
MP/SP5/SSP3/SSSP2 (Ramp)



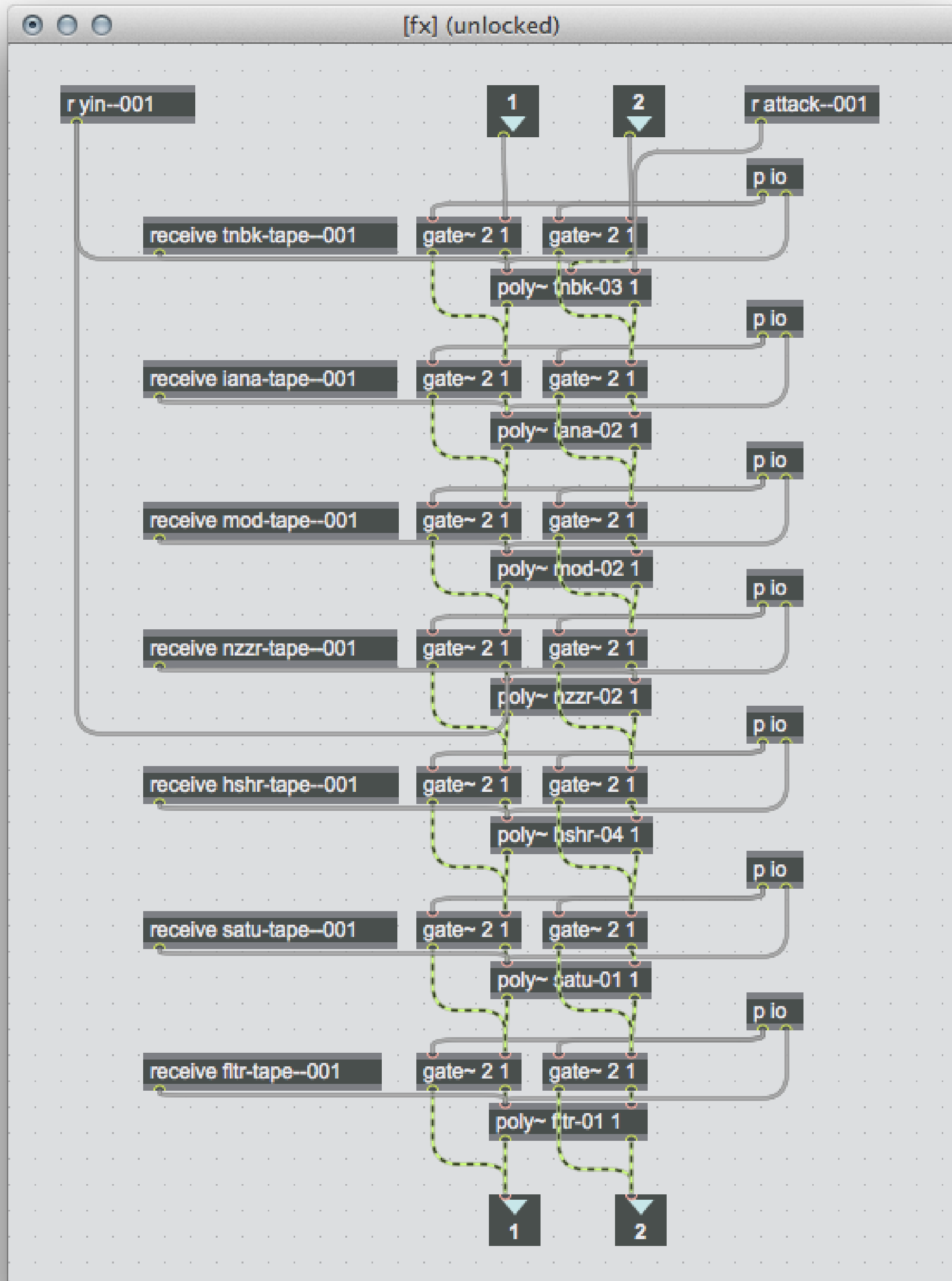
MP/SP5/SSP3/SSSP3 (Gttr-02)



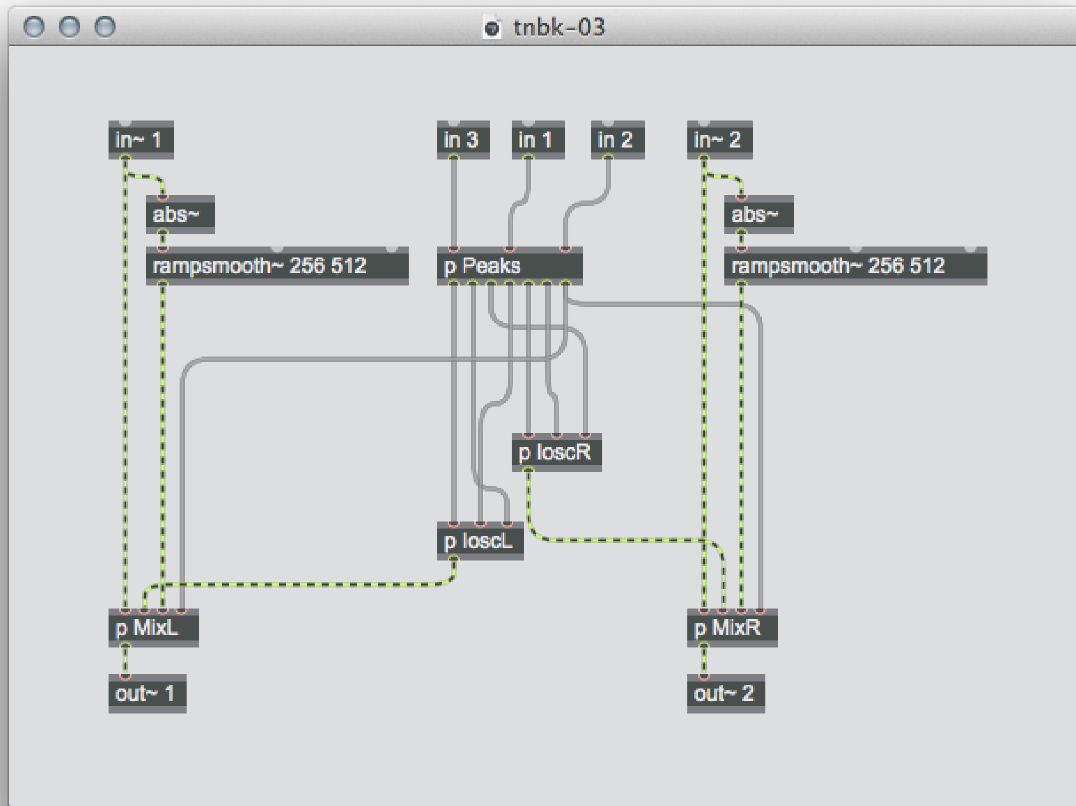
MP/SP5/SSP3/SSSP4 (Grnn-01)



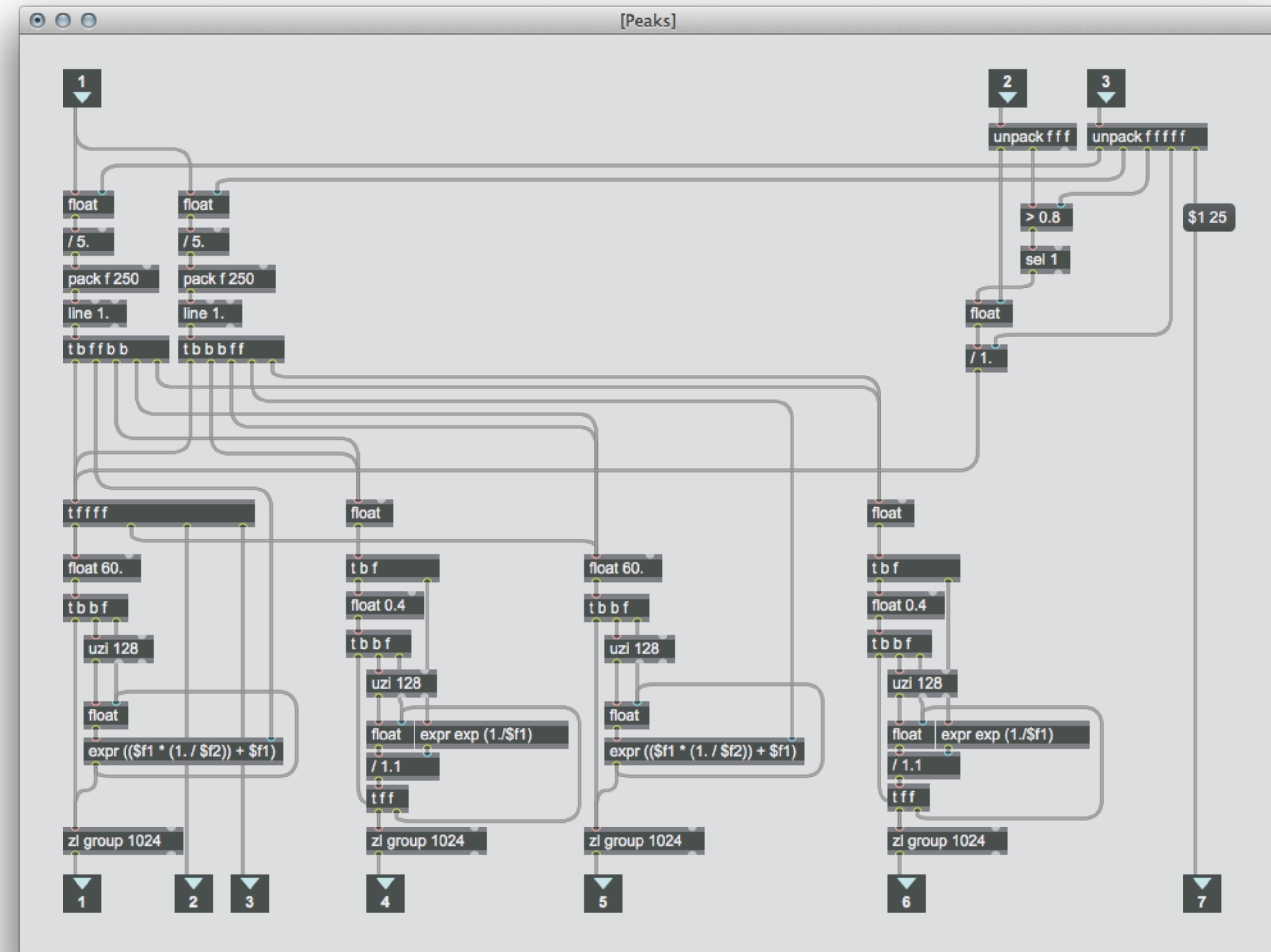
MP/SP5/SSP3/SSSP5 (Sfft-01)


[fx] (unlocked)
r yin--001
1
2
r attack--001
p io
receive tnbk-tape--001
gate~ 2 1
gate~ 2 1
poly~ tnbk-03 1
receive iana-tape--001
poly~ iana-02 1
receive mod-tape--001
poly~ mod-02 1
receive nzzr-tape--001
poly~ nzzr-02 1
receive hshr-tape--001
poly~ hshr-04 1
receive satu-tape--001
poly~ satu-01 1
receive fltr-tape--001
poly~ fltr-01 1
1
2

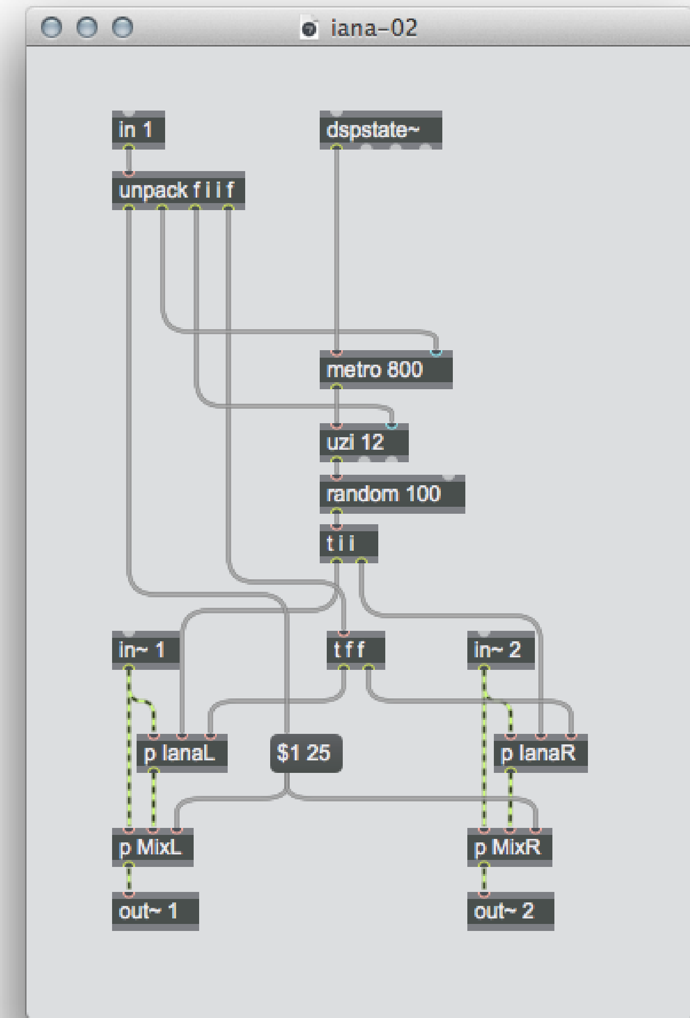
MP/SP6 (FX)



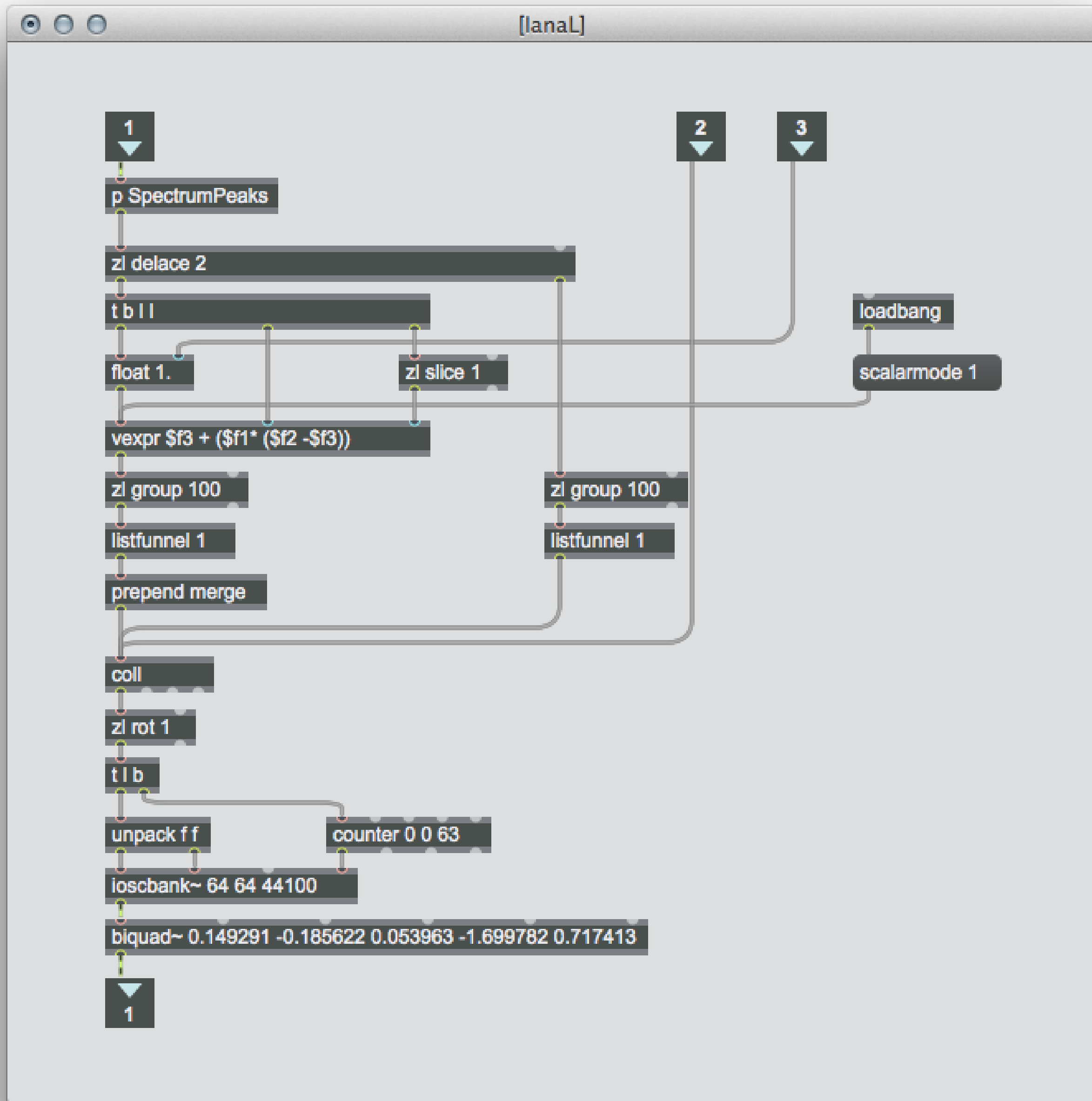
MP/SP6/SSP1 (Tnbk-03)



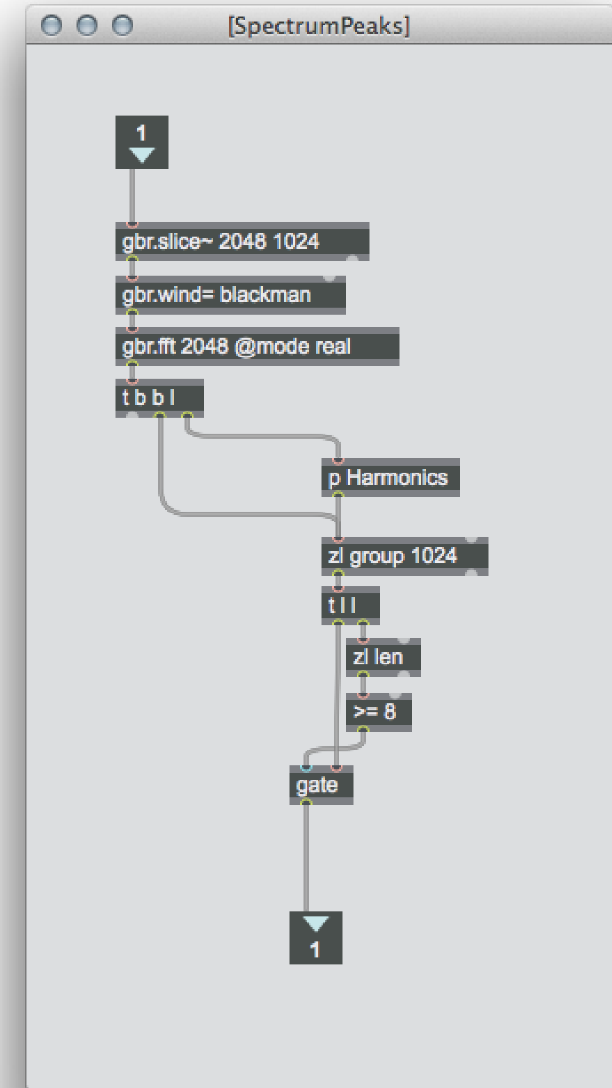
MP/SP6/SSP1/SSSP1 (Peaks)



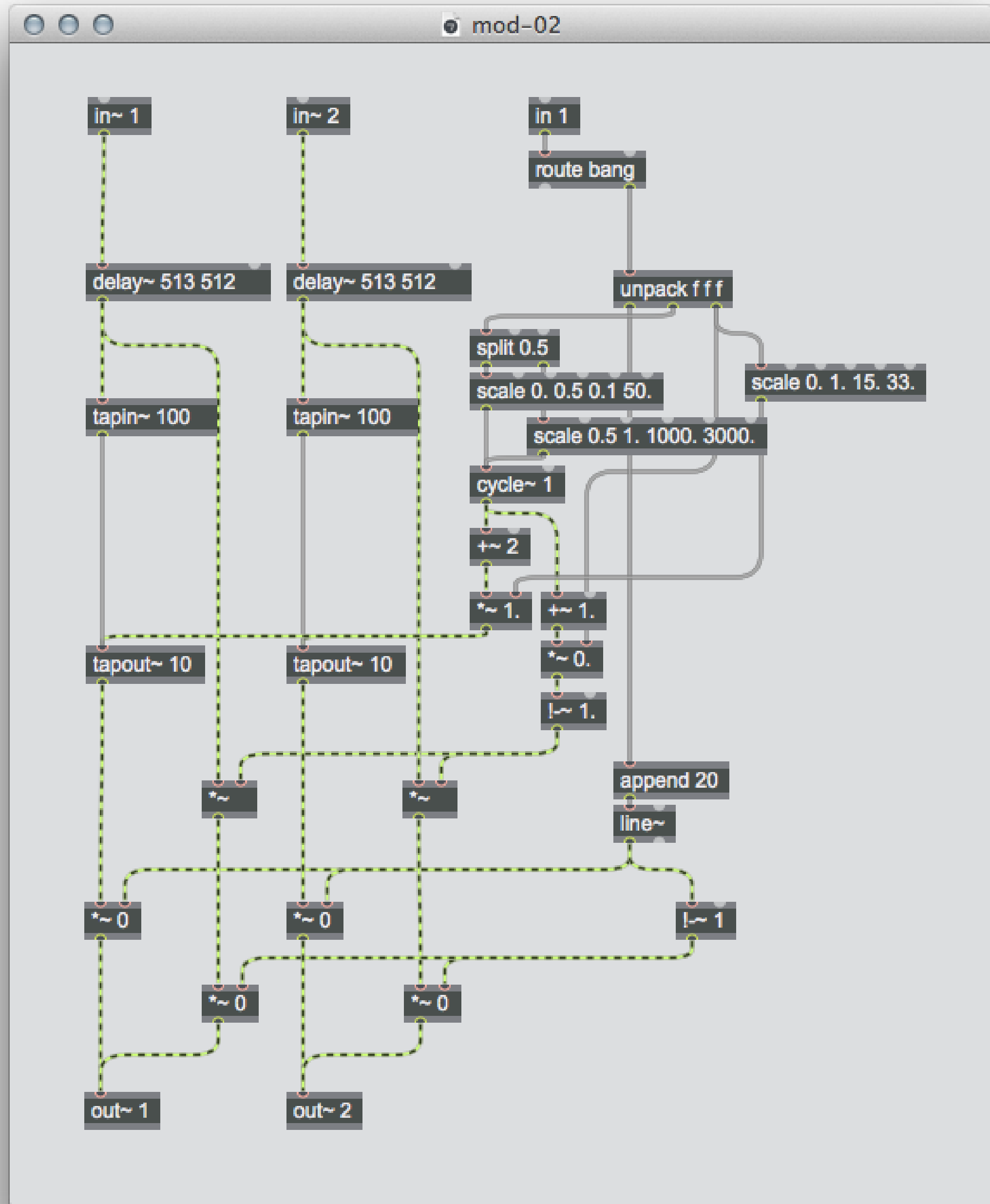
MP/SP6/SSP2 (Iana-02)



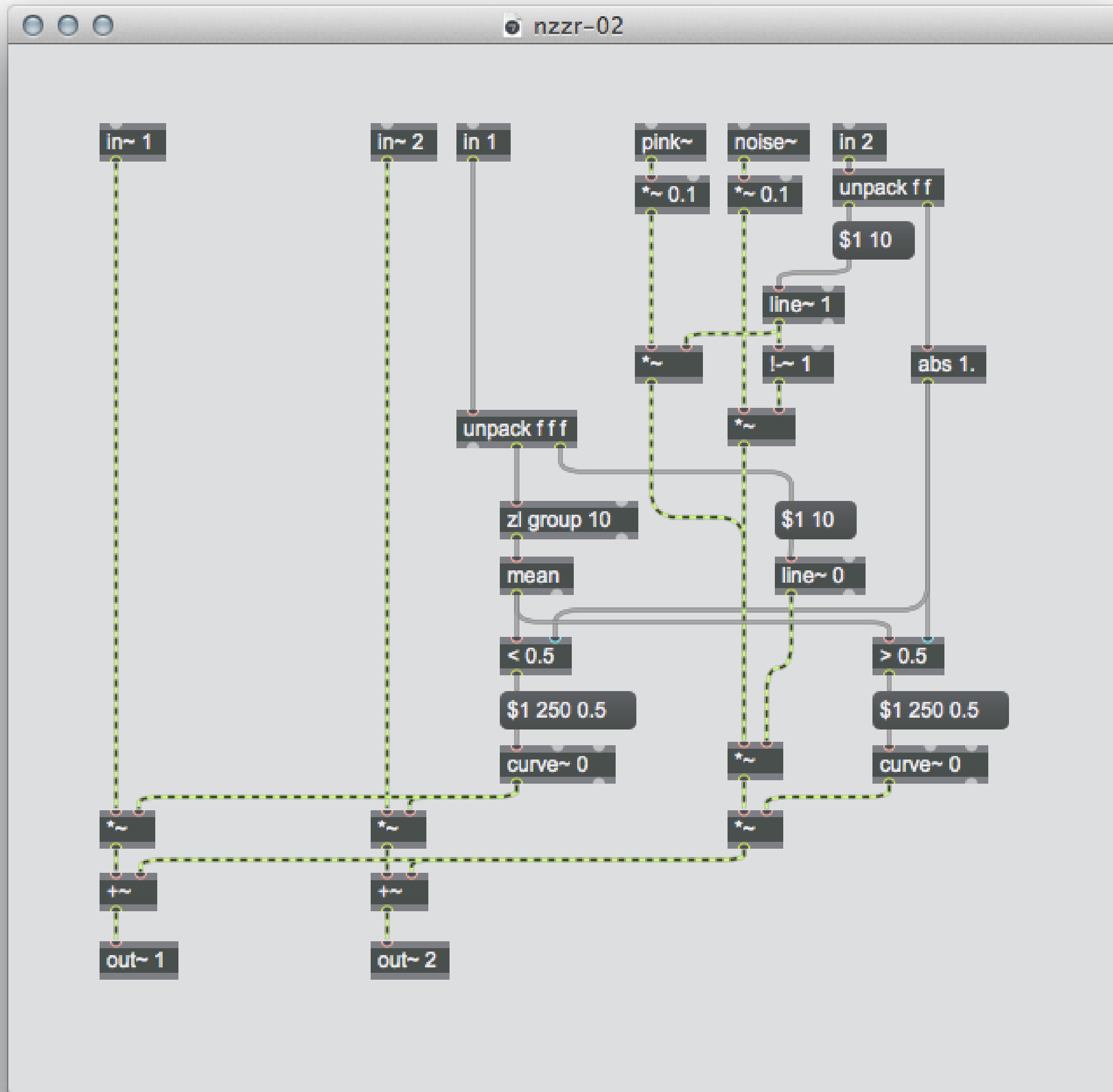
MP/SP6/SSP2/SSSP1 (IanaL)



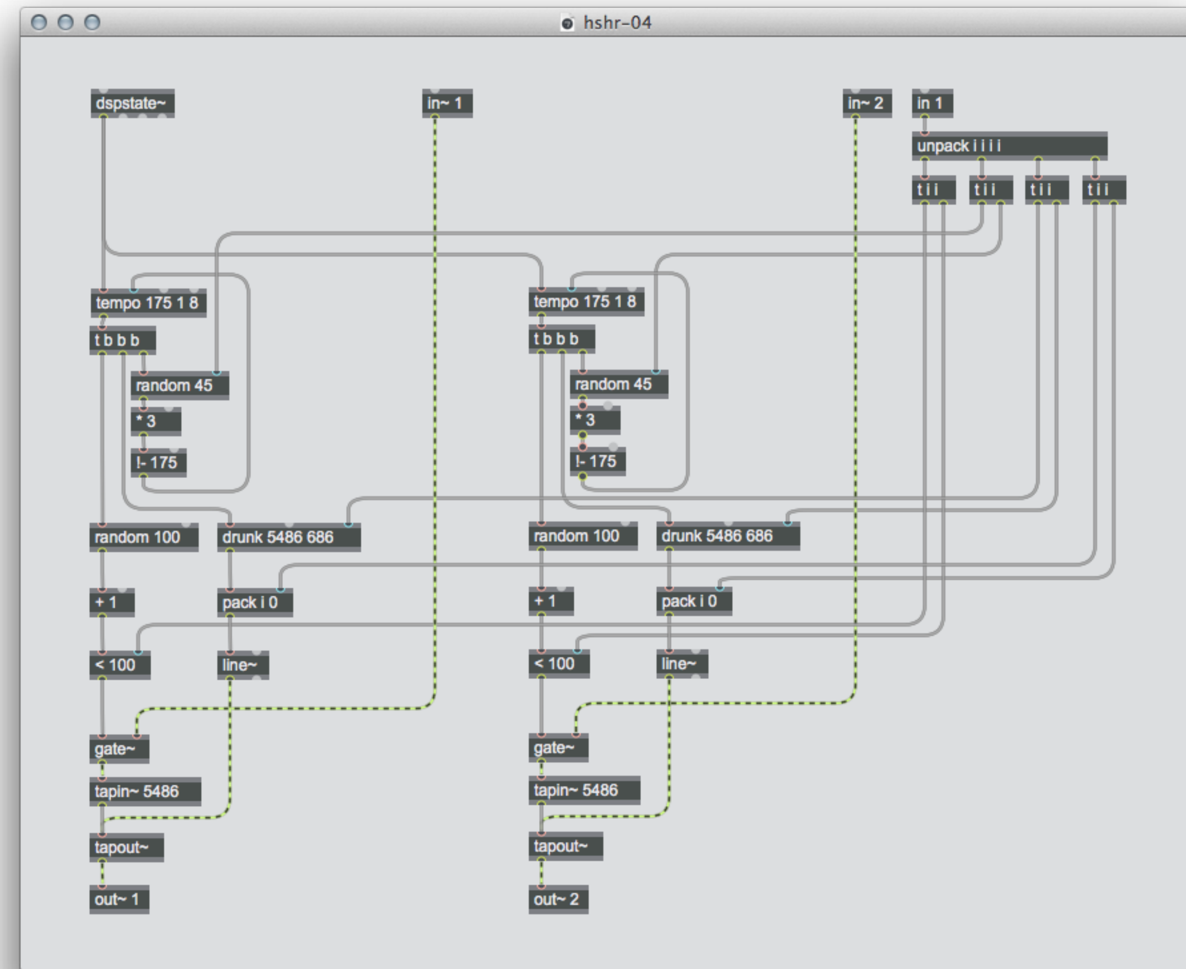
MP/SP6/SSP2/SSSP1/SSSSP1 (SpectrumPeaks)



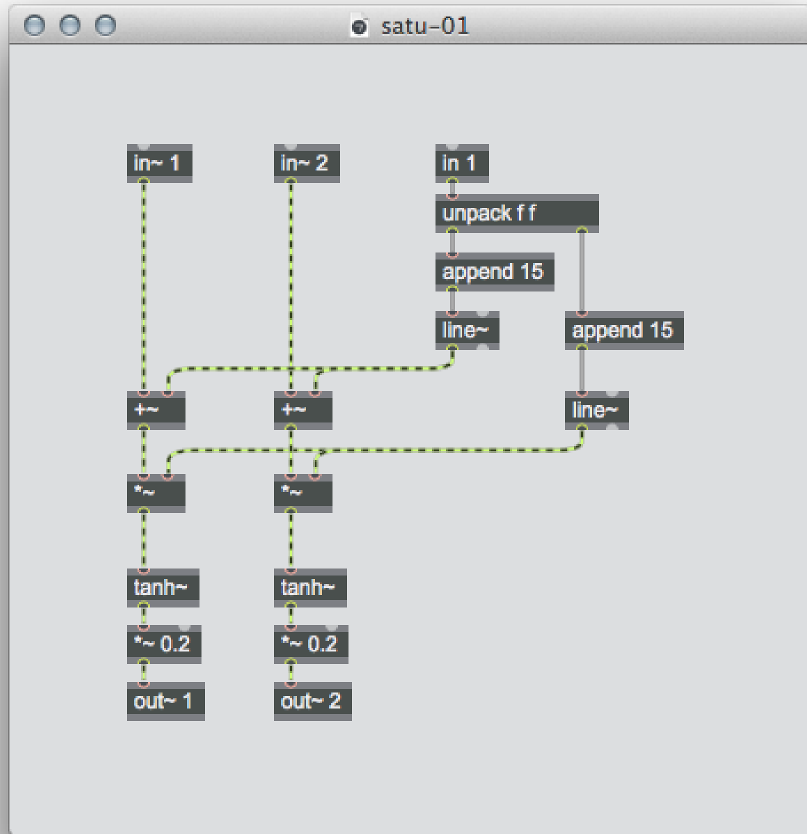
MP/SP6/SSP3 (Mod-02)



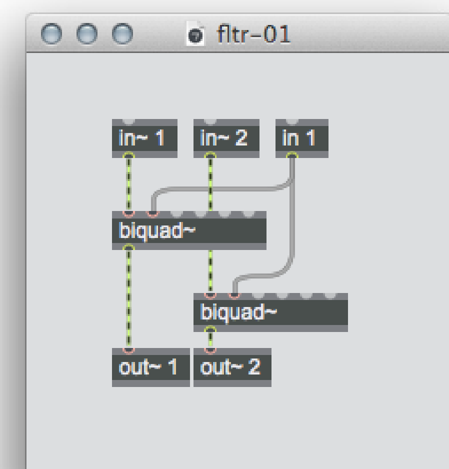
MP/SP6/SSP4 (Nzzr-02)



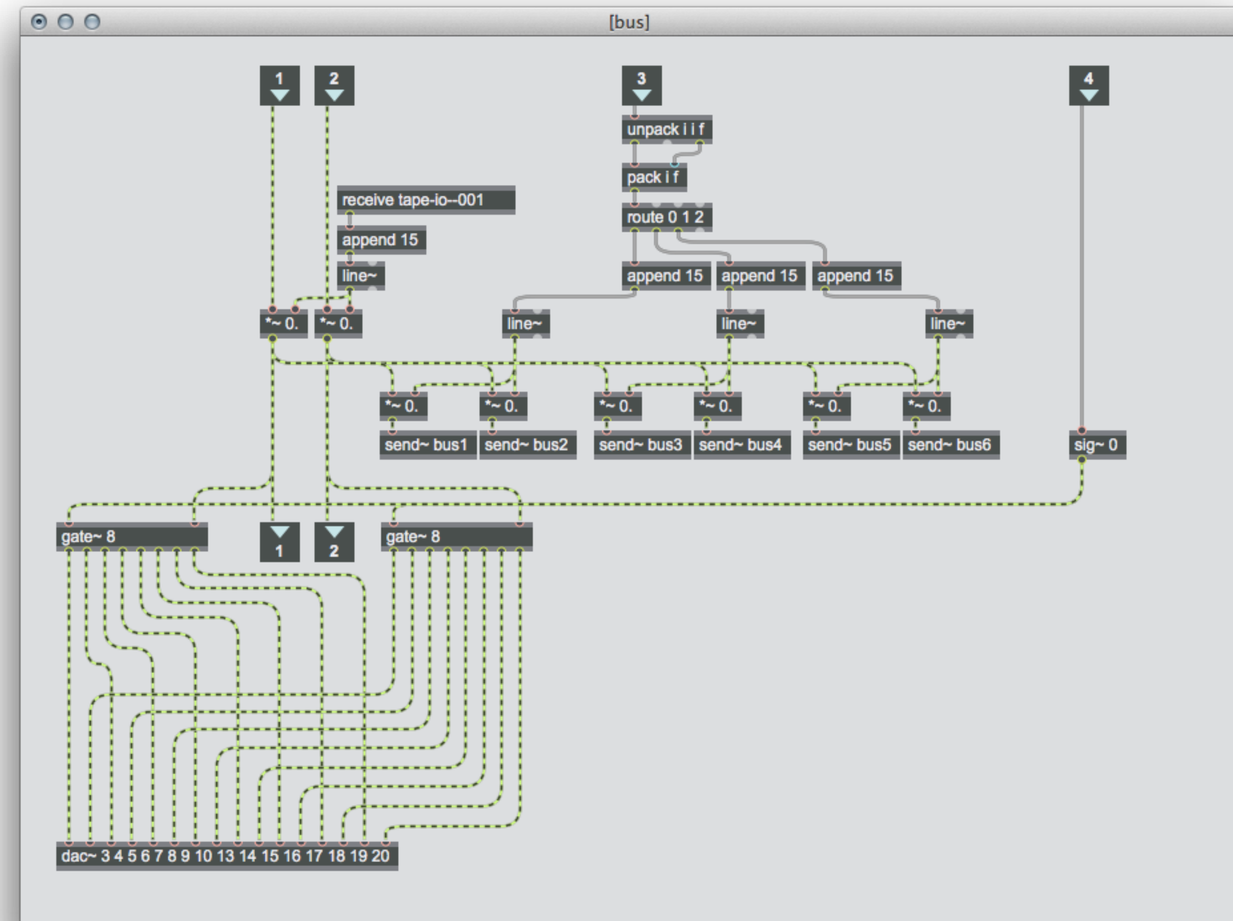
MP/SP6/SSP5 (Hshr-04)



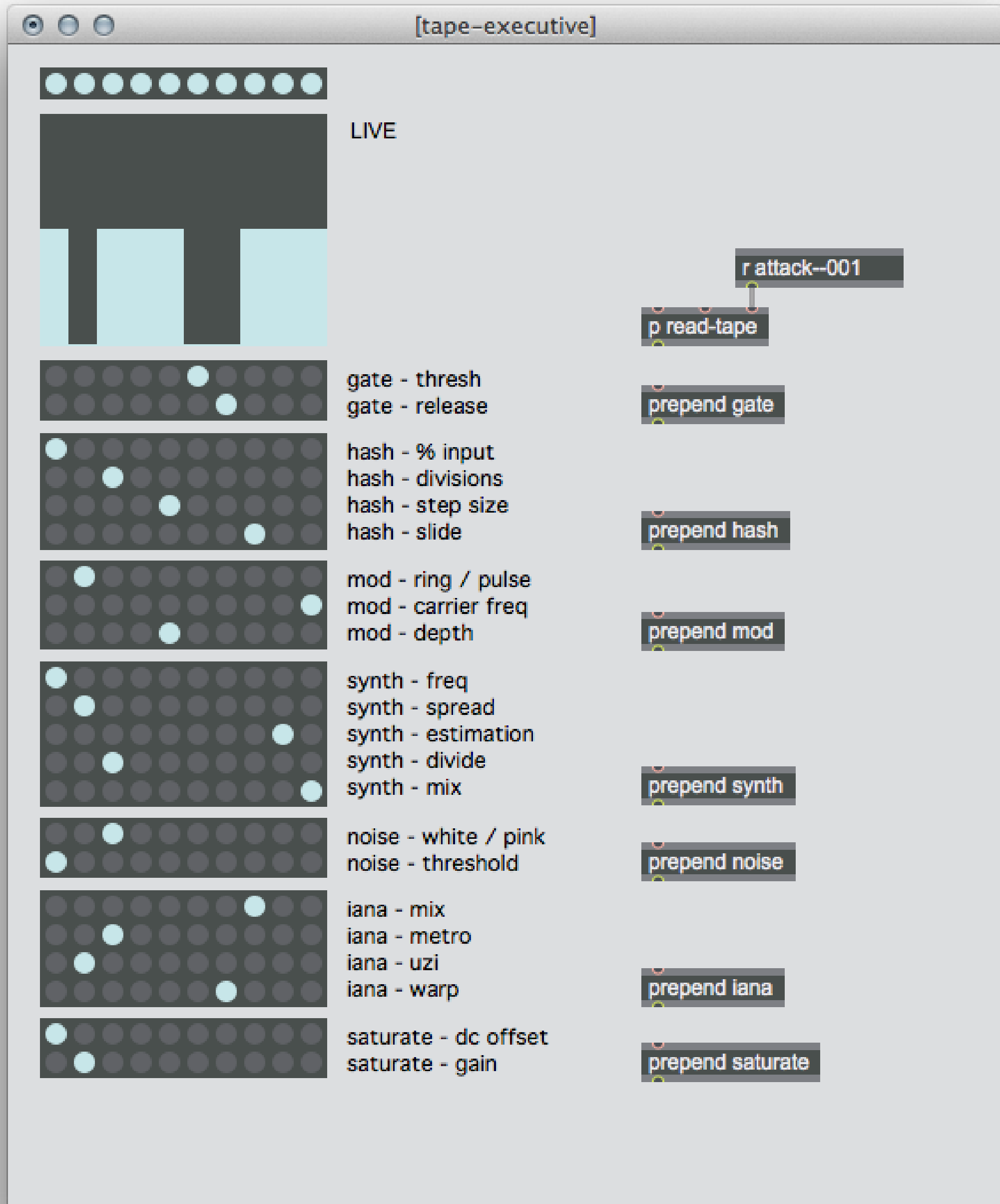
MP/SP6/SSP6 (Satu-01)



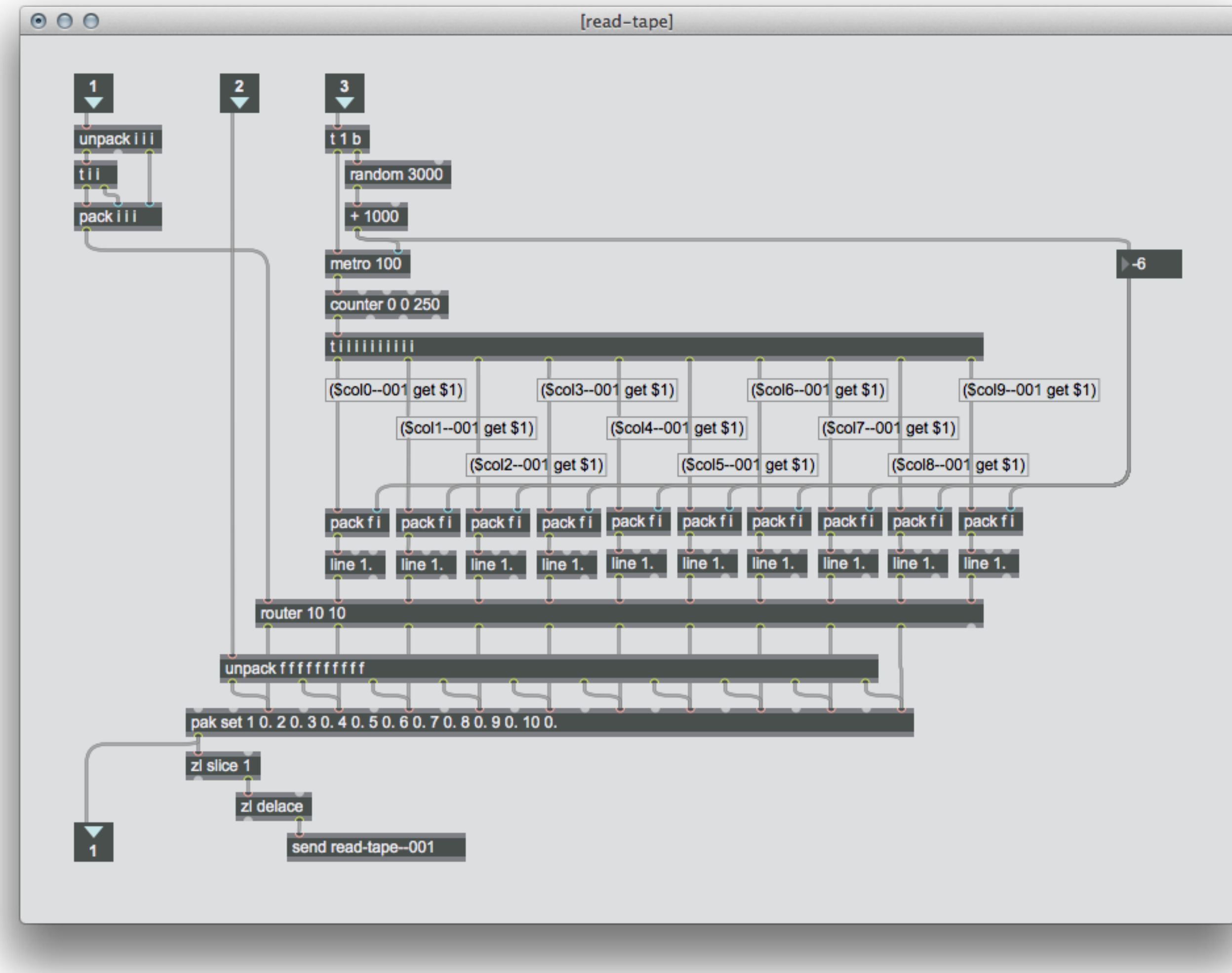
MP/SP6/SSP7 (Fltr-01)


[bus]
1
2
3
4
unpack i i f
pack i f
route 0 1 2
receive tape-io--001
append 15
line~
append 15
append 15
append 15
*~ 0.
*~ 0.
line~
line~
line~
*~ 0.
*~ 0.
*~ 0.
*~ 0.
*~ 0.
*~ 0.
send~ bus1
send~ bus2
send~ bus3
send~ bus4
send~ bus5
send~ bus6
sig~ 0
gate~ 8
1
2
gate~ 8
dac~ 3 4 5 6 7 8 9 10 13 14 15 16 17 18 19 20

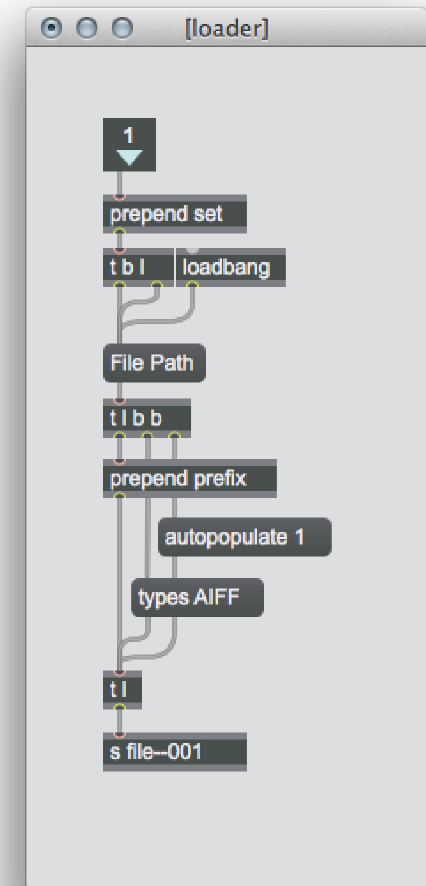
MP/SP7 (Bus)



MP/SP8 (Tape-Executive)



MP/SP8/SSP1 (Read-Tape)



MP/SP9 (Loader)

Appendix B

Audio Files Available To The *Bricolage*

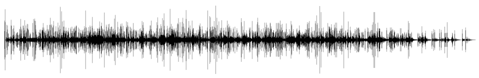


Figure 1: 122101-korn length: 00:05:04.64

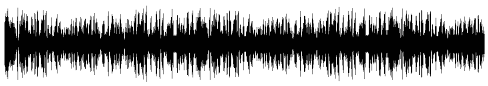


Figure 2: 23-bass length: 00:08:00.00

Figure 3: 23-braids length: 00:09:04.00

Figure 4: 23-gazi length: 00:08:00.00

Figure 5: 23-klang length: 00:08:00.00

Figure 6: 7777-vox length: 00:04:05.94

Figure 7: 7777-wibble length: 00:03:53.75

Figure 8: aarp-drone-H length: 00:02:55.54

Figure 9: aarp-drone-L1 length: 00:02:55.54

Figure 10: aarp-feed length: 00:02:55.54

Figure 11: aarp-jangle-A length: 00:02:55.54

Figure 12: aarp-jangle-B length: 00:02:55.54

Figure 13: apor-struck length: 00:05:32.75

Figure 14: bbr3-1500 length: 00:03:28.87

Figure 15: bbr3-orch length: 00:09:09.27

Figure 16: bbr3-quartet length: 00:03:45.04

Figure 17: bbr3-tronic length: 00:20:59.71

Figure 18: beez-cont1 length: 00:20:28.54

Figure 19: beez-cont2 length: 00:20:16.96

Figure 20: brkz-dstep length: 00:05:07.20

Figure 21: brkz-quan length: 00:06:57.90

Figure 22: buch-la length: 00:15:47.00

Figure 23: carter-dbass length: 00:03:32.81

Figure 24: carter-git length: 00:08:00.39

Figure 25: carter-long length: 00:04:20.30

Figure 26: carter-vibes length: 00:03:38.00

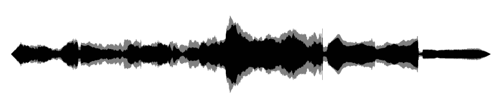


Figure 27: carter-wind length: 00:01:00.01

Figure 28: cllr-arp-P1 length: 00:03:39.43

Figure 29: cllr-gllk-1 length: 00:01:01.80

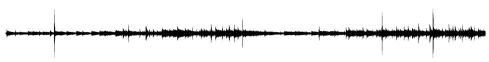


Figure 30: cllr-gllk-2 length: 00:00:55.39

Figure 31: cllr-gllk-P1 length: 00:03:39.43

Figure 32: cllr-harmonics-P1 length: 00:03:39.43

Figure 33: cllr-harmonics length: 00:04:58.47

Figure 34: cllr-hits-P1 length: 00:03:39.43

Figure 35: cllr-vibz-P1 length: 00:03:39.43

Figure 36: cllr-vibzz-1 length: 00:02:06.86

Figure 37: cllr-vibzz-2 length: 00:01:42.11

Figure 38: cllr-vibzz-3 length: 00:02:03.81

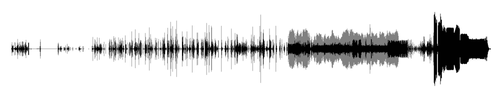


Figure 39: cola-hausen length: 00:06:24.76

Figure 40: cola-rhodes length: 00:07:15.33

Figure 41: cola-tech length: 00:12:44.31

Figure 42: cwcawhw-all length: 00:08:26.30

Figure 43: cwcawhw-mel length: 00:10:14.40

Figure 44: cwcawhw-noiz length: 00:10:15.20

Figure 45: despair-bass length: 00:00:32.91

Figure 46: despair-henry length: 00:02:50.06

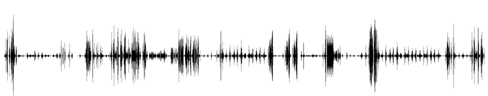


Figure 47: despair-highskip length: 00:01:05.82

Figure 48: despair-lowskip length: 00:00:08.23

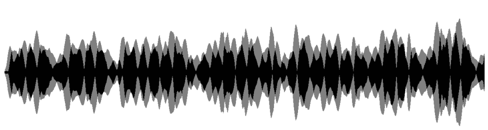


Figure 49: despair-wine length: 00:00:16.46

Figure 50: drnn-01 length: 00:10:40.00

Figure 51: fbr-cello length: 00:03:25.65

Figure 52: fbr-sherm length: 00:07:50.00

Figure 53: fiium-bassdrone length: 00:02:09.25

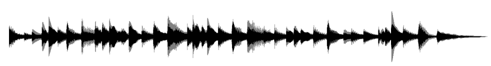


Figure 54: fiium-bowls length: 00:01:10.70

Figure 55: fiium-china length: 00:01:43.00

Figure 56: fiium-crowz length: 00:01:18.04

Figure 57: fiium-digg length: 00:05:49.53

Figure 58: fiium-flup length: 00:03:12.00

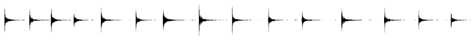


Figure 59: fiium-fmann length: 00:05:14.55

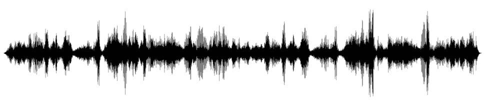


Figure 60: fiium-hler length: 00:05:14.00

Figure 61: fiium-imba-m1 length: 00:00:56.76

Figure 62: fiium-imba-m2 length: 00:00:56.76

Figure 63: fiium-imba-m3 length: 00:00:56.76

Figure 64: fiium-imba-r1 length: 00:00:56.76

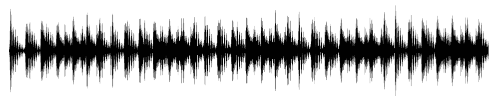


Figure 65: fiium-imba-r2 length: 00:00:56.76

Figure 66: fiium-imba-r3 length: 00:00:56.76

Figure 67: fiium-imba-r4 length: 00:00:56.76

Figure 68: fiium-imba-r5 length: 00:00:56.76

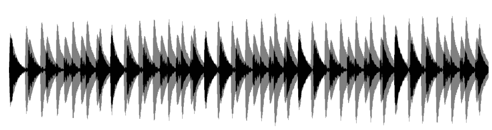


Figure 69: fiium-imba length: 00:00:56.76

Figure 70: fiium-mapp length: 00:01:36.00

Figure 71: fiium-nzzlp length: 00:10:34.62

Figure 72: fiium-pizzz length: 00:02:53.77

Figure 73: fiium-pizzzrev length: 00:02:53.77

Figure 74: fiium-stringz length: 00:02:40.22

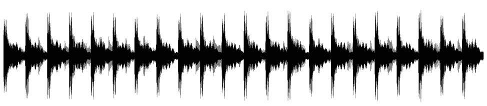


Figure 75: fiium-suite length: 00:01:50.00

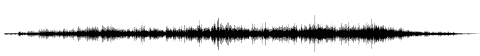


Figure 76: fiium-tibowl length: 00:01:39.44

Figure 77: fiium-wzzend length: 00:02:25.92

Figure 78: foxx-N4 length: 00:04:58.32

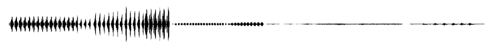


Figure 79: foxx-cog-grinder length: 00:04:00.11

Figure 80: foxx-figg length: 00:01:36.00

Figure 81: foxx-flibbered-bass length: 00:00:49.80

Figure 82: foxx-flibbered length: 00:05:23.50

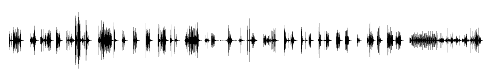


Figure 83: foxx-prang-voices length: 00:01:40.35

Figure 84: foxx-rubbed-out length: 00:03:34.12

Figure 85: foxx-shramp length: 00:05:54.95

Figure 86: foxx-strix length: 00:04:00.60

Figure 87: foxx-the-spume length: 00:05:17.16

Figure 88: foxx-trump length: 00:00:56.01

Figure 89: foxx-wasp1 length: 00:09:08.13

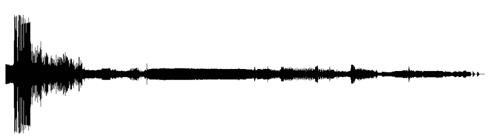


Figure 90: foxx-wasp2 length: 00:08:27.17

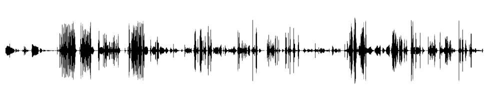


Figure 91: frnk-01 length: 00:06:03.04

Figure 92: frnk-02 length: 00:05:17.68

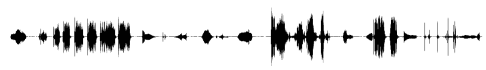


Figure 93: frnk-03 length: 00:02:48.76

Figure 94: frnk-nkkk-03s length: 00:10:20.04

Figure 95: fxxx-moleman-bass length: 00:06:09.65

Figure 96: fxxx-moleman-drums1 length: 00:01:52.01

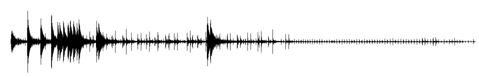


Figure 97: fxxx-moleman-drums2 length: 00:02:04.51

Figure 98: fxxx-moleman-end-drone length: 00:00:53.84

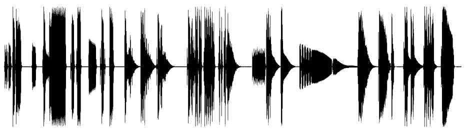


Figure 99: fxxx-solitary-wasps-drum-pad length: 00:01:37.34

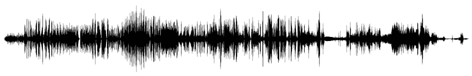


Figure 100: fxxx-solitary-wasps-ice length: 00:01:37.34

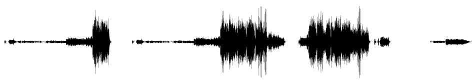


Figure 101: fxxx-undecillion-bass+ length: 00:12:06.42

Figure 102: fxxx-undecillion-drones length: 00:12:06.42

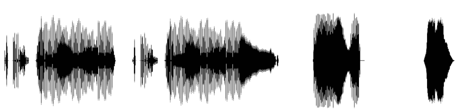


Figure 103: fxxx-undecillion-drum-pad length: 00:12:06.42

Figure 104: fxxx-whippy-groan length: 00:05:54.31

Figure 105: fxxx-whippy-stylophone length: 00:05:54.31

Figure 106: fxxx-whippy-whippy length: 00:05:54.31

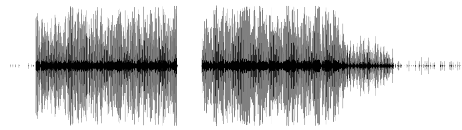


Figure 107: fxxx-woodbelly-bitwize length: 00:03:01.53

Figure 108: fxxx-woodbelly-drum-pad length: 00:03:01.53

Figure 109: fxxx-woodbelly-noiz length: 00:03:01.53

Figure 110: ghfl-fxfx length: 00:05:04.88

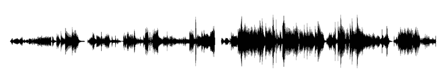


Figure 111: ghfl-instr length: 00:05:04.88

Figure 112: gkro-grrr length: 00:07:12.00

Figure 113: gkro-kkgg length: 00:11:14.00

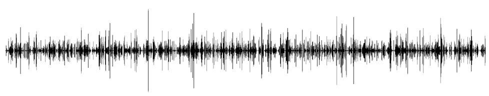


Figure 114: gkro-korg length: 00:11:14.00

Figure 115: gkro-krag length: 00:11:14.00

Figure 116: grm-nice length: 00:12:32.06

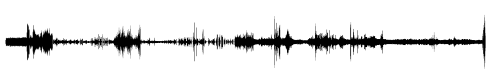


Figure 117: grm-sfce length: 00:07:38.00

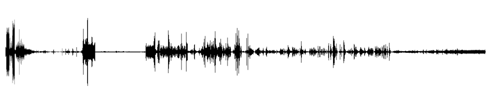


Figure 118: grm-solstice length: 00:26:02.01

Figure 119: grm-vlf length: 00:05:11.03

Figure 120: grm-xian length: 00:07:42.82

Figure 121: higg-ohmn length: 00:08:32.00

Figure 122: hnng-brush length: 00:02:52.87

Figure 123: hnng-fingers length: 00:04:30.21

Figure 124: hnng-mosh length: 00:04:03.82

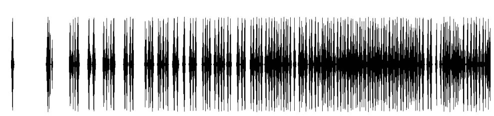


Figure 125: husky-bass length: 00:02:23.87

Figure 126: husky-brrd length: 00:01:54.24

Figure 127: husky-fogg length: 00:06:08.26

Figure 128: ic11-colour-field length: 00:18:04.40

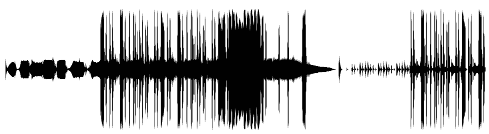


Figure 129: ic11-dumptruck length: 00:08:21.63

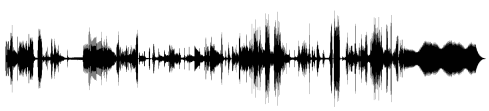


Figure 130: ic11-md-skillz length: 00:01:42.43

Figure 131: ic11-old-d length: 00:07:39.93

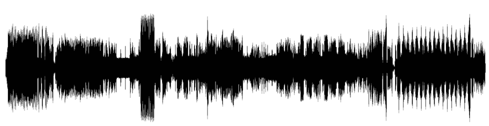


Figure 132: ic11-spineez length: 00:11:19.76

Figure 133: ic11-stupidities length: 00:03:51.89

Figure 134: intr-blip length: 00:02:27.17

Figure 135: intr-chords-x10 length: 00:05:06.15

Figure 136: intr-hippy length: 00:10:15.40

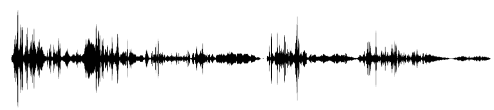


Figure 137: intr-lucc length: 00:03:18.88

Figure 138: intr-silence length: 00:04:26.70

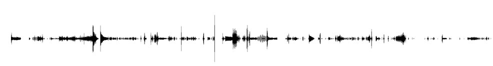


Figure 139: intr-vinyl length: 00:02:29.81

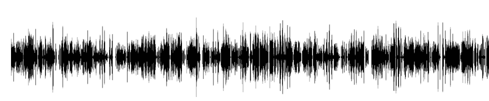


Figure 140: ionn-flex length: 00:12:56.01

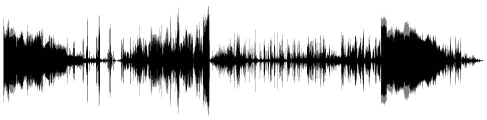


Figure 141: ionn-intr length: 00:14:00.01

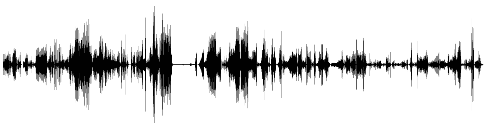


Figure 142: ionn-shred1 length: 00:09:05.59

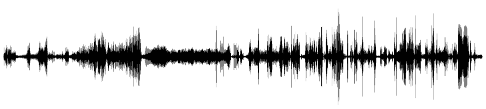


Figure 143: ionn-shred2 length: 00:07:00.54

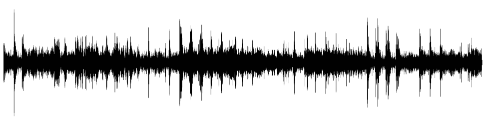


Figure 144: ionn-vven length: 00:03:04.01

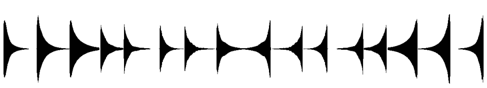


Figure 145: jyske-bass length: 00:04:14.00

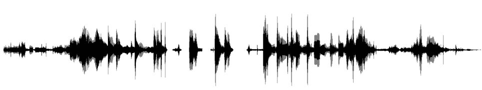


Figure 146: jyske-rugkiks length: 00:04:11.39

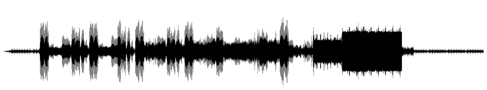


Figure 147: kfulz-all length: 00:16:08.26

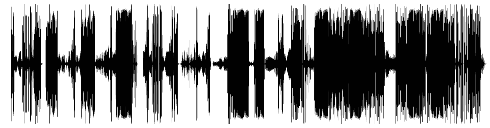


Figure 148: khoi-hobo length: 00:07:12.00

Figure 149: khoi-san length: 00:07:12.00

Figure 150: khoi-syn length: 00:07:12.00

Figure 151: kord-14384 length: 00:04:40.07

Figure 152: kord-3106 length: 00:02:35.95

Figure 153: kord-bayl length: 00:03:40.00

Figure 154: kord-card length: 00:03:54.65

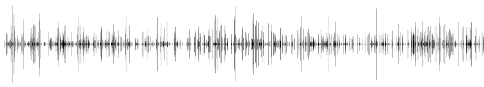


Figure 155: kord-gakk length: 00:08:55.77

Figure 156: kord-gett length: 00:08:24.71

Figure 157: kord-lann length: 00:01:17.64

Figure 158: kord-rezz length: 00:13:27.02

Figure 159: kord-schnee length: 00:04:26.67

Figure 160: kryp-bass length: 00:04:13.33

Figure 161: kryp-glass length: 00:02:22.22

Figure 162: kryp-kalimba length: 00:02:57.78

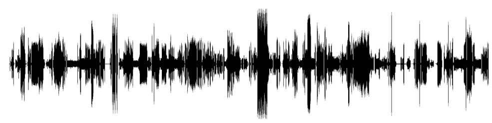


Figure 163: kwik-bass-P1 length: 00:14:20.14

Figure 164: kwik-dtmtrx length: 00:06:15.46

Figure 165: kwik-mixr length: 00:09:16.27

Figure 166: kwik-print-P1 length: 00:14:20.14

Figure 167: mad-balloon-high length: 00:02:11.07

Figure 168: mad-balloon-low length: 00:02:09.00

Figure 169: mad-balloon length: 00:01:08.86

Figure 170: mad-coke length: 00:01:22.00

Figure 171: mad-hoover length: 00:03:51.10

Figure 172: mad-krak length: 00:09:35.49

Figure 173: mad-magnet length: 00:10:16.43

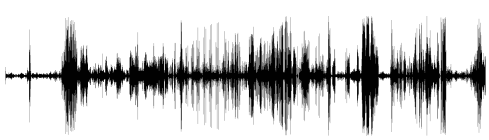


Figure 174: mbls-blood1 length: 00:04:39.51

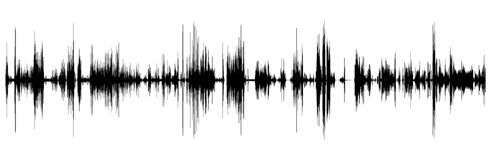


Figure 175: mbls-blood2 length: 00:06:59.30

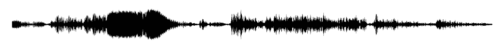


Figure 176: mbls-stone1 length: 00:05:51.34

Figure 177: mbls-stone2 length: 00:04:34.32

Figure 178: mbls-stone3 length: 00:05:58.67

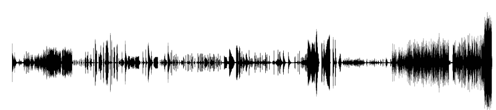


Figure 179: mdmd-krunk length: 00:12:50.01

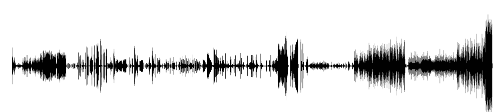


Figure 180: mdmd-nostalgia length: 00:14:16.00

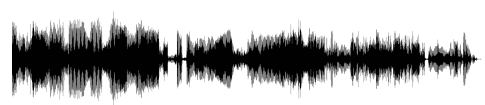


Figure 181: nk-scelsi length: 00:03:57.22

Figure 182: noiz-12m length: 00:09:47.39

Figure 183: noiz-1p5 length: 00:01:19.78

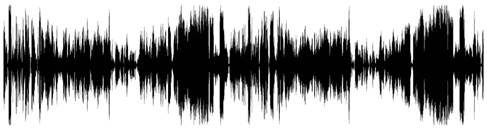


Figure 184: noiz-34m length: 00:42:47.92

Figure 185: noiz-7m length: 00:07:17.84

Figure 186: noto-gllk length: 00:08:39.87

Figure 187: noto-lppr-1 length: 00:11:14.44

Figure 188: noto-lppr-2 length: 00:09:35.64

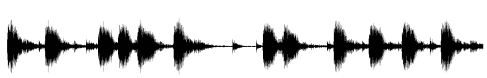


Figure 189: obsv-01 length: 00:00:16.66

Figure 190: obsv-02 length: 00:00:25.81

Figure 191: obsv-03 length: 00:00:34.34

Figure 192: obsv-04 length: 00:00:45.42

Figure 193: obsv-05 length: 00:01:09.19

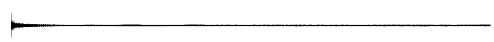


Figure 194: obsv-06 length: 00:00:48.48

Figure 195: obsv-07 length: 00:01:16.28

Figure 196: obsv-08 length: 00:00:52.08

Figure 197: obsv-all length: 00:06:08.26

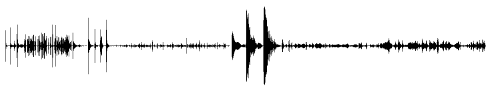


Figure 198: oceans-contra length: 00:06:20.09

Figure 199: oceans-drag length: 00:01:33.98

Figure 200: oceans-merz length: 00:02:55.54

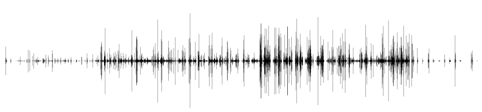


Figure 201: olld-perc-octo length: 00:03:28.63

Figure 202: olld-perc-pizz length: 00:04:53.26

Figure 203: olld-pju length: 00:03:35.32

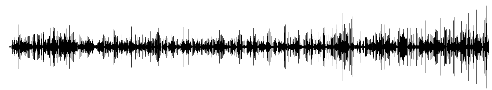


Figure 204: olld-zark-skylark length: 00:02:11.17

Figure 205: perc-banpik length: 00:04:27.17

Figure 206: perc-blah length: 00:03:05.77

Figure 207: perc-bowls length: 00:03:48.48

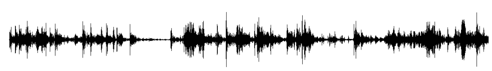


Figure 208: perc-crunch length: 00:00:28.26

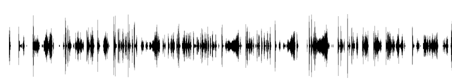


Figure 209: perc-fabric length: 00:00:41.14

Figure 210: perc-junk length: 00:08:14.00

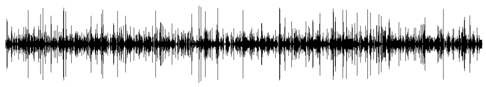


Figure 211: perc-quan length: 00:06:57.90

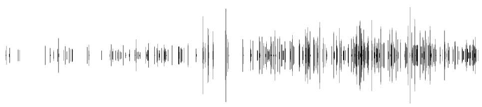


Figure 212: perc-spike length: 00:02:14.39

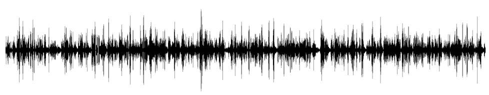


Figure 213: perc-stronen-on-ice length: 00:01:25.07

Figure 214: phze-air length: 00:01:15.10

Figure 215: phze-bulb-P1 length: 00:13:05.13

Figure 216: phze-bulb length: 00:01:55.10

Figure 217: phze-hiss-P1 length: 00:13:05.13

Figure 218: phze-krak length: 00:11:38.57

Figure 219: phze-slap-P1 length: 00:13:05.13

Figure 220: phze-valve length: 00:00:31.63

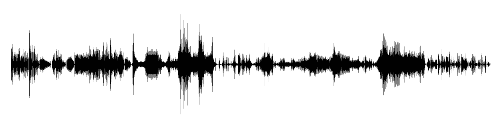


Figure 221: pink-all length: 00:12:00.00

Figure 222: pink-brrd length: 00:02:01.44

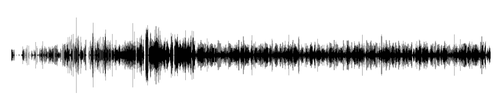


Figure 223: pink-kust length: 00:10:25.67

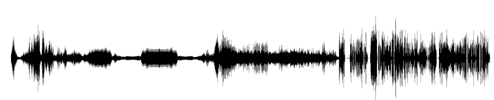


Figure 224: pink-orch length: 00:04:24.00

Figure 225: quin-percussino length: 00:01:14.18

Figure 226: quvo-01 length: 00:14:56.00

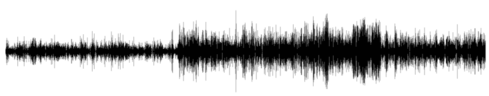


Figure 227: quvo-02 length: 00:17:04.00

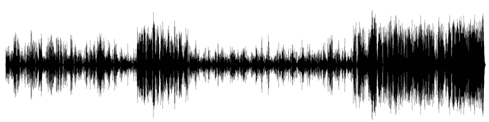


Figure 228: quvo-03 length: 00:14:03.52

Figure 229: radio-raw length: 00:10:00.50

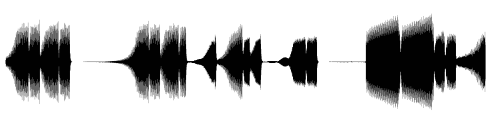


Figure 230: sides-bass length: 00:01:27.77

Figure 231: sides-ebow length: 00:26:21.70

Figure 232: smak-brahms length: 00:06:12.78

Figure 233: smak-irk-drum length: 00:01:52.93

Figure 234: smak-khan length: 00:06:06.01

Figure 235: smak-ksyn length: 00:06:06.01

Figure 236: smak-spindle length: 00:07:37.42

Figure 237: snrz-child1 length: 00:04:59.03

Figure 238: snrz-child2 length: 00:02:36.97

Figure 239: snrz-child3 length: 00:05:12.22

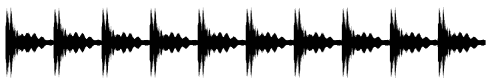


Figure 240: suit-boom length: 00:00:50.00

Figure 241: suit-pno length: 00:07:20.00

Figure 242: suit-revv length: 00:00:32.00

Figure 243: suit-rezz length: 00:13:31.90

Figure 244: tlt-piano length: 00:12:10.47

Figure 245: toowo-beat length: 00:11:05.83

Figure 246: toowo-cola length: 00:11:05.83

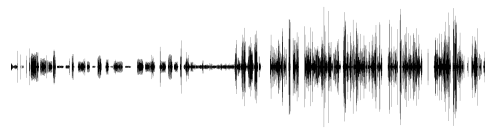


Figure 247: trrm-cb length: 00:08:40.01

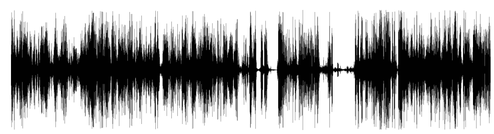


Figure 248: trrm-leo length: 00:02:40.64

Figure 249: wize-chiped length: 00:10:07.00

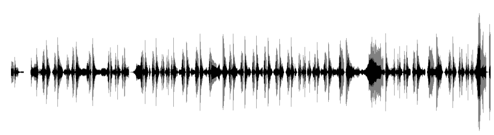


Figure 250: wize-group length: 00:10:07.00

Figure 251: wize-synth length: 00:10:07.00

Figure 252: zapp-all length: 00:10:00.00

Figure 253: zapp-arpp length: 00:10:00.00

Figure 254: zapp-bass length: 00:10:00.00

Figure 255: zapp-foo length: 00:10:00.00

Figure 256: zapp-jfh length: 00:07:06.42

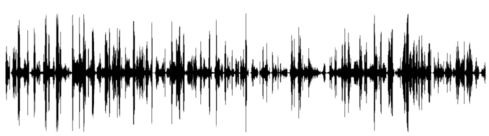


Figure 257: zapp-owc length: 00:10:00.00

Figure 258: zark-dronecut length: 00:10:39.62

Figure 259: zark-piano length: 00:03:17.49

Figure 260: zhel-chopstick length: 00:00:21.94

Figure 261: zoet-01 length: 00:02:22.98

Figure 262: zoet-02 length: 00:03:36.57

Figure 263: zoet-03 length: 00:00:54.81

Figure 264: zoet-04 length: 00:02:06.67

Figure 265: zoet-134 length: 00:07:04.77

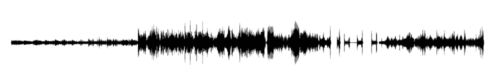


Figure 266: zoet-qeh length: 00:09:01.82

Figure 267: zzzg-cola length: 00:03:20.43

Figure 268: zzzg-static length: 00:11:50.01

Appendix C

Analysis Diagrams Of The Recordings

For the purposes of analysing the recorded works of this thesis I have settled on a methodology that involves annotating a spectrogram[1] analysis of each recording. The recording itself is depicted via the spectrogram in such a way that it forms a guide for the listener, allowing for a correlation between the time-line of the recording, its notation as frequency banded energy in the spectrogram and an analysis of the processes used in the *bricolage* at that point in the recording.

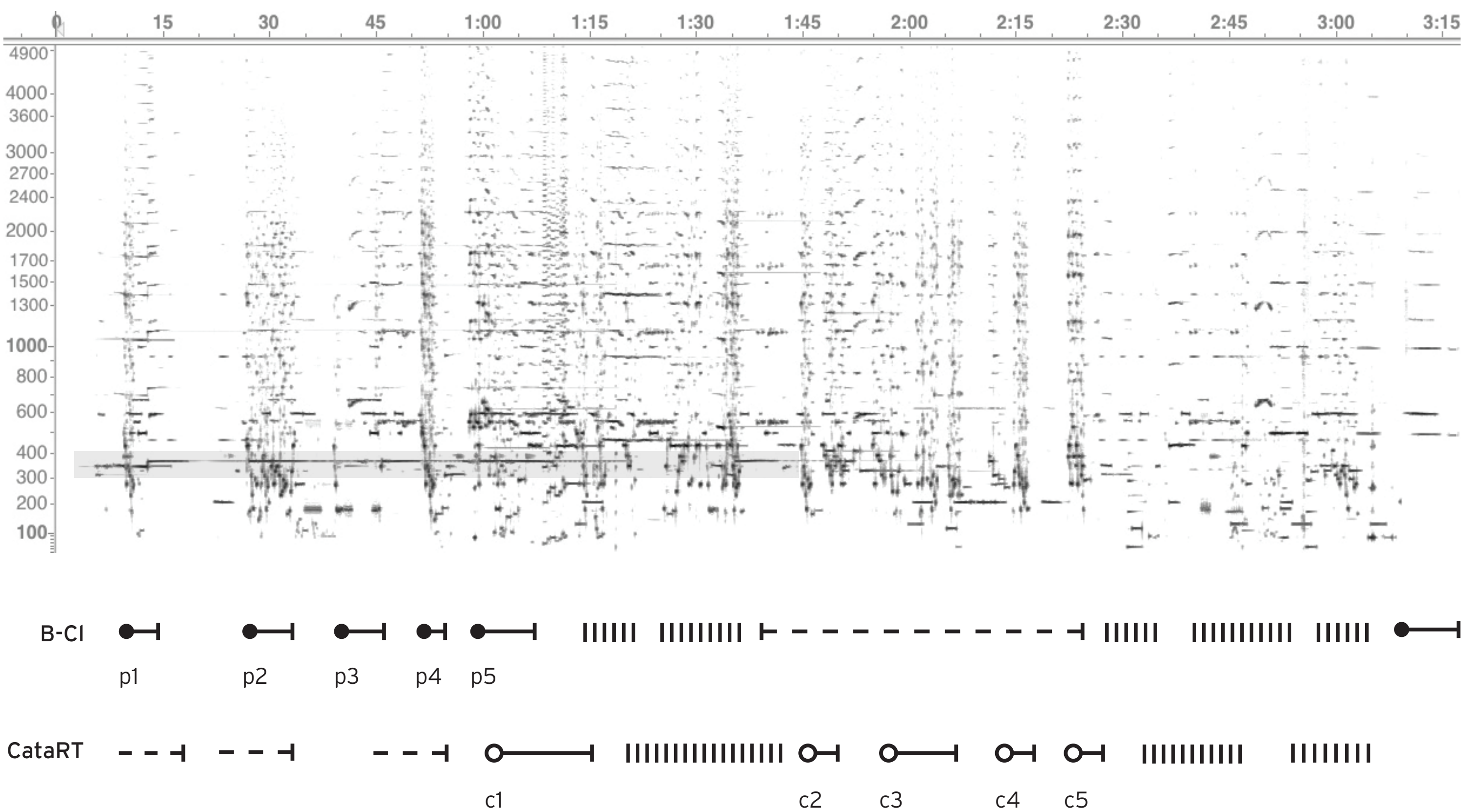
Key:

B-Cl : Bass Clarinet
CataRT : Real Time Concatenative synthesis (see section 5.2.1 for details).
R : Real time recording and processing of an external input to the *bricolage* (in general of an instrumental performance via a microphone).
C1-3 : instance of a real time Concatenative synthesis engine (see section 5.2.1 for details).
str : granular synthesis / stretching.
SA : Spectral Additive synthesis (see section 5.2.3 for details).
SR : Spectral Re-synthesis (see section 5.2.3 for details).
M : ring / frequency Modulation (see section 5.2.3 for details).
GG : Gestural Gating (see section 5.2.3 for details).

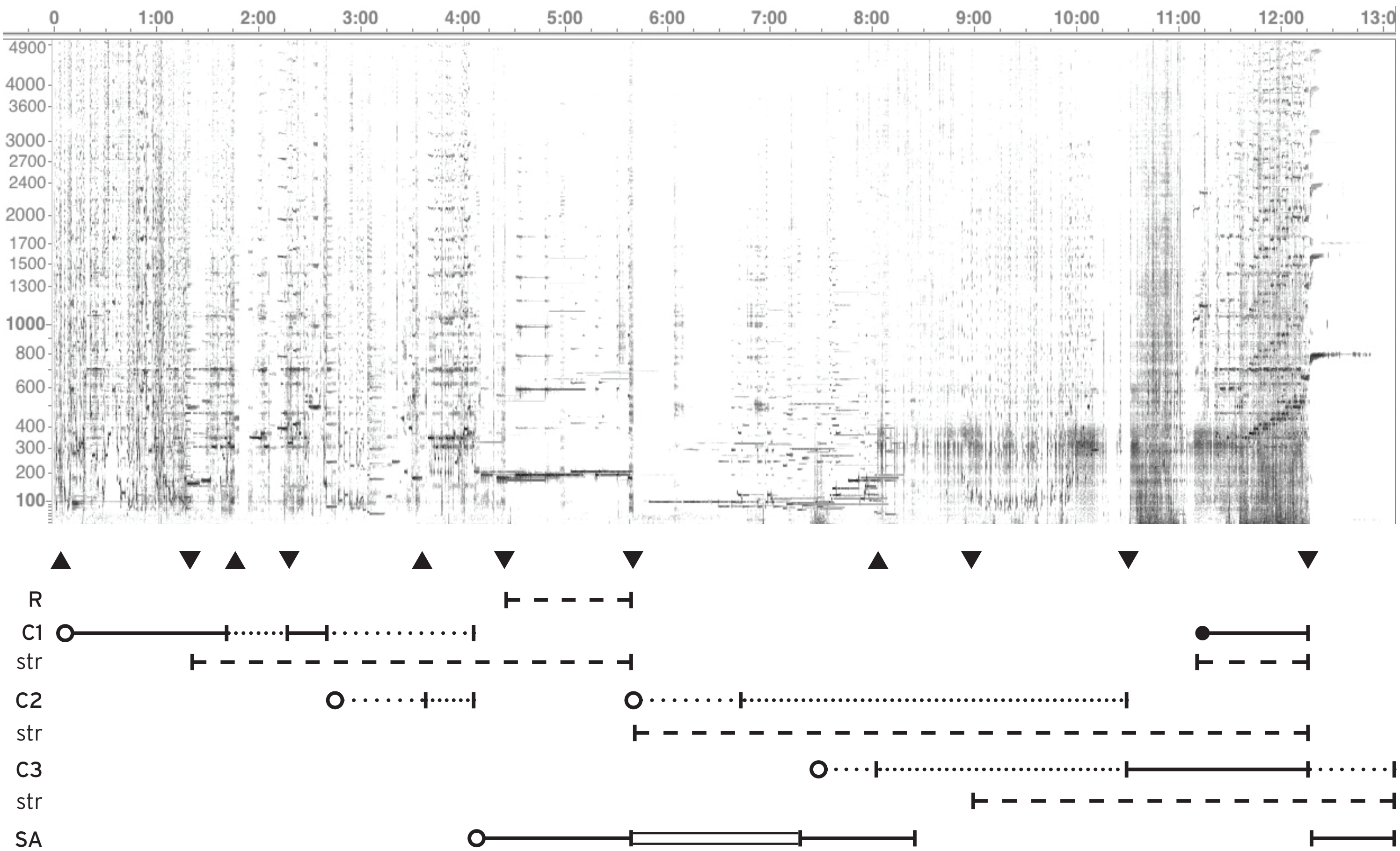
Continuous Lines denote continuous audible performance. **Hatched Lines** denote gestural articulation in the performance. **Dashed Lines** denote intermittent episodes in the performance. **Dotted Lines** denote more dense areas of sporadic performance. **Wavy Lines** denote pitch variation. **Thin Parallel Lines** denote extreme frequency variation in the sound.

[1] "A spectrogram is a visual representation of the spectrum of frequencies in a sound or other signal as they vary with time" from the Wikipedia entry on the Spectrogram.

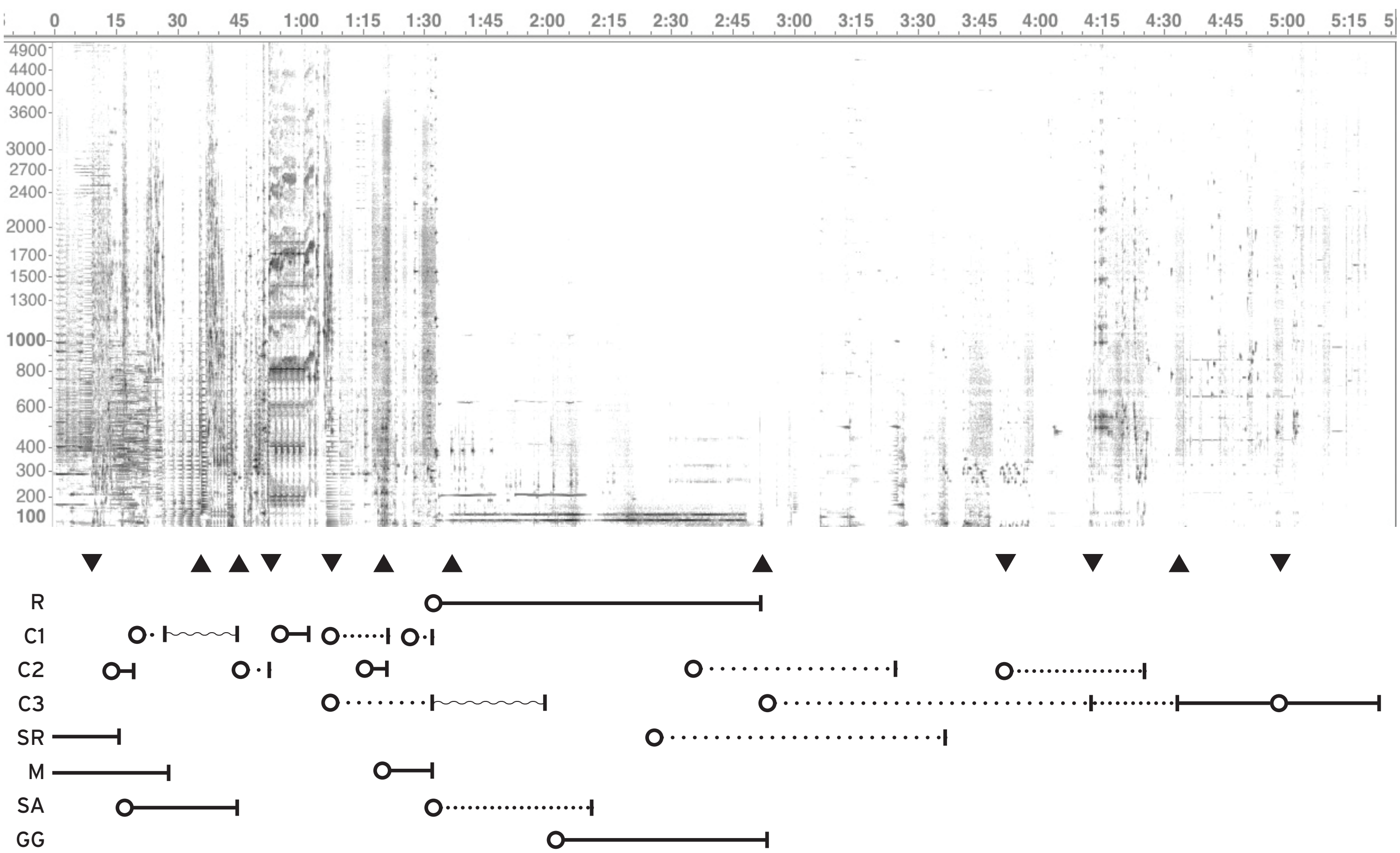
Haze (excerpt) - Lothar Ohlmeier / Isambard Khroustaliov



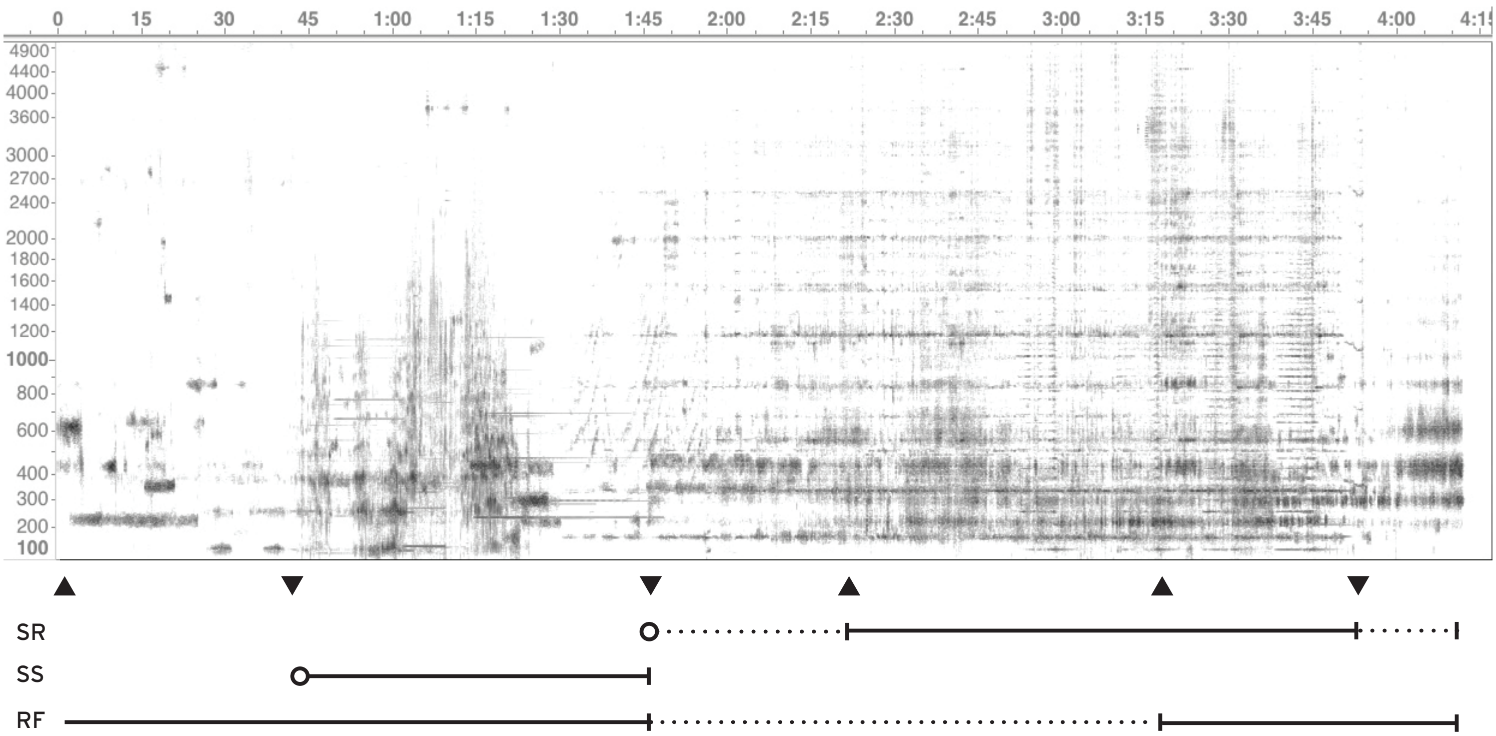
Scratch - Lothar Ohlmeier / Isambard Khroustaliov



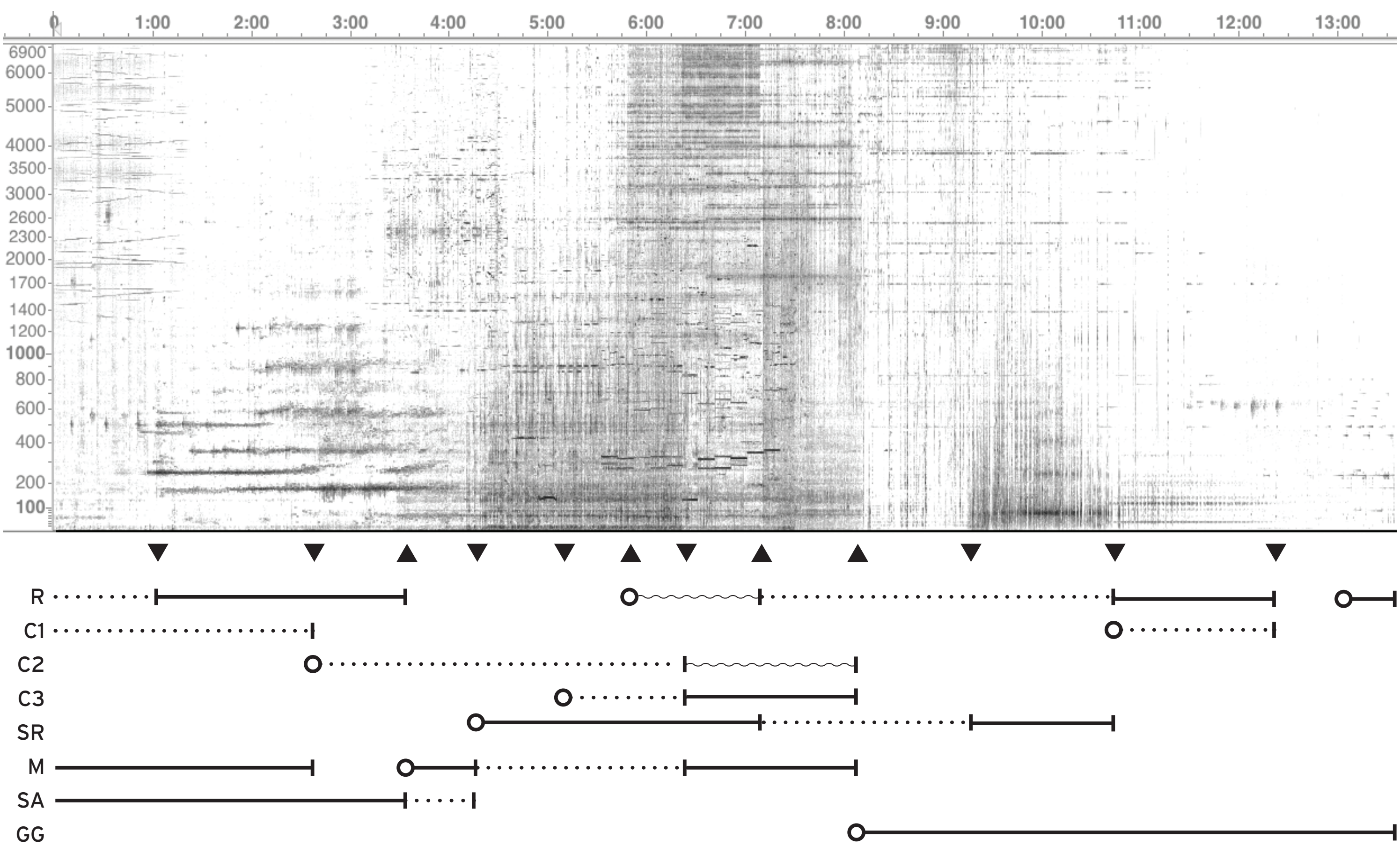
Avenue (excerpt) - Lothar Ohlmeier / Isambard Khroustaliov



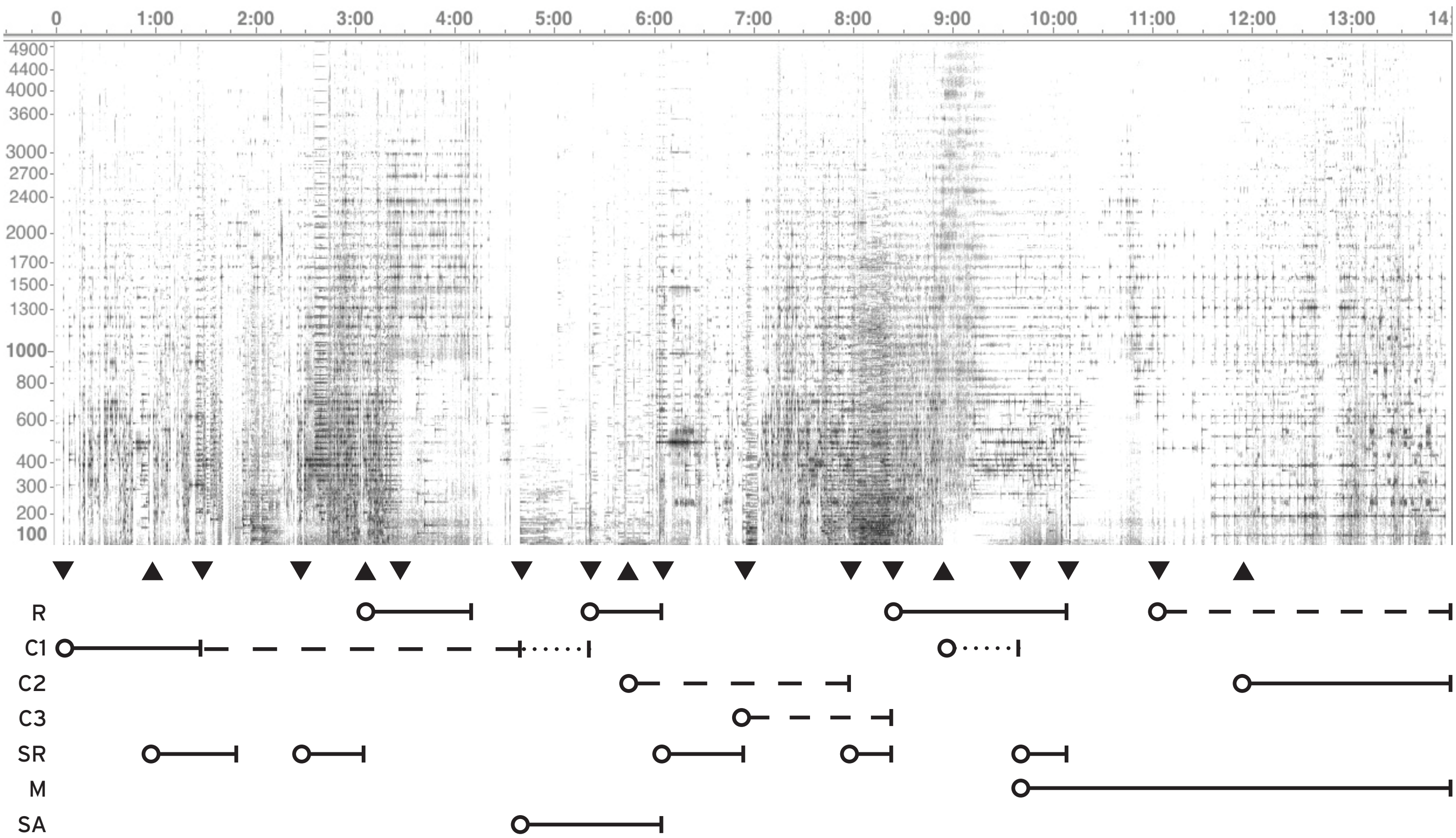
Fear Of Bees - Maurizio Ravalico / Isambard Khroustaliov



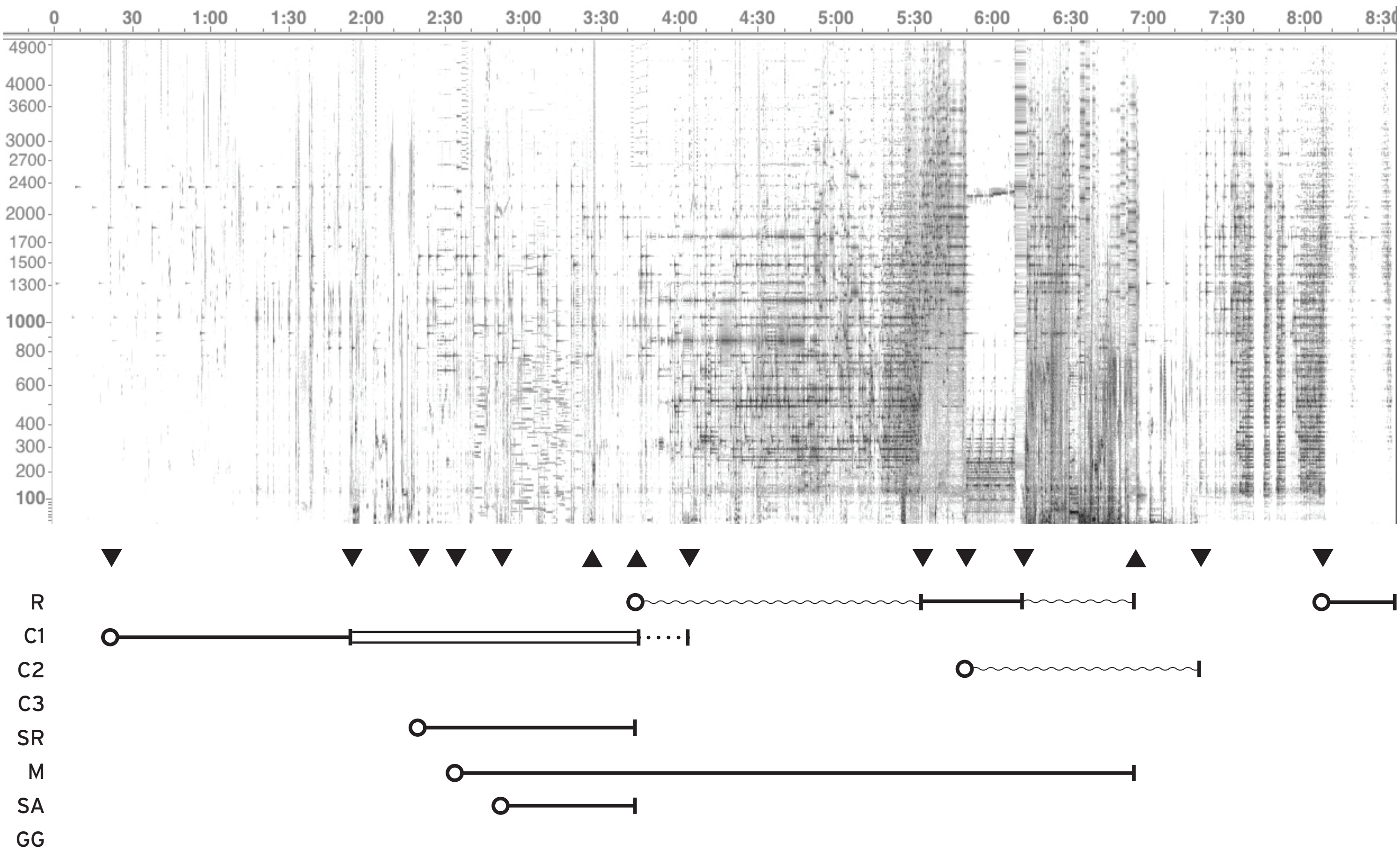
The Leisurely Exploration of a Karstic Area - Maurizio Ravalico / Isambard Khroustaliov



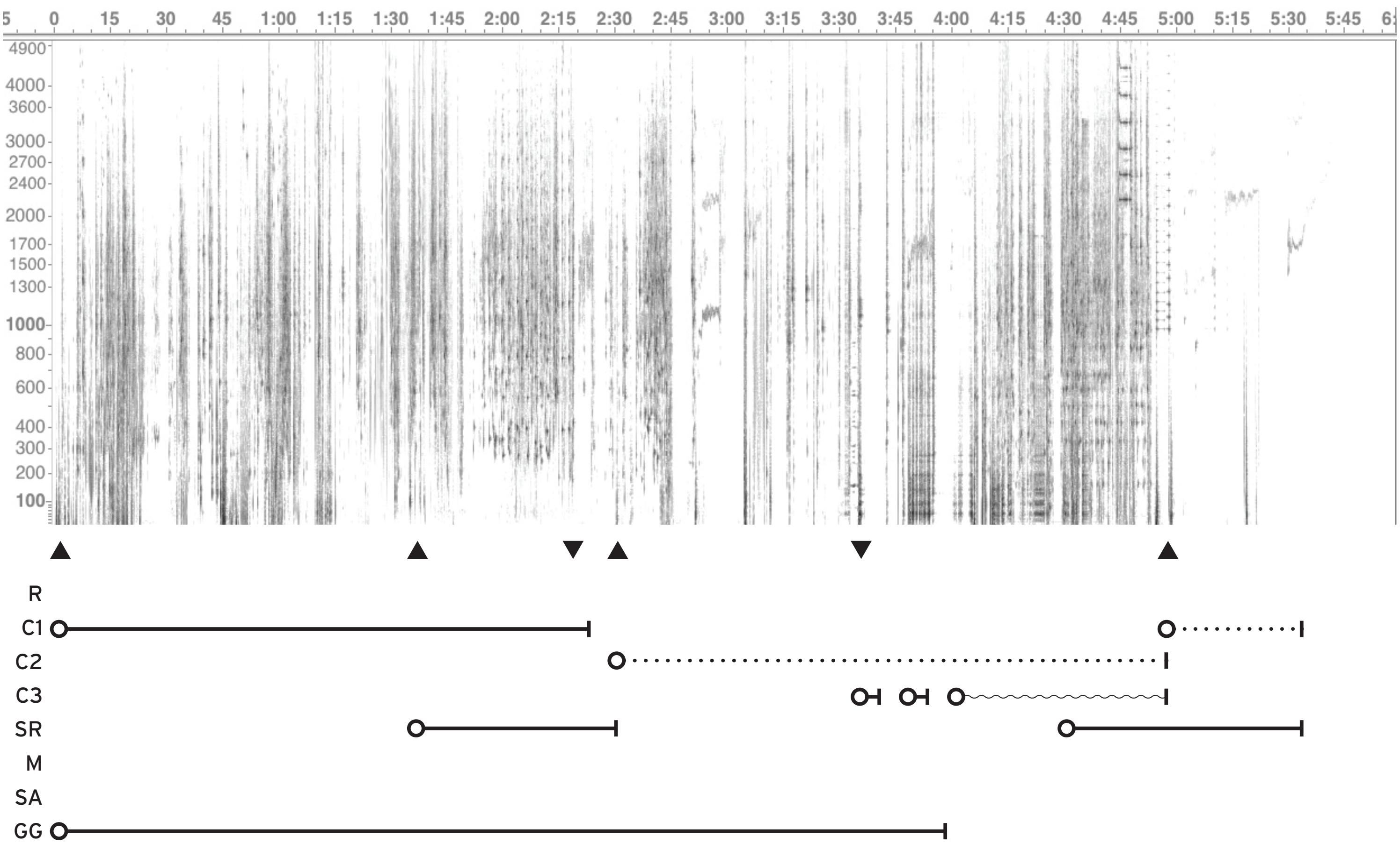
Until Yet - Tolga Tuzun / Isambard Khroustaliov



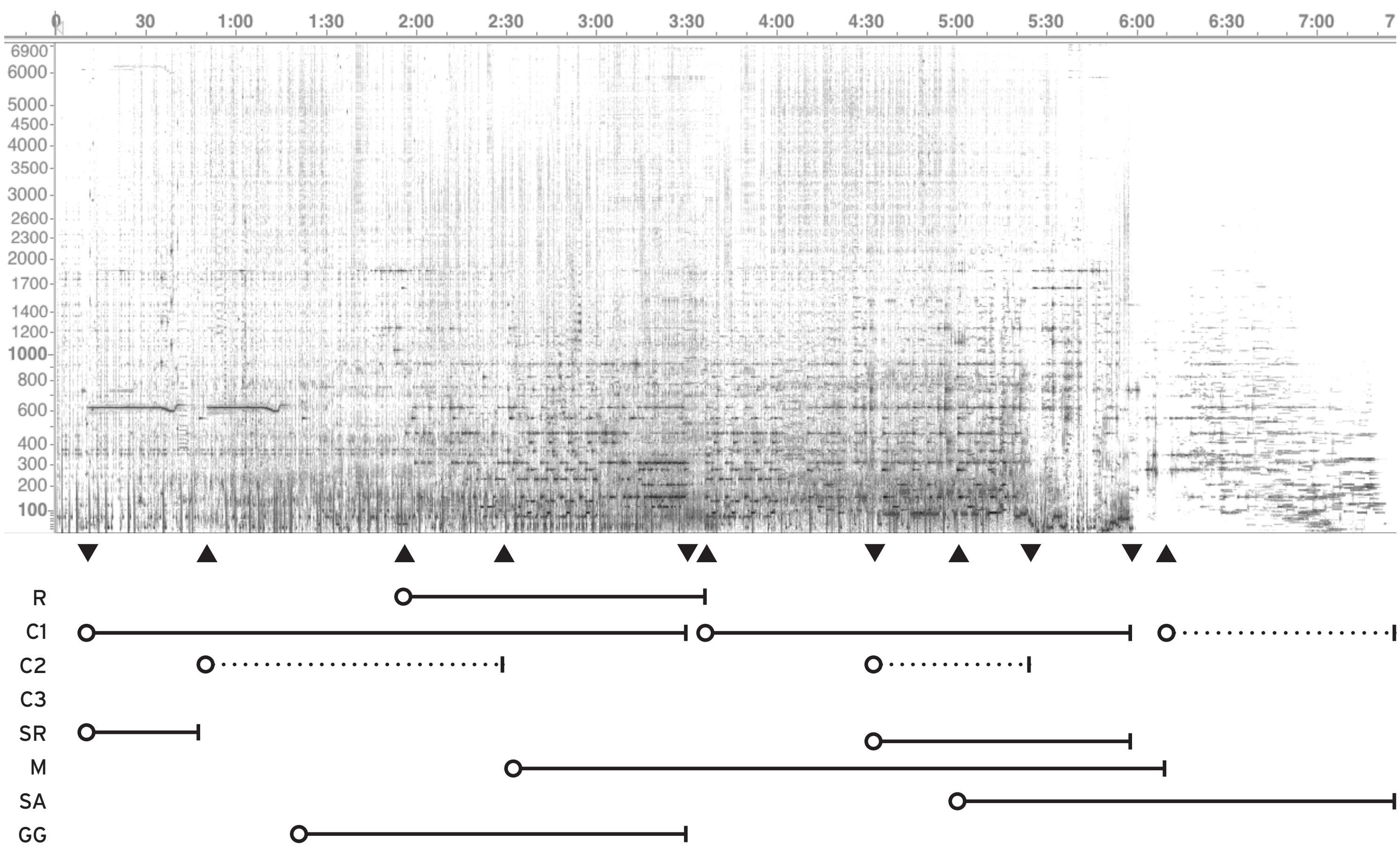
From Bloom To Bust I (excerpt) - Tolga Tuzun / Isambard Khroustaliov



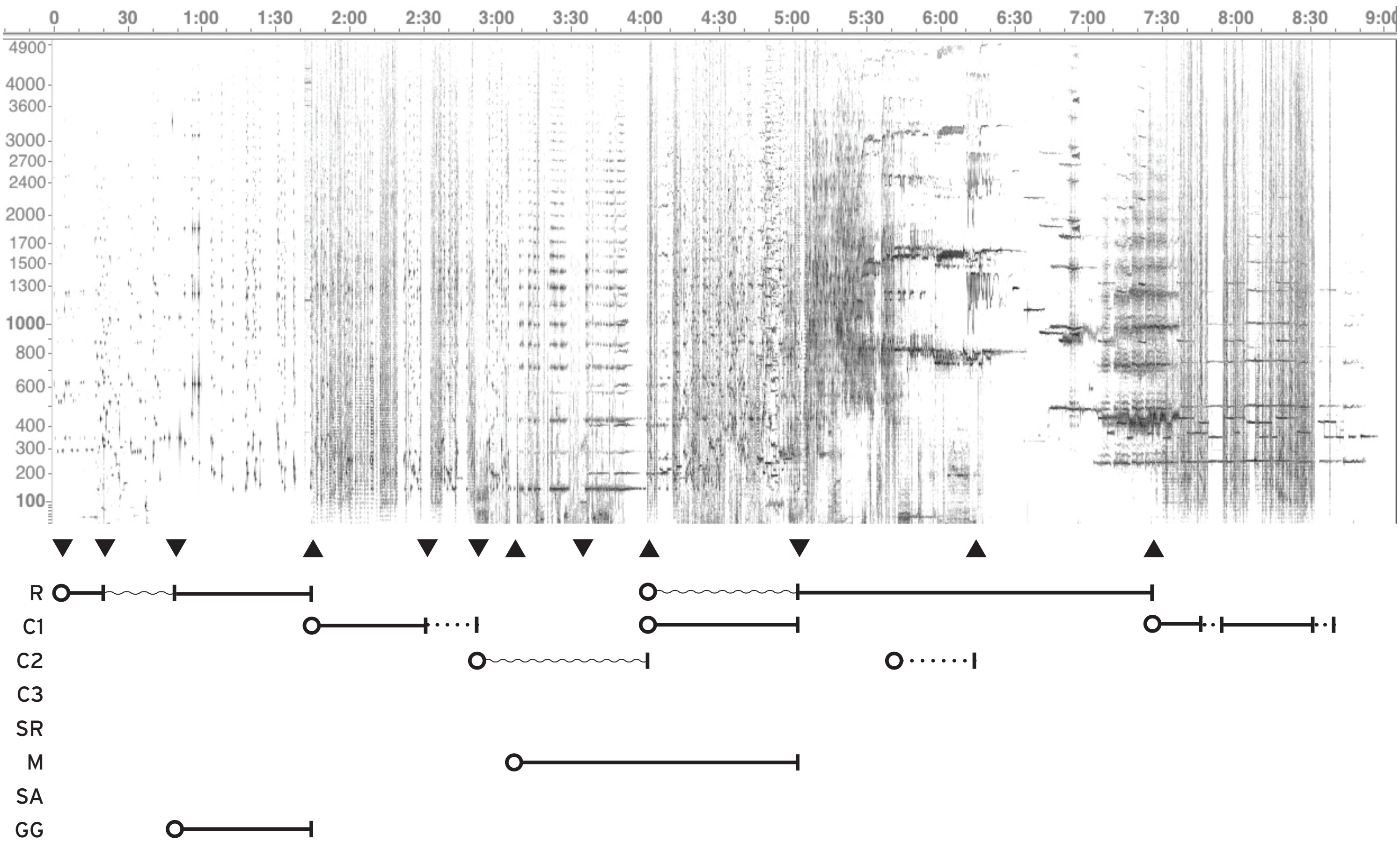
Irena Piperin - Tom Arthurs / Isambard Khroustaliov



Sparkly Bear - Icarus



Long Division - Tom Arthurs / Lothar Ohlmeier / Isambard Khroustaliov



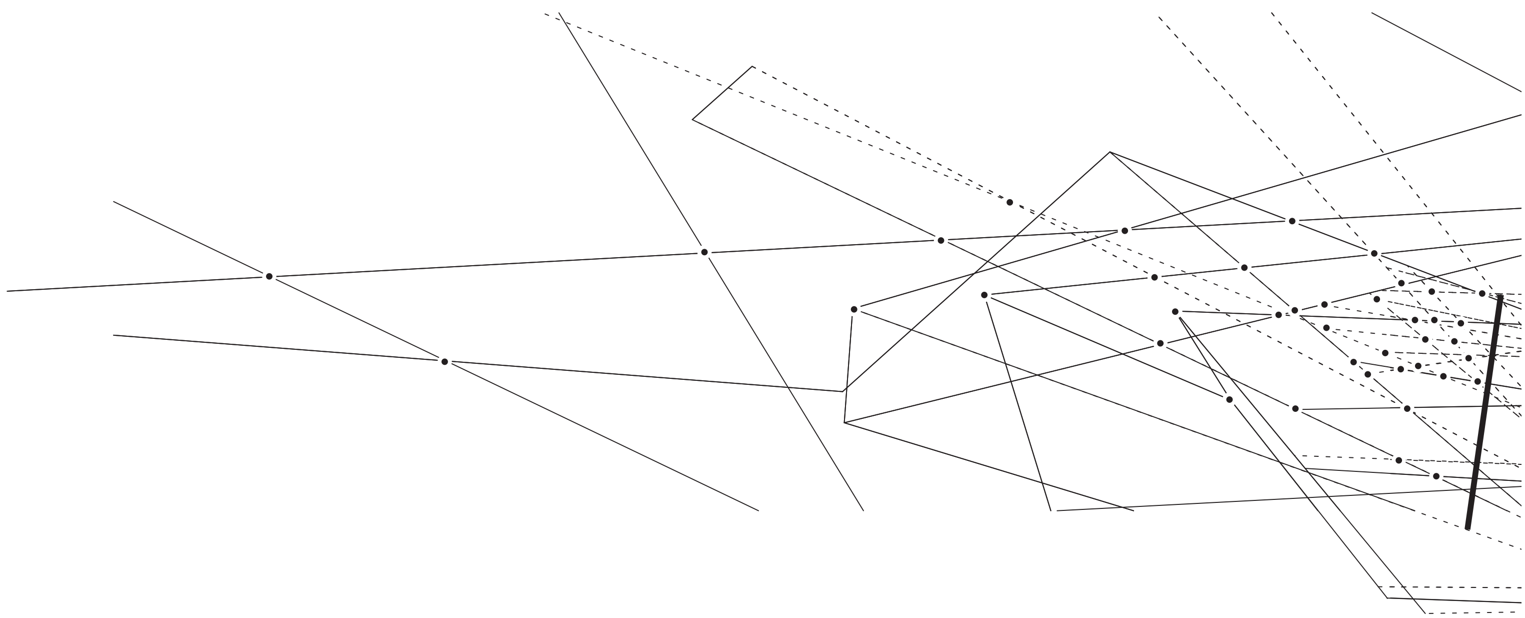
Appendix D

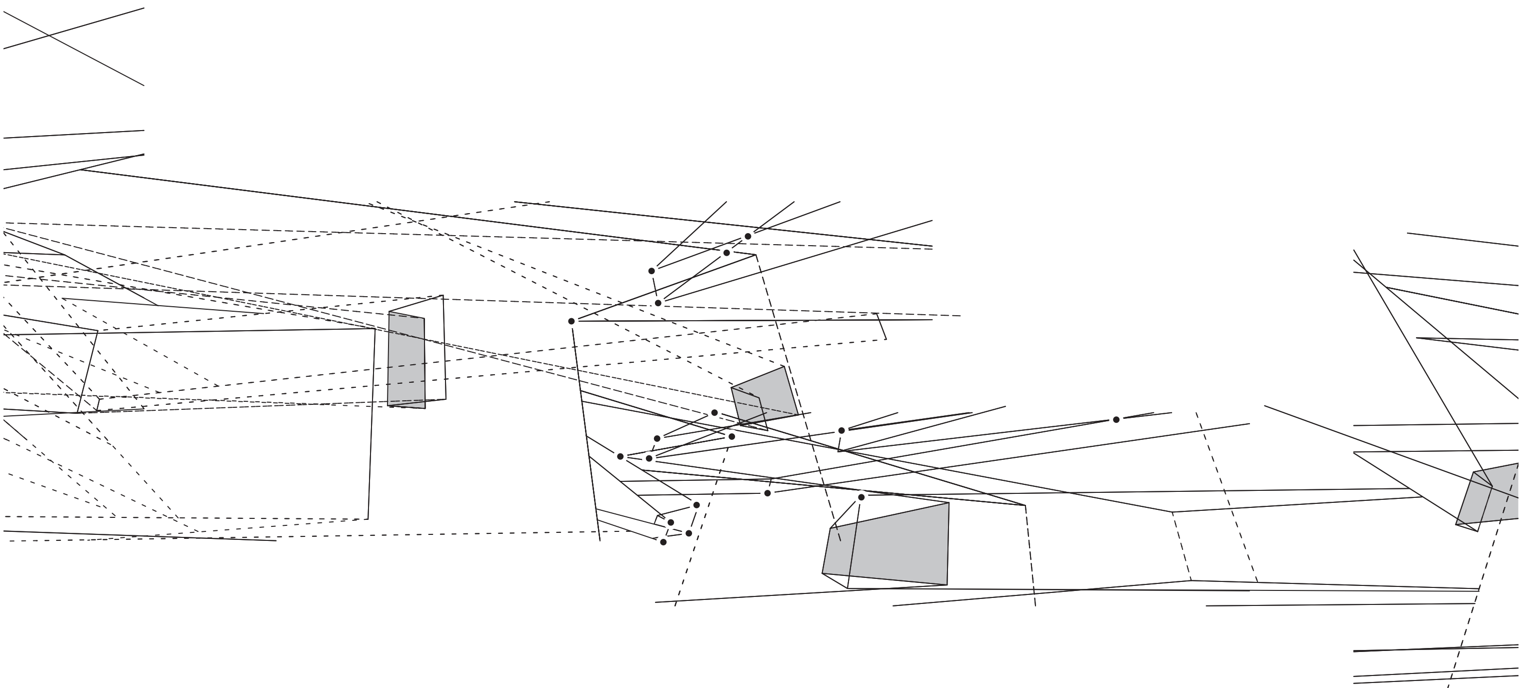
Scores

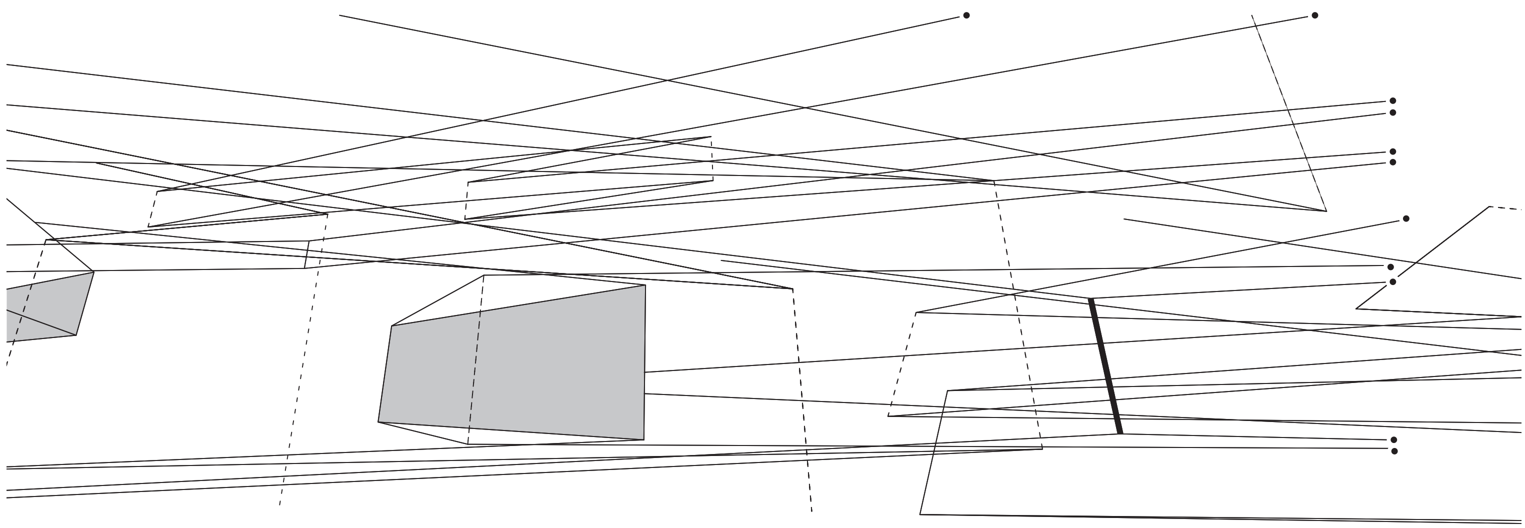
D.1 Aporia

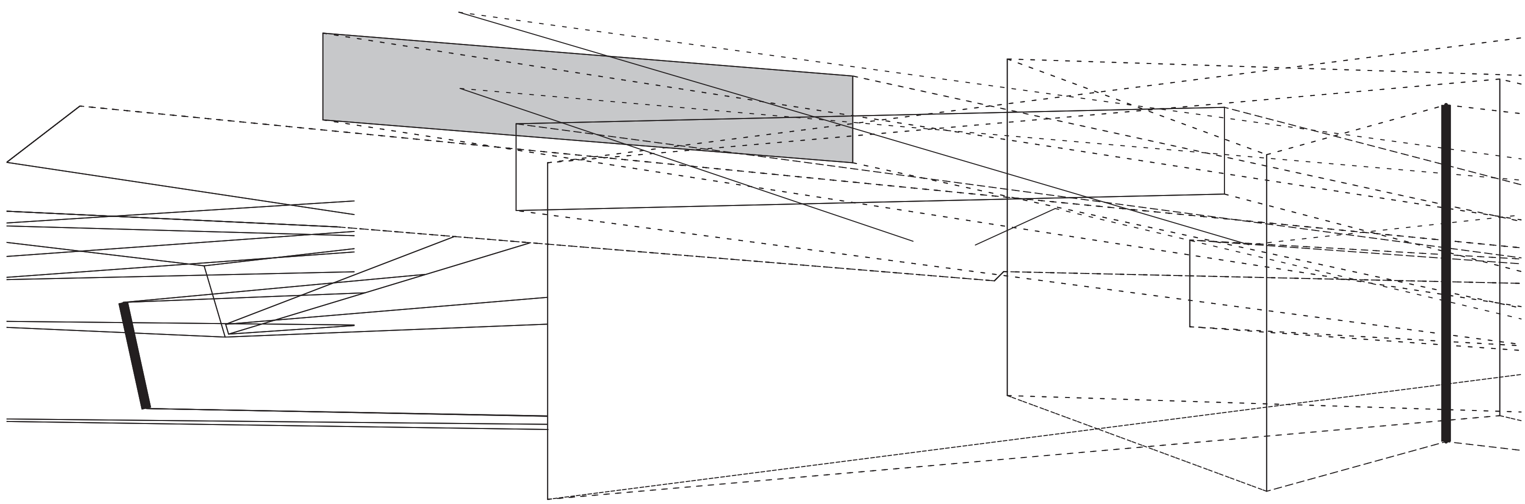
aporia - catalyst for an improvisation

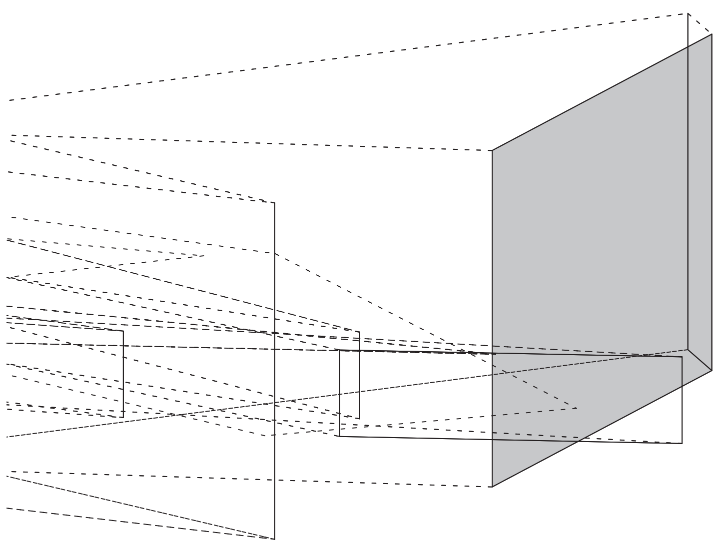
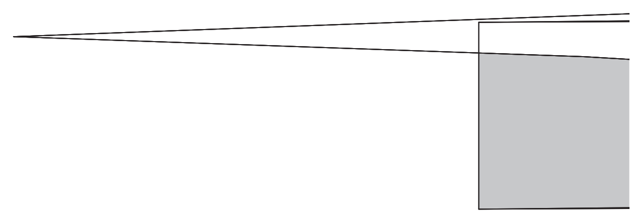
sam britton - london - spring 2007

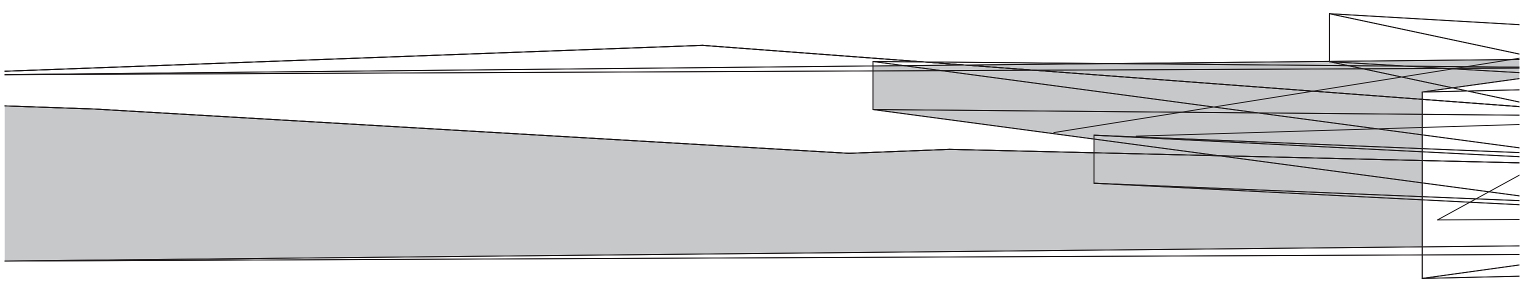


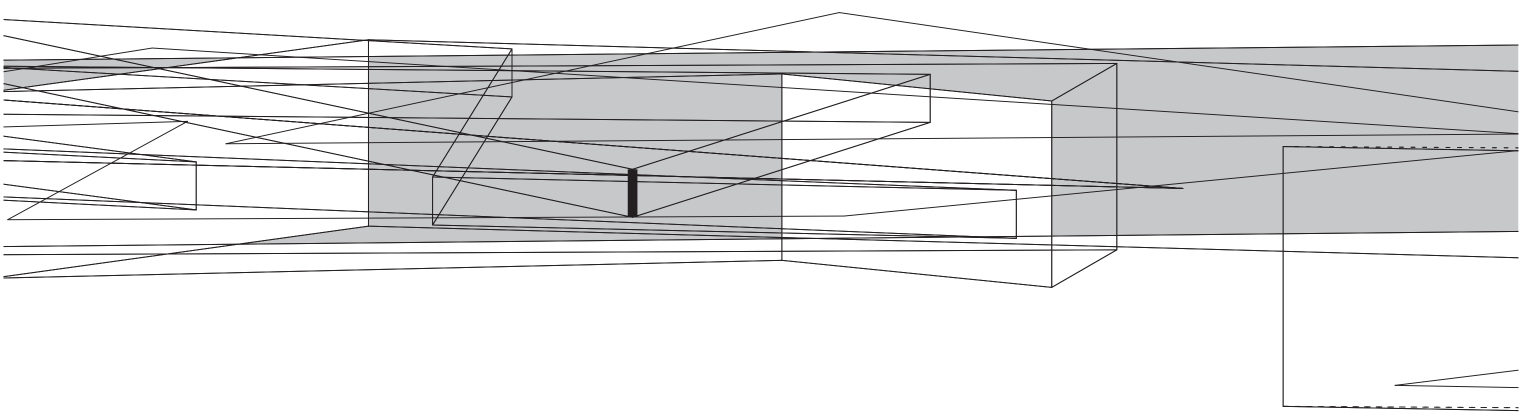


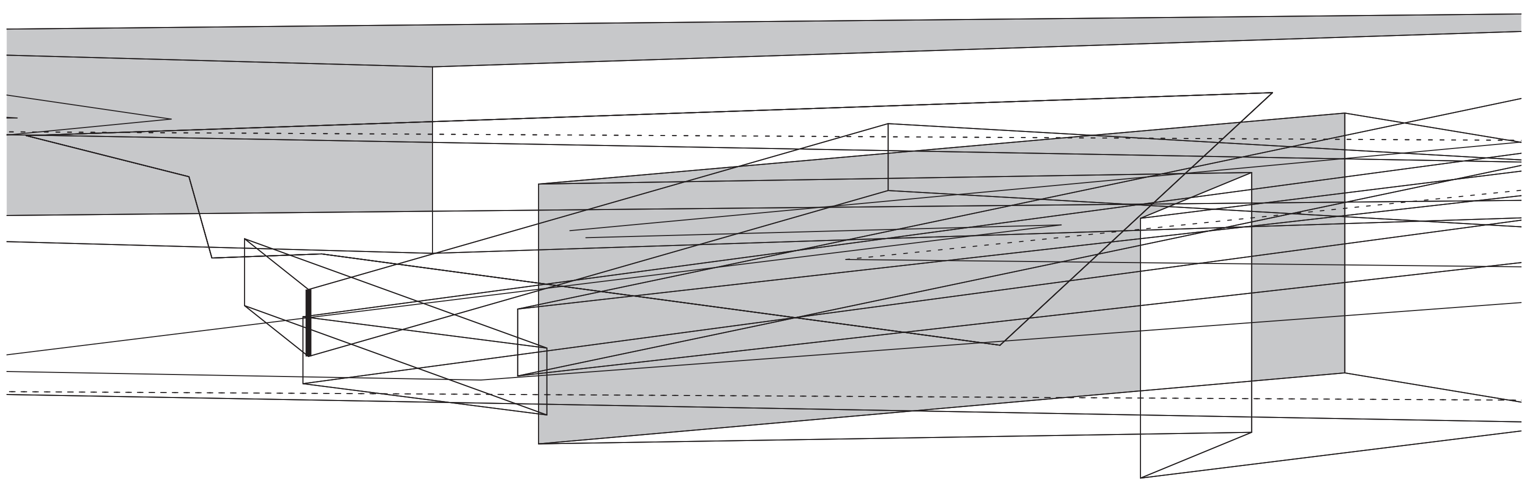


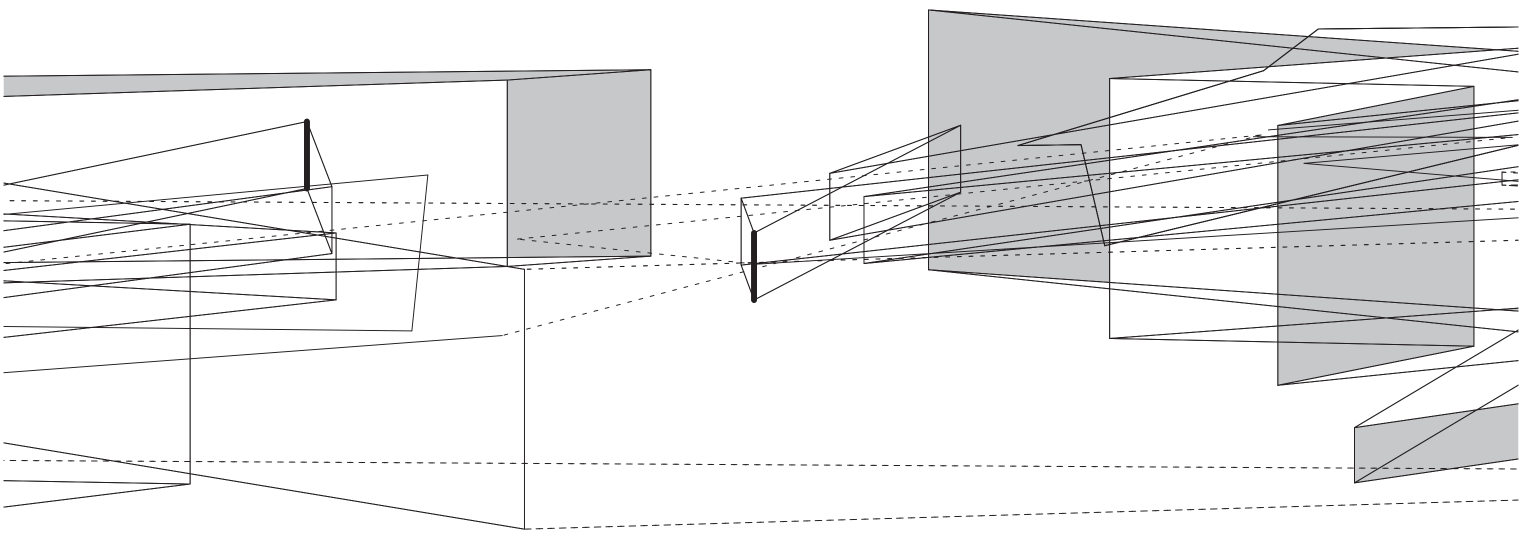


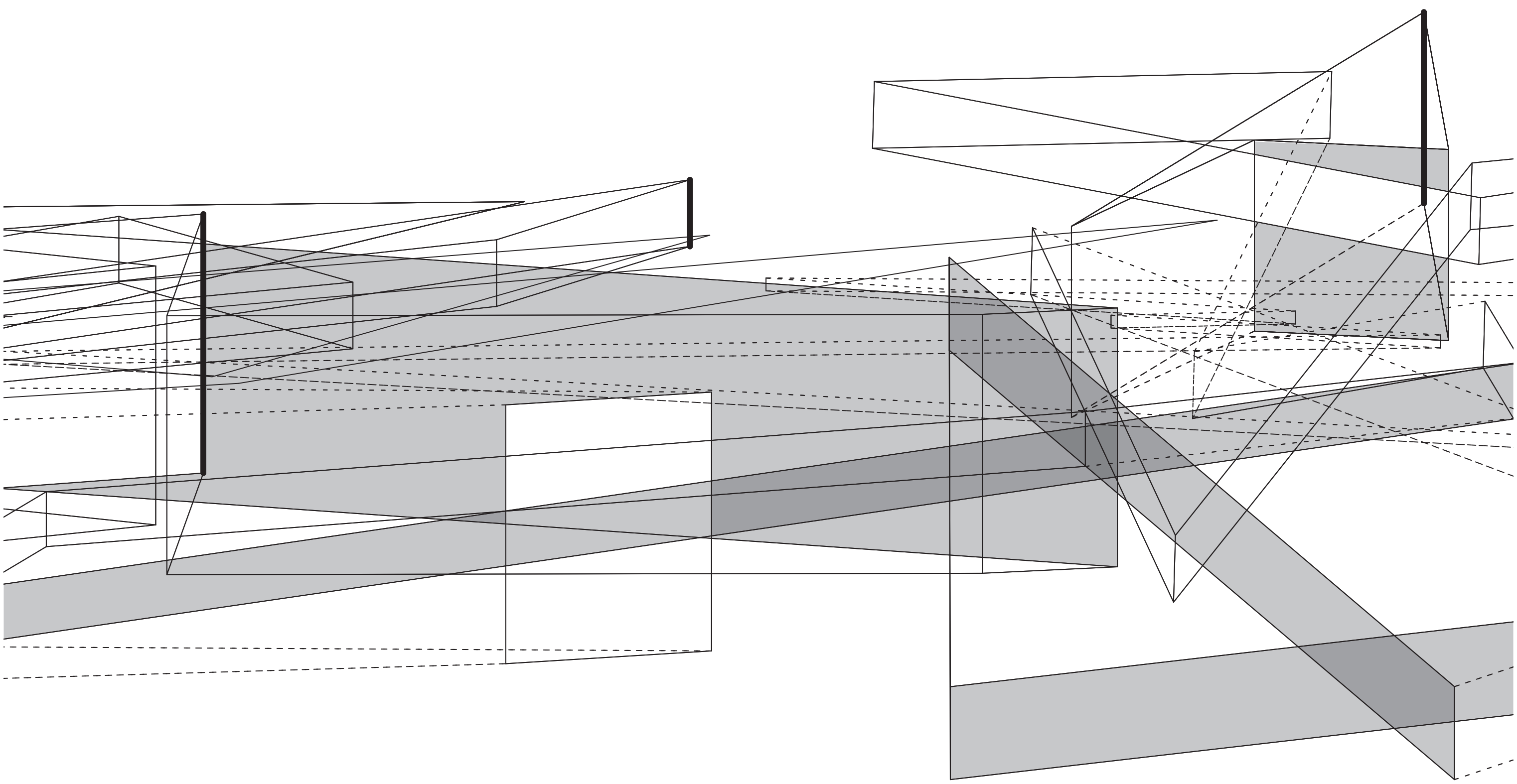



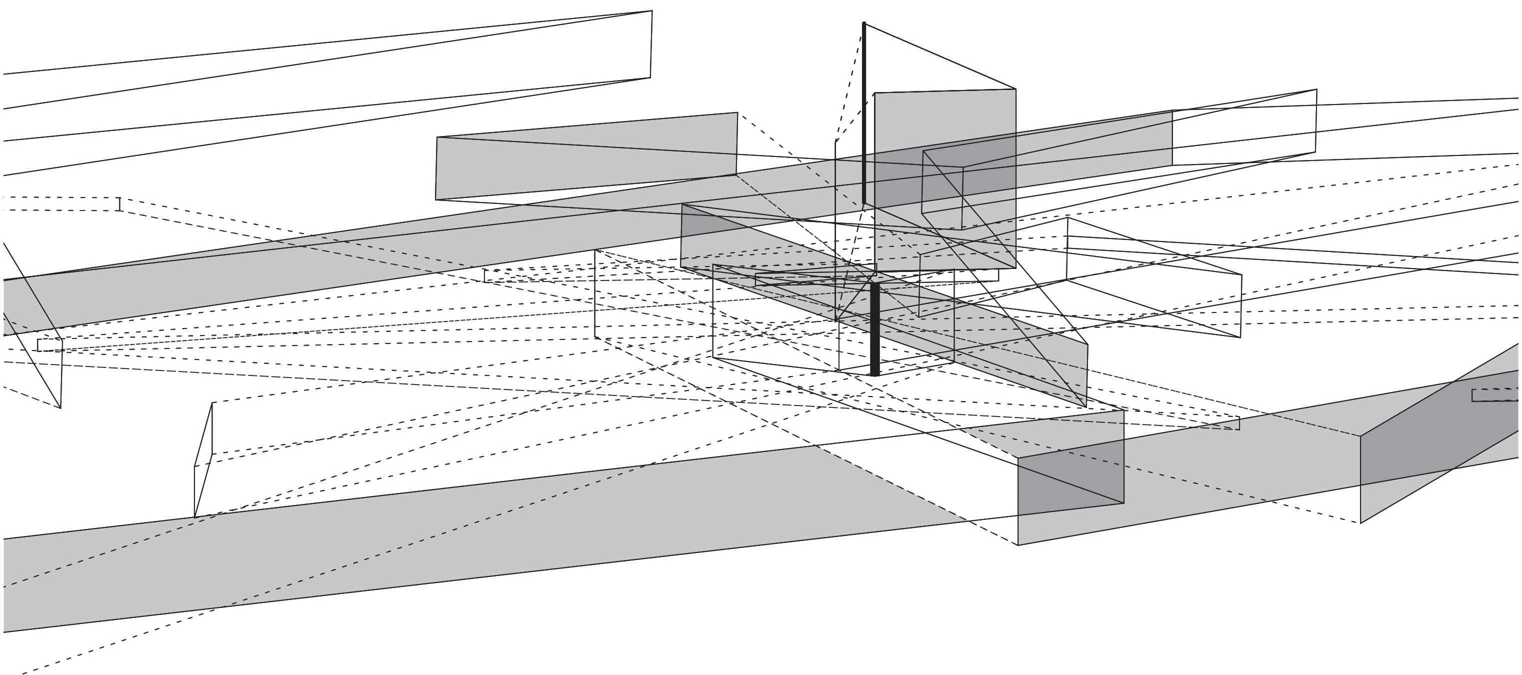


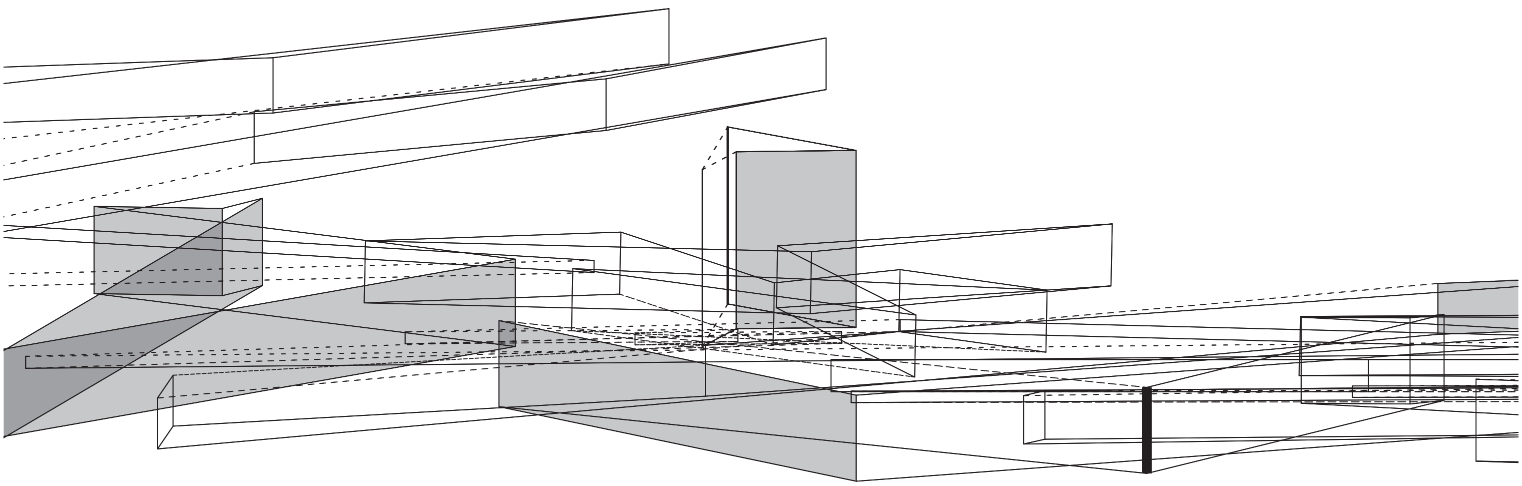


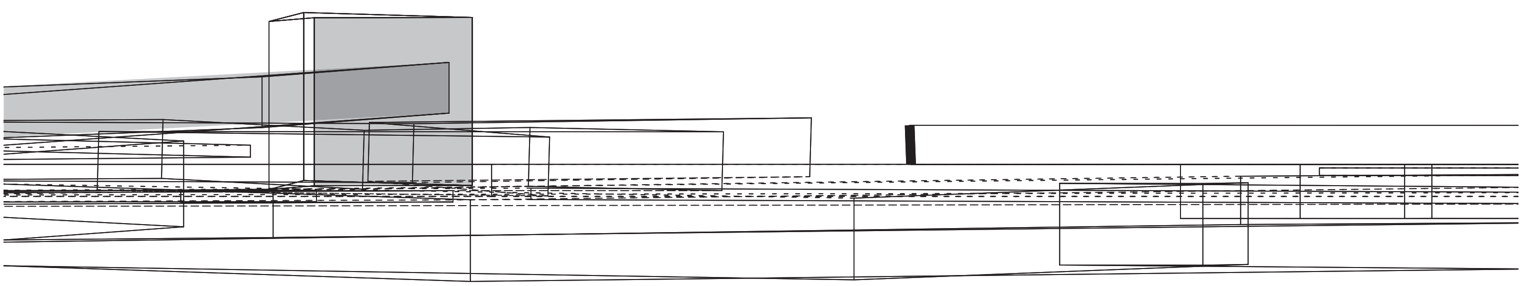


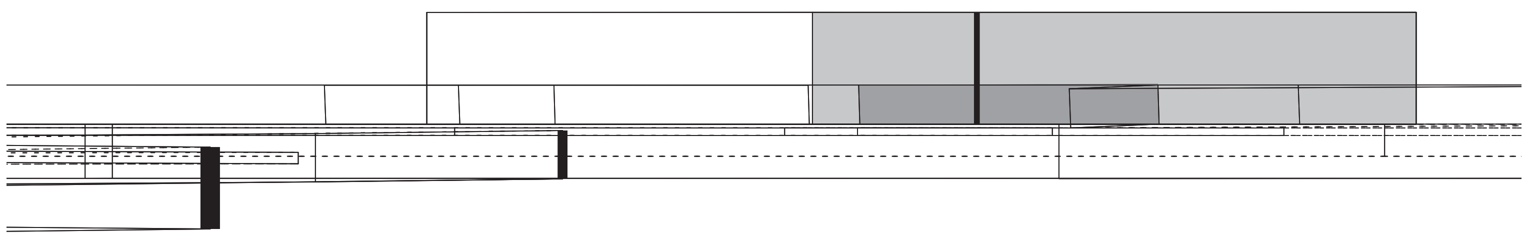


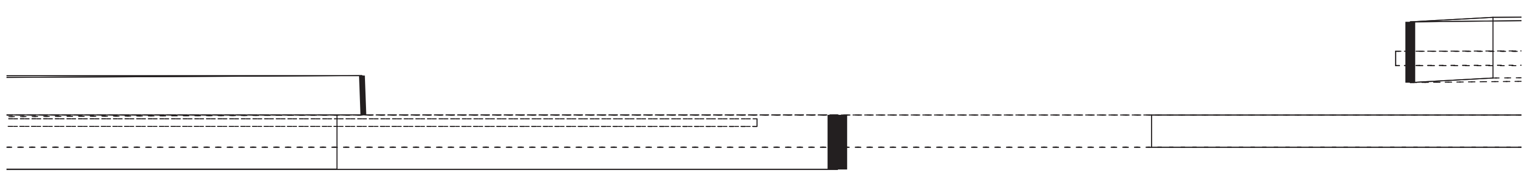


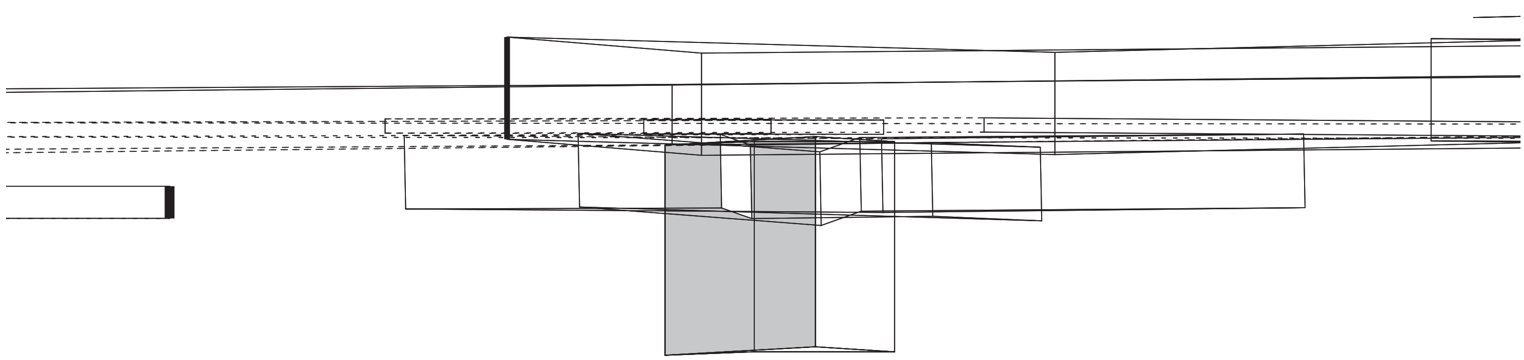


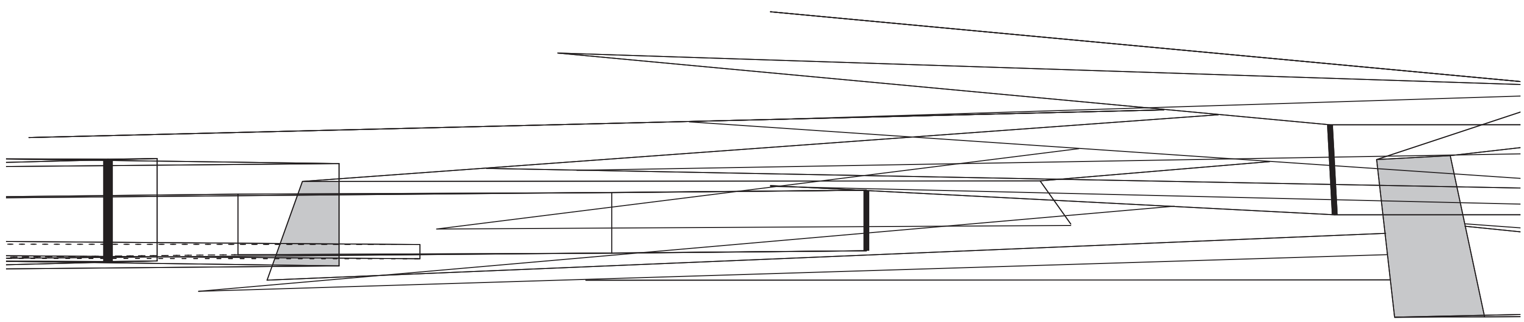


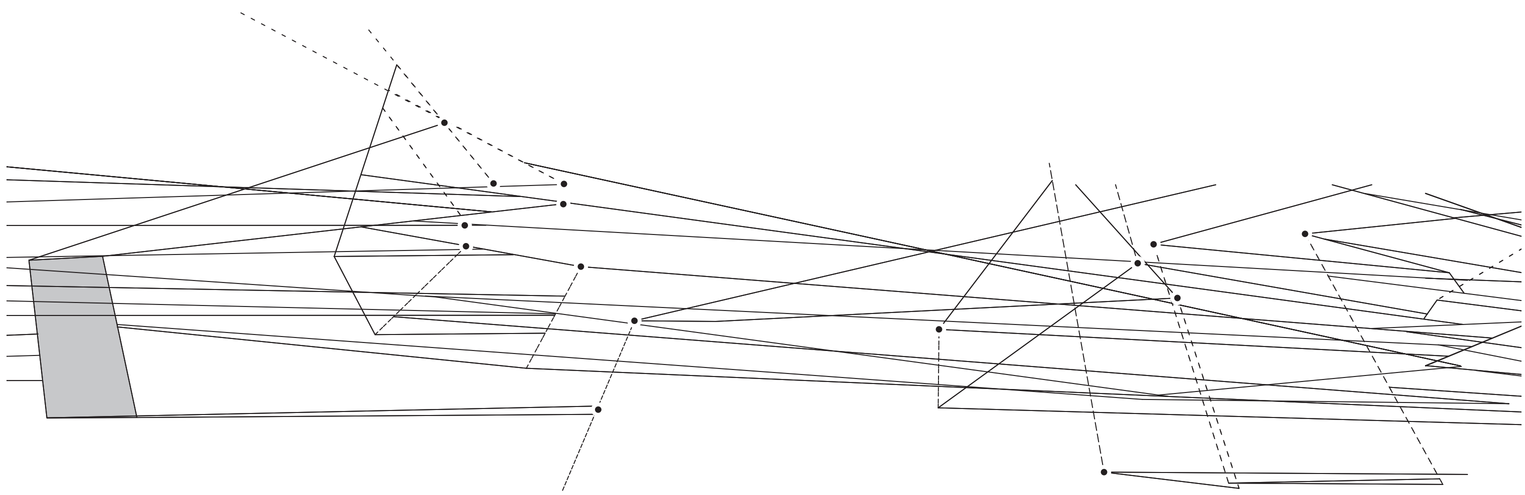


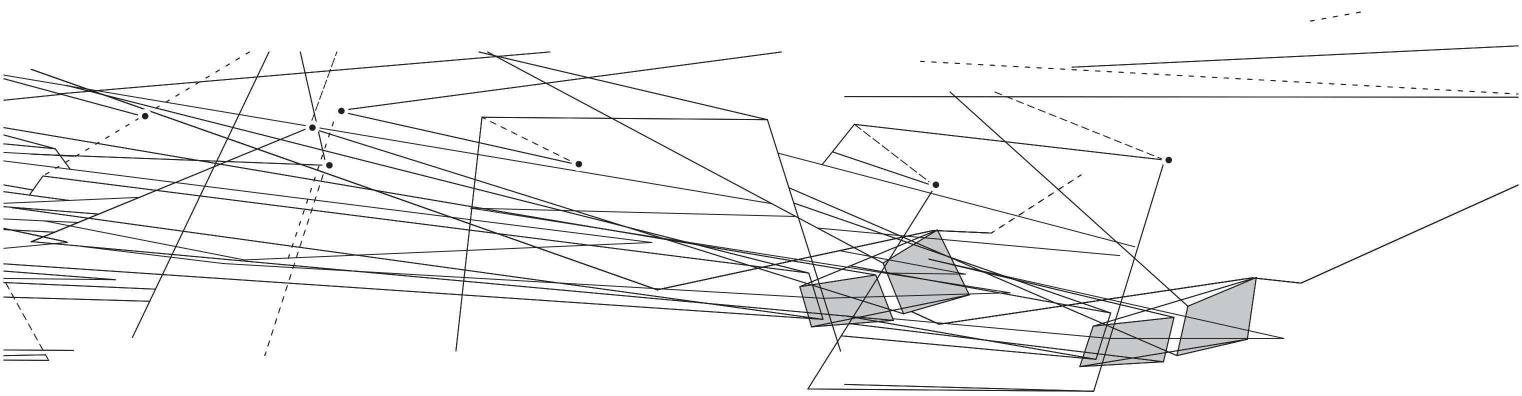


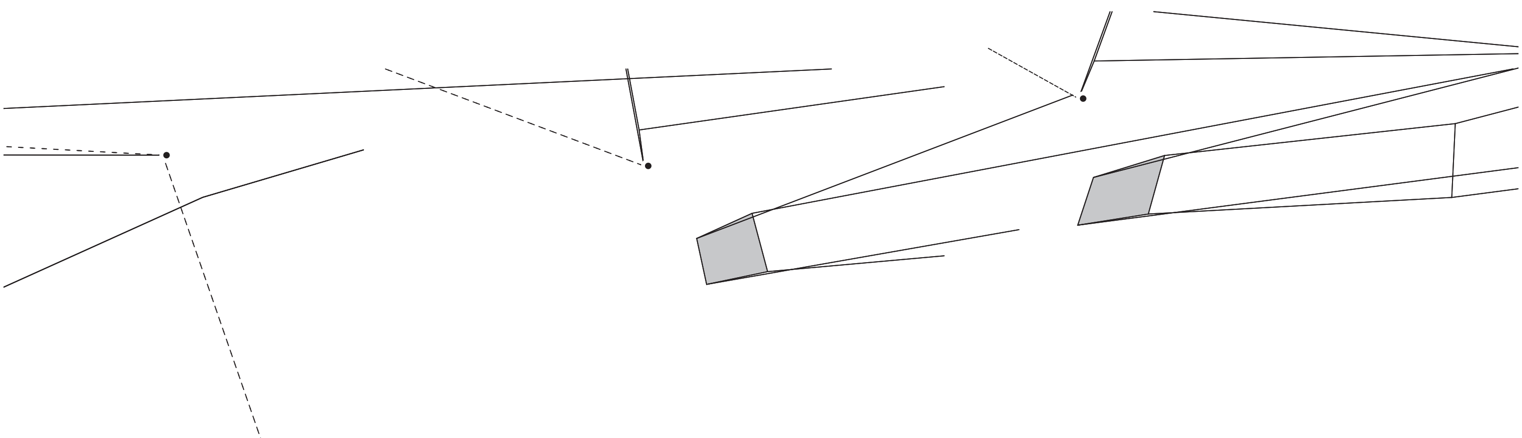


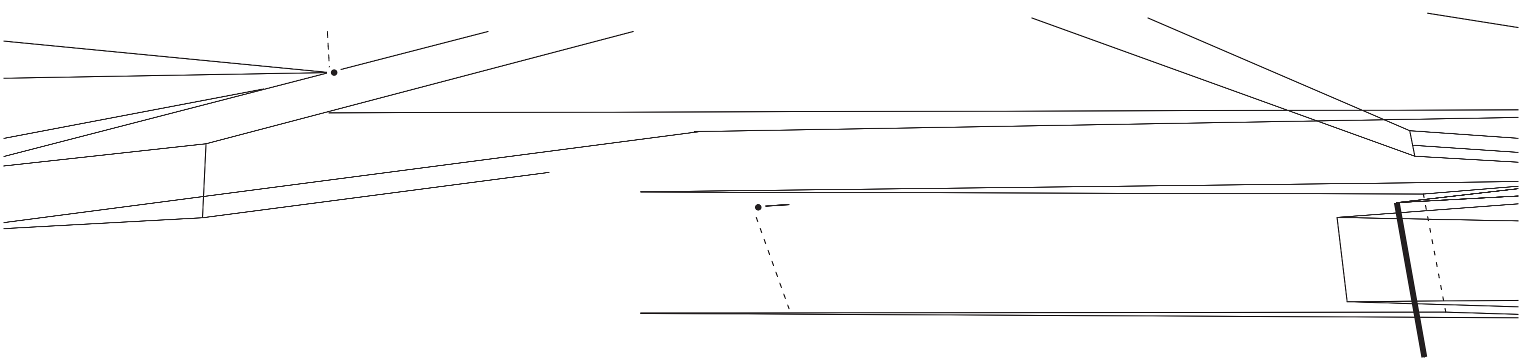


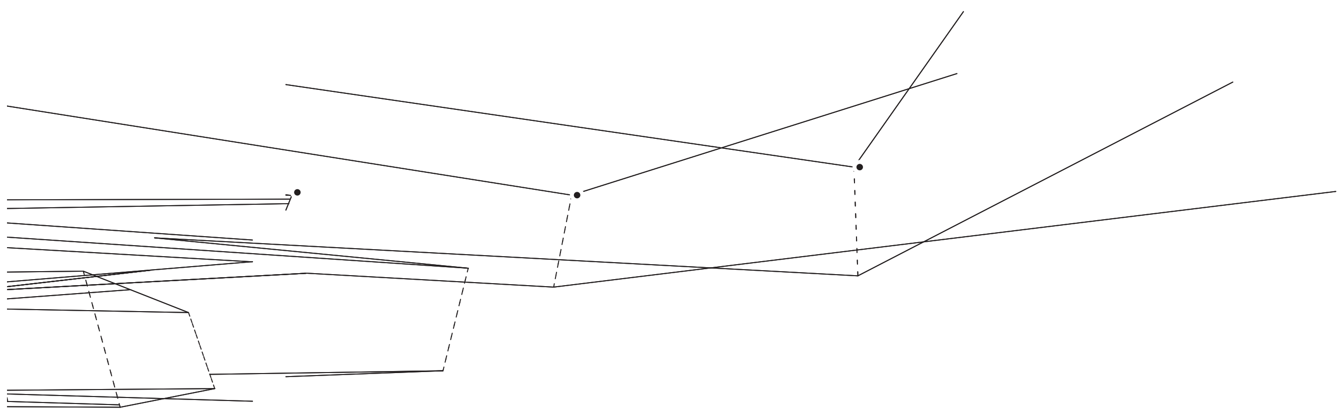




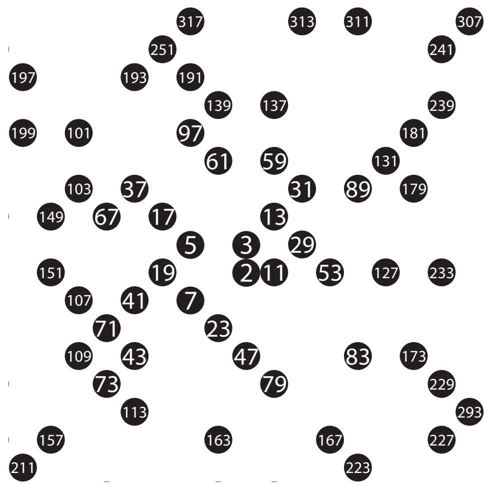








D.2 Axiom



AXIOM (a battle) Op. 3

Sam Britton, London, August 2010

DESCRIPTION:

Axiom is a piece designed for any number of musicians and a prompter and seeks to explore questions of compositional decision making by highlighting the roles of reflection and production that inform music. The piece is conceived as a simple collection of elements whose combination can lead to increasingly complex musical propositions. The interpretation of these signs and signifiers through the act of performance produces differing musical genealogies which must be reflected upon from a semantic point of view. It is this reflection and the identification of meaningful passages or otherwise that can be seen to condition the broader sense and form of the music itself.

STRUCTURE:

The score consists of two discreet parts:

1. A SHEET OF PROPORTIONAL GRAPHIC NOTATION (Divided into zones and sub-sequences)

The sheet of proportional graphic notation is provided which is intended to give a concrete indication as to what should be played. It is important to note that, in keeping with the general proposition of the piece, the graphic notation is not arbitrary, but in fact derived from prime number sequences. In the same sense that the overall piece proposes to construct a more complex edifice through simple building blocks, the notation here is built from the proportions of one of the simplest, yet unresolvable sequences in mathematics.

The score is separated into ZONES (1 - 5), which are read from left to right and from top to bottom. REGIONS within the ZONES are also indicated by triangular MARKERS. A black triangular marker indicates the beginning of a region and a corresponding white triangle indicates the end of a region. The distinction between REGIONS and MARKERS is an important one and can be defined by the fact that whereas REGIONS have a designated endpoint MARKERS simply indicate a starting point and therefore can refer to any length of material after that point. Note that not all MARKERS have endpoints, meaning that a REGION may span two or more markers.

There are also LOOPS indicated in each sequence ➤I (forwards) and ➤⮜ (alternating forwards and backwards). When called, LOOPS should be played as many times as deemed relevant by the individual. They may also involve a pause between repetitions, although the pause between repetitions should not exceed 30 seconds.

When playing REGIONS or MARKERS, any LOOPS contained within should be played and the relative TEMPO indication, found in the track above the timeline should also be taken into account. TEMPO is relative and is calculated by each player in consideration to the speed at which they start playing each cue.

The sections delineated by dashed areas and marked with U are UNIQUE events, to be chosen by the player and played once. These UNIQUE events differ from REGIONS and MARKERS in that they exclude any LOOPS contained within them and are free from the TEMPO references above the timeline.

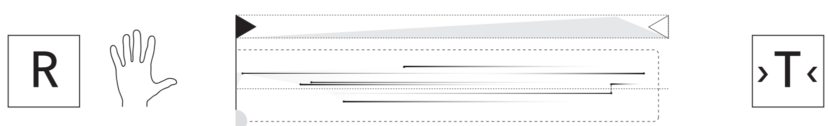
Another thing to note is the fact that LOOPS and UNIQUE events are sometimes nested within each other. When playing MARKERS and REGIONS the nesting is relative to the convention of reading from left to right, meaning that only the lowest level, self-contained LOOPS in the cue are read and the UNIQUE events ignored. However when a LOOP or UNIQUE event is called specifically, the nested structures must be read hierarchically, starting with the smallest element and preceeding upwards.

Ultimately, it remains up to the individual performer as to what level of detail they wish to render their performance and how they wish to interpret each parameter (the score allows for any number of levels of interpretation). Naturally, familiarity will always play a role in this kind of a piece, but it is also important to note that the desire to engage with the notation and the way in which the piece is played is in every respect much more important, without this, there is nothing.

2. PROMPTERS CARDS

The prompter (or conductor) has at his disposal a series of cards which control the actions of the piece (outlined on page 4). The cards indicate regions within the sheet of notated material and how these regoins are cued, the cards also indicate modifications to the current state of play and also permit functions such as storing a particular configuration, to be recalled later on in the piece.

In addition to the cards, the prompter uses his hands to indicate which players the cards are intended for and additionally, which zone of the notated material the players are to interpret. So in the example below, the card R with five fingers held up would indicate that players called can pick any REGION within ZONE 5 on the score to play:



The prompter then might also choose to modify the way the region is being interpreted by calling, for example, a TEMPO variation (which would be indicated by moving the card UP for faster and DOWN for slower).

SELF ORGANISATION

Finally, the players are also able to make suggestions to the prompter. If any particular player feels that there is something they wish to see happen in the course of the performance, they can relay this to the prompter by indicating which of the sequences they wish to have played (by holding up the corresponding number of fingers) and by pointing at the player(s) they wish to have interpret it. In this way, players are able to influence and suggest paths for the composition to take. It should be noted however that the prompter can take on or ignore suggestions at will.

M	MARKER - Play from any black marker in the indicated zone for as long or short a period as you wish.	Mx	[M]	›T‹	TEMPO	S1	SOUND MEMORY - A particular combinaion and state is recorded during play and may then be recalled at any time.
R	REGION - Play from any black marker to the next white marker, starting in the indicated zone.	Rx	[R]	›V‹	VOLUME	S2	
L	LOOP - Play any loop in the indicated zone as many or few times as you wish.	Lx	[L]	F«	FOLLOW - A leader is indicated and other players MUST accompany the leader	S3	
U	UNIQUE - Play any unique event only once.	Ux	[U]	H«	HARMONISE - A leader is indicated and other players MUST harmonise with the leader	-1	REVERT - Players must revert to the previous state of play before the last SWITCH card was called.

SWITCH

Players playing MUST stop, those indicated by the prompter MUST come in.

CROSSFADE SWITCH

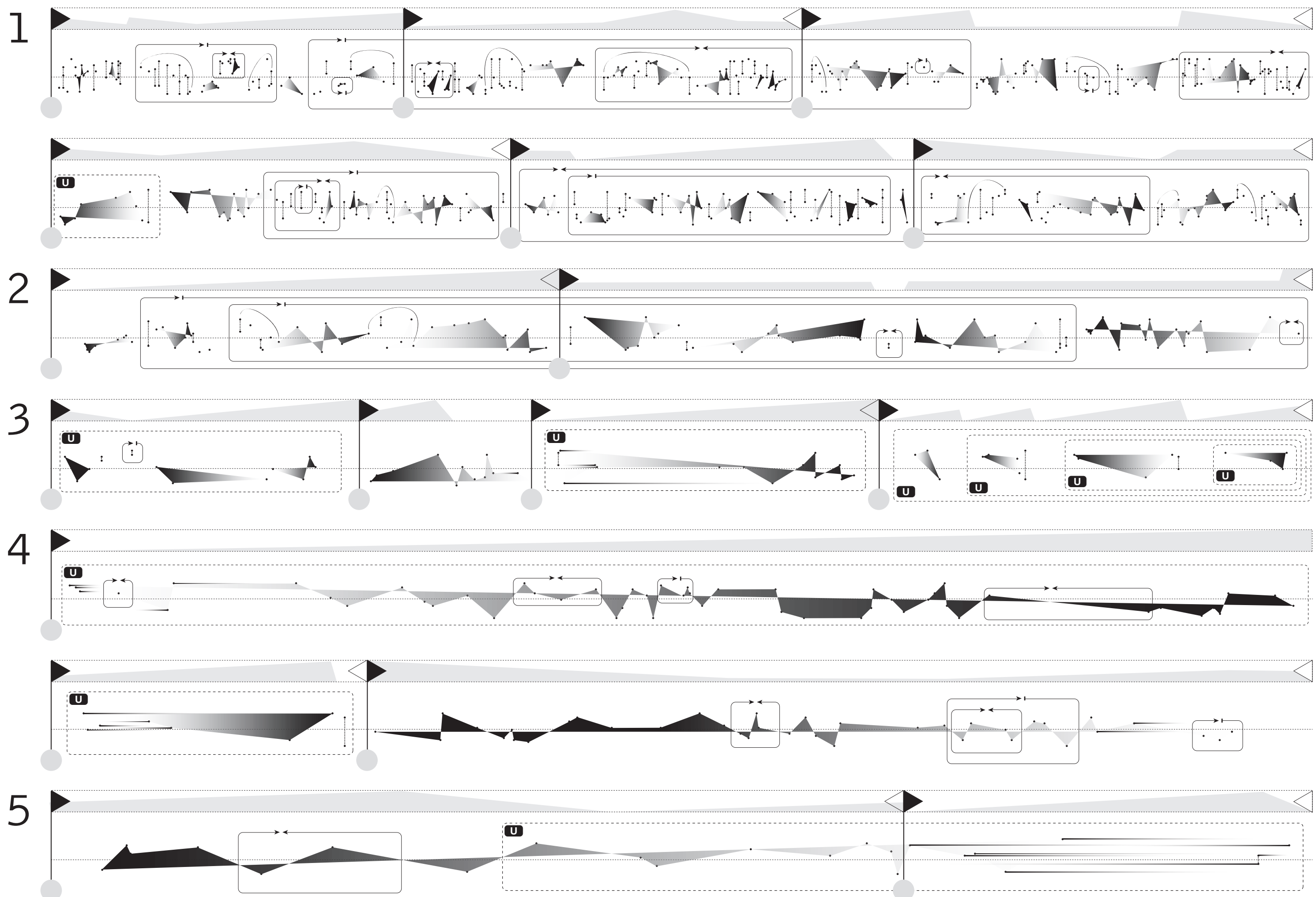
Indicated by bringing the card down from top to bottom to fade between one state and the next.

SUB-GROUP

Players playing CONTINUE, players indicated JOIN the others.

MODIFIERS

Indicate operations that modify the current state of play.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2
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U

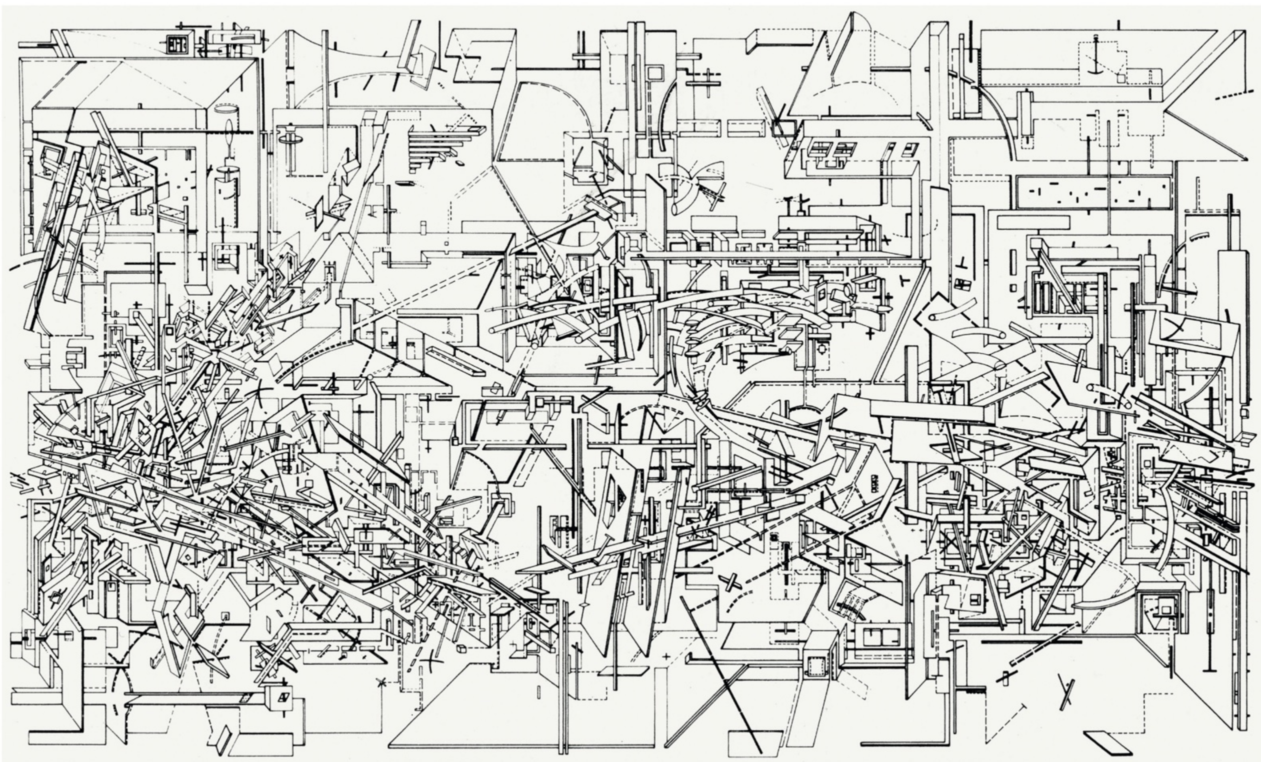
Appendix E

Articles

E.1 The Inner Sleeve

The Inner Sleeve

Artwork selected this month by **Isambard Khroustaliov**



Daniel Libeskind, *Dance Sounds* (1979)

The Architectural Association

Daniel Libeskind
***End Space* (exhibition catalogue)**
Architectural Association Pbk 36 pp 1980

The Architectural Association in London's Bedford Square is doubtless a place Cornelius Cardew, whose *Treatise* is one of the most radical graphic scores of the 1960s, would have had strong views about at the time this exhibition was taking place in 1980 (well after he had spectacularly renounced all of his avant garde work). Nevertheless, I often wonder what Cardew would have made of these drawings by Daniel Libeskind, himself a musician by training before migrating to architecture. From my perspective, as an architectural student in 1996 habitually holed up into the small hours with my drawing board, AMM (with whom Cardew played in the 1960s), Cecil Taylor, György Ligeti, Luc Ferrari, Christian Marclay, Robert Hood, Autechre, Gerard Grisey and Ryoji Ikeda were the sonic counterparts for this type of future architecture the cognoscenti labelled Deconstructivism. Perhaps unsurprisingly, this exhibition catalogue (which itself resembles a 7" record) had pride of place next to the music I used as midnight oil for the grey matter while wielding my Rotring pens.

Engaging once more with Cardew's *Treatise* – as I have had the pleasure of doing in preparation for some forthcoming performances – what remains striking for me is the level of critical attention and analysis Cardew manifests for music in honour of philosophy (*Treatise* derives its name from Ludwig Wittgenstein's *Tractatus Logico-Philosophicus*). I find a similar affirmation in these drawings by Libeskind, especially given that while the palaces of Deconstructivism (Libeskind's Jewish Museum in Berlin, Frank Gehry's Guggenheim in Bilbao and Bernard Tschumi's Parc de la Villette in Paris) made optimal use of the contemporaneous digital revolution in computer-aided design to facilitate their prototyping and construction, by contrast their genesis returns us to the question of how a language of architecture is manifested. For me, as an electronic musician and composer, inevitably wrapped up in the negotiation and creation of software and hardware to realise projects, architectural Deconstructivism as a movement is a poignant reminder that the digital language which has transformed architecture as well as music making (and our lives in general) necessitates an equally radical appraisal of our engagement with philosophy.

Currently there is a commonly held criticism that one of the prominent gestures of Deconstructivism is a theoretical obscurantism that conceals an almost baroque obsession with pushing boundaries and 'going beyond', encapsulated by the aesthetics of fracture, disjunction and juxtaposition. A parallel voice often finds a similar distaste for avant garde music on the basis of its eschewing of classical/popular musical forms, exploration of microtonality and use of extended techniques. Looking at these early drawings by Libeskind and similar manifestations by the likes of Bernard Tschumi, Lebbeus Woods, Frank Gehry and Rem Koolhaas it is clear to me that to resign such a philosophical engagement to aesthetic criticisms is missing the point. As Jacques Derrida writes in *Of Grammatology*: "To avoid 'going beyond', one risks returning to a point that falls short", a return whose only logic is deconstructive, something I think Libeskind's drawings and Cardew's *Treatise* both begin to articulate.

These days, now holed up in my recording studio, but still often into the small hours, it is deconstruction and its possible relationship to music that preoccupies me. ☐ Isambard Khroustaliov is an alias of Sam Britton, who also plays in Icarus, Fiium Shaarrk and Leverton Fox. He performs selections from Cardew's *Treatise* as part of Graphic Scores: Celebrating The Art Of Music, which tours the UK from 3–11 October. sounduk.net

E.2 An Album in 1000 Variations

An Album in 1,000 Variations: Notes on the Composition and Distribution of a Parametric Musical Work

Oliver Bown and Sam Britton

ABSTRACT

The authors discuss the making and distribution of an audio album that was created using parametric techniques and released in 1,000 distinct variations, as a kind of limited edition for the age of digital distribution. After describing the project, they discuss how the project has affected their thinking about the production of electronic music, the process of musical distribution and the concepts of tracks, musical works and uniqueness.

The Object

In 2011, under our collective moniker Icarus, we created an album that was available to download in 1,000 subtly varying versions, released with the title *Fake Fish Distribution* (FFD), on 6 February 2012 [1]. The album's download site was set up such that each purchaser would get a unique version, and once all the versions were sold, the album would no longer be available for sale. Through this process we engaged with issues of rights and ownership, collectibility and uniqueness, and authorship and methods of music distribution. The album was composed using a combination of software development and digital music production using the new possibilities afforded by the integration of Cycling 74's MaxMSP [2]—a visual programming environment for computer music—and Ableton's Live [3]—a popular modern Digital Audio Workstation (DAW) with a strong emphasis on live performance. In building the software and composing the album, we engaged with issues of systems music, parametric composition, designing variation, remix, issues of creative intent and determinacy, and the search for a creatively satisfying workflow when using the above methods. In this article we describe the project and discuss the pertinent issues that arose during its development, with the hope of identifying and clarifying some key themes in current technologically mediated creative music practice.

Musical Background

Through Icarus, we have explored various forms of electronic music production, creating music with elements of electronica, breakbeats, free improvisation and electroacoustic composition. Beginning in the late 1990s, we produced a series of studio-based albums in which the musical material was created from scratch through detailed editing on a timeline—either a MIDI piano-roll controlling multiple synthesizers and samplers, or a multi-track DAW, the traditional "project studio" or "bedroom studio" [4].

From around 2002, real-time algorithmic processes entered our repertoire through patches made in MaxMSP, and we became involved in improvising with computers, leading to a number of recorded works based on live material. During this time our creative process evolved towards the production of electronic music through a combination of algorithmic generative processes and collectively improvised long-term structures. In this respect we were part of a wider movement, initially inspired by the futurism of electronic dance music, which—somewhat intuitively—explored the methodologies pioneered in 20th-century avant-garde music through creative programming.

Mechanical Variation

In 2011, we set out to return to studio production and make a full-length album from scratch, meaning a rendered rather than performed work, while still drawing upon our experience working with live improvised electronic music performance. At the time of our last full studio album, released 6 years previously, Apple's iPod was 4 years old and the "mp3 revolution" was only a looming threat to CDs. In light of the subsequent revolution, returning to studio production in 2011 involved a rethink of our motivations and an appraisal of the context in which the music would be presented. With the age of mechanical reproduction fast approaching a point, in the digital realm, where all objects may be instantly available to all users all of the time, paywalls notwithstanding, the burgeoning presence of mechanical variation seemed to us to both fit the challenges of the age and define an appropriate ambition given current technological-creative possibilities. This is not a new idea; parametric design is a mature subject in many fields, particularly architecture. However, the idea remains relatively unexplored in commercial musical culture. We define parametric composition as the composition of musical elements that contain one or more controllable parameters with which specific instances of the music can be specified.

Our idea of producing an album in 1,000 variations was motivated by the desire to seek a balance between various forces: to produce music in the standard distribution medium—the

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See <www.mitpressjournals.org/toc/leon/47/5> for supplemental files associated with this issue.

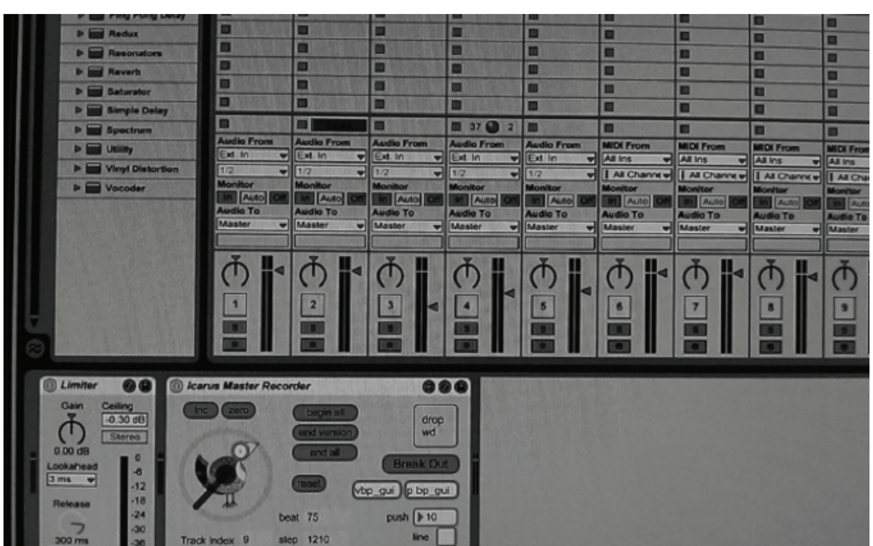
 doi:10.1162/LEON_a_00866

digitally distributed album—as opposed to producing custom generative software, but with mechanical variation as a key element; to work with code and algorithms as key production elements, but still to compose creatively in timelines with audio and MIDI and virtual studio elements; to act as creative authors, while handing over part of the production process to an automated system; and to provide a listening experience that is familiar—in that it is repeatable—and that can be experienced as any other album, but can also be perceived as a vast multifaceted entity with musical qualities that are noticeably the product of a process of automated variation. We chose 1,000 variations in order to take on a quantity of music (1,000 times 45 minutes equals almost exactly 1 month's worth of audio) with which we could conceivably engage, but not in any practical way. This quantity of music could be considered out of reach, but only just.

Music that adopts systems and processes that might otherwise be described as "extra musical" as part of a compositional procedure has a rich history: from early examples such as Mozart's dice games to the introduction of chance operations in the work of John Cage and the mapping of stochastic processes in the work of Iannis Xenakis. Amongst the 20th-century avant-garde, algorithmic and mathematical strategies are not uncommon. Examples include the player piano compositions of Conlon Nancarrow or works such as *Plus-Minus* by Karlheinz Stockhausen and György Ligeti's piano etudes. By the latter half of the 20th century, as a result of the increasing proliferation of computers within music production and composition, such strategies could be said to have become commonplace (the chapter "Representations and Strategies for Algorithmic Composition" in Curtis Roads's 1996 *Computer Music Tutorial* [5] gives a good overview).

Within this ecosystem of systematized music, our focus was to approach parametric composition by fitting a DAW-based approach to music creation into traditional electronic dance music. This approach is not based on generative processes but on human creativity in a timeline-based composition environment. In order to make it parametric, a number of elements in a work that would typically be fixed are left as controllable variables, the adjustment of which results in a different output. Creating parametric music is therefore in the first instance a simple step back from normal electronic music composition, in which the final positions of various dials and sliders are left unknown. But in reality, a simple leaving-open of possibilities does not in itself solve the problem of how to achieve mechanical variation, as the capacity for variation needs to be *designed* through the appropriate mapping of parametric variables onto musical outcomes, along with a suitable high-level strategy for then representing variation within the work.

Fig. 1. A master Max for Live device with version dial indicated by the bird logo. The device took care of recording and all aspects of variation management, and could be used to dynamically link in track-specific Max patches and read timeline data from a track-specific project folder. Besides pop-up timeline editors, the only essential (non-debugging) interface element is the version dial, which immediately adapts the contents of the track to a different version state.



Making and Distributing an Album in 1,000 Variations

We made FFD using Ableton Live and a series of additional tools we created using Max for Live. At the core of this suite of Max for Live tools was a single parametric control, which could be used to determine which of the 1,000 different versions was currently being played back. This control, rendered as a large dial—the version dial in the main Ableton Live interface (Fig. 1)—was used to interpolate between a series of keyframe timelines across multiple control channels, defining parameters that were then used to control various aspects of the Ableton Live composition, either directly or via more or less complex transformations in MaxMSP.

Through the version dial, the one-dimensional timeline of the traditional DAW becomes joined by a second one-dimensional control, which can be freely set by the composer at any time during the compositional process, just as the playback transport position can be freely set along the timeline. Together, these allow a composer to move seamlessly around the two-dimensional time-version space that defines each piece. A composition can then be thought of as a two-dimensional structure, slices of which form actual musical outputs.

The various time-dependent parameters that go on to define the musical content form surfaces over this 2D domain. The simplest way to build such surfaces without manually specifying the entire set of resulting points (this being the purpose of parameterization) is to create keyframe timelines and then use the version dial to interpolate between them (Fig. 2). We therefore built a system for creating, managing and describing the interpolation between such timelines using Emmanuel Jourdan's advanced breakpoint editor for MaxMSP [6]. The result of these steps is a system for parametric music composition in which any aspect of a musical piece can be specified in the resulting two-dimensional time-version space. Parameterized tracks, once defined, can be rendered into their 1,000 constituent audio file outputs through an automated process, across multiple machines if necessary. After each version is rendered, the version dial is incremented by a single step and the next rendering is initiated. Since the version parameter is used to interpolate between different parameter timelines, the result is a smooth variation from one version to the next.

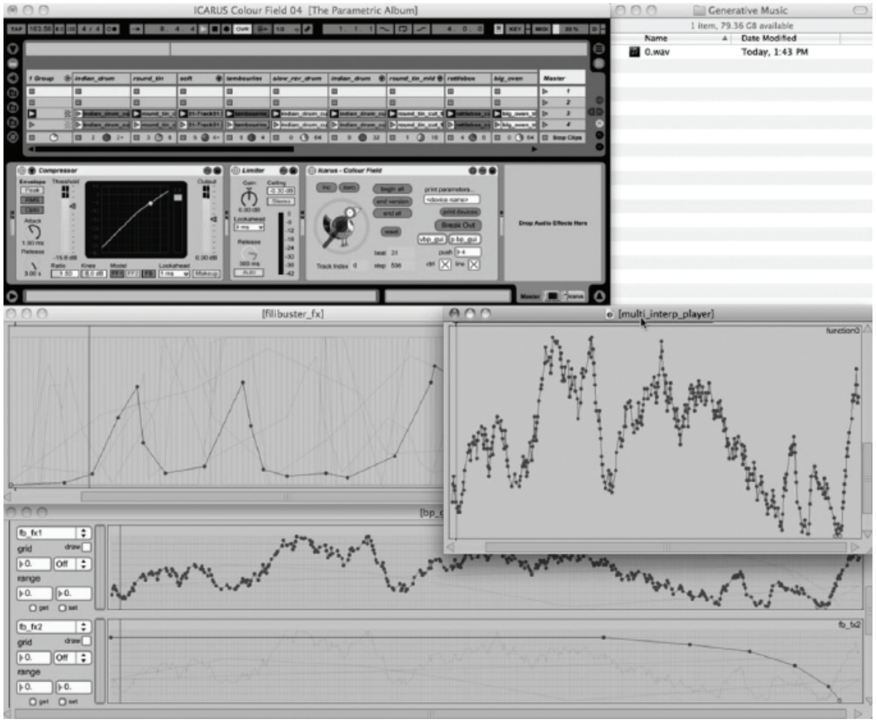


Fig. 2. A live project showing the process of interpolation between breakpoint functions (lower two track lanes) to produce a resulting interpolated pattern (upper right breakpoint function). The upper left breakpoint function describes a mapping from the version dial (x-axis) to the actual value used to interpolate between the input breakpoint functions. This could be repeated multiple times for each piece. At top right the outputted renderings are shown being recorded into a directory.

What Was Controlled and How Was It Parameterized?

Broadly, we pursued three strategies. In the first approach, a piece of music was conceived of as a set of states, arranged in a space, through which any given trajectory would result in a specific instantiation of the music. The parametric variation consisted of interpolating between different trajectories through the musical state space. The arrangement of the state space and the choice of which paths to interpolate between defined the characteristics of the ultimate composition, both in terms of individual outputs and in terms of the entire set of outputs. Actual states consisted of groups of parameters, such as specific clips or tracks being activated. This approach allowed us to have a fairly preconceived idea of the final piece while we worked on the musical material. For example, in one track we decided upon a fixed ending and conceived of a number of musical trajectories that would arrive at that ending [7].

The second approach was more intuitive and bricolage-like, and involved iteration between parameters and compositional material, with all elements being mutually adapted until we found satisfying results. For example, we created a number of musical components, with parameterized elements identified, and defined a number of abstract parameter trajectories. Whilst auditioning the track in a number of different states, we made connections between abstract parameters and parameterized elements, while altering both musical material and keyframe parameter timelines. In this case the ability to audition the musical output rapidly over a range of variation indices and at different points in time was invaluable in allowing us to gain a broad enough understanding of the musical dynamics [8].

In the third approach, the mapping from parameters to musical outputs took a more opaque form through the use of parameterized number sequences and other generative processes. In the track *Colour Field*, we fed the version number directly into a quadratic residue equation to produce a number sequence, which determined the durations between sequential updates. The process was applied to a number of distinct tracks, each stepping through a preconceived sequence but at different rates. In this case, the notion of interpolation did not apply.

In reality, we freely applied a mixture of each of these processes, and variations of them, in the composition of all the works.

Reflections: Singletons, Formats and the Standard Listening Model

Owing to our mix of motivations, the final form of the record and the experience of composing it were elements about which we had few expectations; the project provided an opportunity to reflect on both the inherent structure and entrenched habits in our technologically mediated compositional process. It has shone some light on our intuitive understanding of aspects of musical production, suggesting notions and creative technological possibilities that could be relevant in the near future of music production and distribution.

Production

A characteristic that distinguishes contemporary studio-based music production for commercial release from other forms of music production is that the musical work may never be conceptualized by its makers or experienced by its audience as an entity separate or separable from the musical *recording*. This view applies most clearly to the practice of studio composition in electronic music, in which the studio acts as a tool in the creative process. That said, much studio activity involves recording songs, in which case the recording is unlikely to be the only instance of the song and is conceptually distinct. Yet, through the mechanical reproduction and distribution of music—be it album, EP or single—the main way people experience those musical works is by listening to instances of a single recording [9].

Borrowing from programming terminology, such a product can be thought of as a "singleton," an object of which there is only one real instance, no matter how many times it is referenced. While some pieces of music exist in many manifestations, a large number effectively have a definitive form, the *album version*. When music is performed live, by contrast, no matter how constrained the demands are for interpreting that music, there is always variation; each performance is different, but all performances that derive from a specific composition are also distinct instances of the same musical work. In the case of singleton studio music, the instantiation occurs simultaneously with the development of the musical concepts and may never be experienced as a separate entity. At the other extreme, a completely improvised piece of music, albeit the antithesis of a studio composition, may go full circle and share this quality with a studio-composed product: a specific recording of a specific performance, once cast as a mass-produced "record," may also become a singleton in exactly the same way that a studio composition does [10], and a number of recorded works fit into this category [11].

Our previous approach to singleton studio work has generally been centered on the affordances of the DAW as a linear structuring tool, which, like the studio in general, allows the composition of musical work to occur simultaneously with the creation of the work's one and only sonic manifestation, the "cut" or "bounce to disk." Live electronic music performance has matured with the advent of "next generation" tools derived from DAWs, including Ableton Live. Ableton Live combines the DAW production process with functionality that enables real-time remixing of predefined structures in live performance. Its popularity demonstrates the musical relevance of this capability. Creative practice emerging around tools such as Ableton Live involves the entangling of musical concepts and actual sound and remains in a state of flux, cut to a singleton output for a commercial release but then also remixed in myriad ways by its creator in a performance context or by other remix artists (either working from the original project file or from stems).

Distribution

The promotion and broadcast of music through digital networks of communication has radically affected the reach of artists, particularly independent producers, and naturally this is now the prevailing medium for the distribution of music.

Despite this transition, the traditional commercial music forms of albums (LPs), EPs and singles still predominate in musical output. This is understandable, as most commercial releases still appear on CD and sometimes vinyl, and the requirements of mainstream radio show playlists continue to influence decisions about song duration. Finally, music reviewers from both traditional and new media remain attached to these forms as legitimate targets for their attention and criticism. For this reason, the album, for most music producers, may continue to be a dominant form of output, although its duration may no longer have an upper limit imposed by its storage medium. Meanwhile, vinyl continues to be a specialist, in-demand format.

The predominant tools of music consumption today, such as iTunes, also reinforce these formats through conventions such as the central use of the "album" in any organizing structure, although increasingly the dominant structure is the playlist (descendent of the mixtape). Naturally, in that these tools are first and foremost "playback devices," they do not change the fundamental relationship between music consumers and their music, largely remaining loyal to pre-Internet music-listening experiences, aside from increases in speed and quantity of access. Whilst digital networks of communication have dramatically changed the relationship between producers and consumers, including the structure of music access rights (e.g. through services such as Spotify), this is less clearly reflected in the typical process of listening to a body of music: the consumer owns or has access to a collection of music, a static entity, which he or she listens to passively (i.e. without interaction, except in the selection of tracks) [12]. Although a consumer's music collection may be a unique set, the fingerprint of their musical interests, the elements of that set, are not unique, but are shared amongst other individuals' collections.

Systems music, algorithmic composition and generativity as tools for the everyday producer offer a fascinating new sense of the "large scale" in creative works [13], complementing interactivity as another digitally facilitated enhancement to musical consumption [14]. As the avant-garde of the 20th century have shown, these processes have the potential to extend and augment the relationship between artists, their audiences and the context within which music is perceived to operate.

Although commentators such as Jaron Lanier [15] despair that the modern Internet is ruining creativity by undermining artists' revenue and promoting homogeneity, in our opinion these processes have equally been responsible for a renewed search for novelty among small dedicated niches of enthusiasts. These digital approaches to varied music consumption experiences are good examples.

In the digital domain, the fact that generative and interactive works cannot be experienced directly through standard digital tools such as iTunes and portable playback devices (although they can be experienced on computers, mobile phones, tablets and other devices capable of running custom software [16]) reinforces the sense that they are outside normal music experience. The requirement for non-standard playback tools means that such works cannot currently be integrated into users' collections in the same way as other music, i.e. in playlists or through standard services such as SoundCloud or Spotify, and they would contravene the existing user experience. This of course does not mean that generative and interactive processes cannot be used offline to produce musical outputs that do conform to the standard playback paradigm; in certain cases standard albums may be produced to distribute or promote generative music systems, just as they may be to distribute or promote multichannel compositions (i.e. it should be understood that these are not the definitive or preferred outputs). Nevertheless, although listeners could add FFD to their playlists, the project required its own server for the custom form of distribution it required and could not have been delivered through any of the standard services.

It is likely that generatively produced, but ultimately static, outputs will play an important role in forthcoming changes to music production and distribution. Static outputs allow producers to produce work that is in keeping with the dominant modes of music distribution, while experimenting with new methods of mechanical variation. They invite listeners to gain familiarity with a musical work, which we think is a desirable feature of our current mode of music consumption. If Brian Eno's re-envisioning of his ambient music from the 1970s through the release of dedicated applications for smartphones [17] is a success story for generative music, this may be due in part to the process of acclimatizing audiences to novel music production techniques via traditional static recordings.

Philosophy

Relevant philosophies of contemporary digital creative practice include Jacques Attali's [18] vision of socialized music creation and Luciano Floridi's observations concerning a "Philosophy of Information" [19]. These both privilege the idea of interaction and share the view that some critical identification with difference or variance in the broadest sense is a key component for the future of music.

As an attempt to engage with the attributes of both static and interactive music, FFD can also be defined as an assemblage [20] that not only harnesses an array of generative techniques that inform its sound, but also encourages subjective interpretation of this sound world by the listener, as an album should. Unlike in many experiments in generative music, the mechanics of how the work is created need not necessarily inform the work as an aesthetic experience. In practice, however, FFD opens up the larger intersubjective territory regarding how each unique version differs musically from another [21].

Critical Appraisal

The commercial release of FFD was accompanied by a publicity campaign. We received a number of reactions, and FFD was featured in numerous contexts, from the traditional music press to music technology websites and blogs. Overall it was positively received.

A predictable outcome was that reviews focused mostly on the concept and not on the musical content. But, in general, reviews both positive and negative indicated that musically FFD was viewed similarly to our previous work.

In negative reactions to the project concept, FFD's distribution was interpreted either partly as a gimmick and not seen as integral to the genesis of the album itself, or elsewhere it was declared an affront to musical industry and human creative authorship. In several blog comments the music was described as cold or inhuman.

FFD was conceived as a labyrinth whose geography remains only partially known even to its designers. The diversity of outputs is made relatively inaccessible to listeners, who are welcome to seek alternative variations if they so choose, but can only do so by communicating with other version owners. In this sense there is substance to the criticism that this production of variation is more conceptual than tangible. Despite the fact that we initiated a discourse about this type of work by using the techniques we have described, we make no claim to be originators in this field. Our intent has been to develop it as a legitimate territory for artistic and creative exploration, and we hope that FFD will be accepted as a useful experiment.

References and Notes

Unedited references as provided by the authors.

1. Available from <www.icarus.nu/FFD>.

2. <www.cycling74.com>.

3. <www.ableton.com>.

4. The latter being a derivation of the former, which has its origins in the 1950s with the many experimental radio studios that were dedicated specifically to electronic music creation. Bedroom studio production emerged as a low-budget, grassroots approach to "commercial" electronic music (as opposed to academic music), the traditional output being the album, EP or single, particularly the 12-in single used by DJs.

5. Curtis Roads, *The Computer Music Tutorial*, MIT Press, 1996.

6. From Emmanuel Jourdan's Ejies collection, available from <www.e--j.com>.

7. Examples of this are the tracks "Old D" and "Two Mbiras".

8. Examples of this are the tracks "Spineez of Breakout" and "Three Stupidities."

9. Clay Shirky makes the point that although we talk of "copies" of a piece of music, in the most abstract sense digital reproductions are not even copies, but instead occurrences of the same thing: "No one ever says, Give me a copy of your phone number. Your phone number is the same number for everybody, and since data is made of numbers, the data is the same for everybody." Clay Shirky, *Cognitive Surplus: Creativity and Generosity in a Connected Age*. Penguin, 2010. p. 55.

10. We can take the programming metaphor one step further and say that an unrecorded musical improvisation is akin to an anonymous class, an entity that does not have a life beyond the given event in which it occurs.

11. An example might be Keith Jarrett's *Köln Concert*, celebrated by many as a definitive performance.

12. According to Truax, however, listening is never passive. Music is that which is constructed internally as a result of actively transforming sound though perception. We do not disagree with this notion, but it is simply more practical in this context to think of the recorded sound as the music. Barry Truax, *The Handbook for Acoustic Ecology*. World Soundscape Project, Simon Fraser University, 1978.

13. Although not itself generative, an excellent, recent semi-musical example of a "large-scale" media work is Christian Marclay's *The Clock*. Here "large-scale" refers to the quantity of content created or brought together.

14. RJDJ is an example of an interactive music application made for the iPhone that is able to both "personalize" songs and "generate" music by analyzing contextual data collected by the host device. Many bands and groups have also released dedicated applications available for mobile devices that allow the user to remix and interact with songs otherwise available as fixed format recordings.

15. Jaron Lanier, *You Are Not a Gadget: A Manifesto*. Knopf, 2010.

16. We exclude the use of Internet radio as a means to stream software-generated music. This exclusion is made on the basis that radio is a one-to-many service and we are talking about personal on-demand listening. We realize of course that a system can spawn personalized streams perfectly well.

17. For example, see <www.generativemusic.com/bloom.html>.

18. Jacques Attali, *Noise: The Political Economy of Music*. University of Minnesota Press, 1977.

19. Luciano Floridi, *Information: A Very Short Introduction*. Oxford University Press, 2010.

20. Here we refer to the theory of assemblage as outlined by Manuel De Landa in "Philosophy & Simulation: The Emergence of Synthetic Reason," in Manuel De Landa, *Philosophy and Simulation: The Emergence of Synthetic Reason*. Continuum, 2011.

21. Our audience was invited to participate by sharing their copies on a private mailing list reserved for version owners.

Manuscript received 15 November 2012.

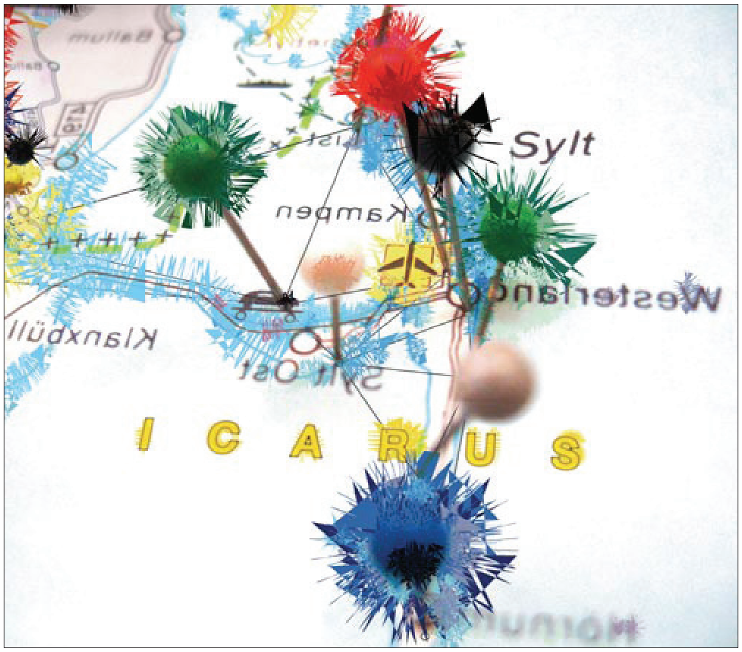
Oliver Bown works across the borders of music composition and performance, creative software development and theoretical research. His recent work explores electro-acoustic improvisation and the design of autonomous improvising software systems, which includes collaborations with trumpeter Tom Arthurs, along with Lothar Ohlmeier, Maurizio Ravalico and Isambard Khroustaliov of the Not Applicable Artists, and in Australia with clarinetist Brigid Burke and trombonist Adrian Sherriff. In 2010 he curated a series of events showcasing autonomous improvising software systems at Melbourne's Guildford Lane Gallery. His performance and installation software, including solo work and collaborations with the multimedia artists Squidsoup, has appeared at numerous festivals and exhibitions. He recently completed an Australia Research Council–funded project with the Centre for Electronic Media Art in Melbourne, exploring the creative aesthetics of ecosystem computer models. He is currently a postdoctoral fellow at the University of Sydney's Design Lab.

Sam Britton studied architecture at the Architectural Association from 1996 to 1999 and began writing electronic music in 1996. In 2006, he attended a master's course in electronic music and composition at IRCAM in Paris (one of the only students in its history to have been accepted without having completed an undergraduate degree in composition) and began to write composed electroacoustic and concert music, for which he was the recipient of a SACEM composer's bursary. In addition to realizing music with Ollie Bown as Icarus and under the alias Isambard Khroustaliov, he has collaborated with numerous artists, directors and software developers, and productions featuring his work have been widely exhibited.

Appendix F

Relevant Recorded Works

Icarus – Sylt



RUMP007 – Album – Release date 19th November 2007

01 – Keet
02 – Rugkiks
03 – First Inf(E)Rænce
04 – Selfautoparent
05 – Second Inf(E)Rænce
06 – Jyske
07 – Volks!

Written, performed and produced by Ollie Bown and Sam Britton.

Album Description

“Sylt” is Icarus’ first album in two years, following the understated Carnivalesque in 2005, and the acclaimed I Tweet the Birdy Electric in 2004, over which time the duo Ollie Bown and Sam Britton have continued working on related projects in electroacoustic performance, composition and music-related research.

The album builds on the band’s inquisitive approach to electronic music production acquired over 6 album releases spanning over a decade, and spread across a mix of record labels: The Leaf Label, Output, Hydrogen Dukebox, Temporary Residence, Not Applicable, and for this latest release, Rump Recordings.

“Sylt” was devised around two extended improvised tracks, “First Inf(e)rænce “ and “Second Inf(e)rænce”, taken from one live performance in Toulouse in 2006. These recordings represent the accumulation of unreleased material built up over a spate of live performances as well as the documentation of the band’s development of an improvised electronic music style in which flourishes of rhythmic and harmonic structures are restlessly set up against each other by the duo.

Alongside these live recordings, “Sylt” also revisits the recognisable structures of Icarus’ earlier anthemic style in tracks such as “Keet” and “Volks”, outbursts of joyous rhythmic lunacy in the bricolage of “Selfautoparent”, and a developing sense of instrumental musique concrète in tracks such as “Jyske” and “Rugkiks”

N/A – An Introduction To Not Applicable

NOT010 – Compilation – Release date 16th September 2008

01 – Spin – Lothar Ohlmeier / Ollie Bown
02 – Musicide – Isambard Khroustaliov
03 – Foil – Javier Carmona / Tom Arthurs
04 – Fear Of Bees – Isambard Khroustaliov / Maurizio Ravalico
05 – Elliogy – Icarus
06 – Duetto (part I) – Maurizio Ravalico / Ollie Bown
07 – Slog – Adem Ilhan / Ollie Bown
08 – Until Yet – Isambard Khroustaliov / Tolga Tüzün
09 – Elastic – Isambard Khroustaliov / Javier Carmona / Maurizio Ravalico / Tom Arthurs
10 – The Immense Swimmer – Maurizio Ravalico / Oren Marshall
11 – Duetto (part II, III) – Maurizio Ravalico / Ollie Bown
12 – Genre Resistance – Lothar Ohlmeier / Geoff Wass
13 – Static – Tom Arthurs / Ollie Bown Electric Duo
14 – Up, Down, Charm, Strange, Top, Bottom – Javier Carmona / Maurizio Ravalico
15 – Scratch – Lothar Ohlmeier / Isambard Khroustaliov
16 – Tubes – Lothar Ohlmeier / Maurizio Ravalico / Ollie Bown / Tom Arthurs
17 – She Closes Her Windows at Night – Adem Ilhan / Lothar Ohlmeier / Maurizio Ravalico / Ollie Bown / Tom Arthurs

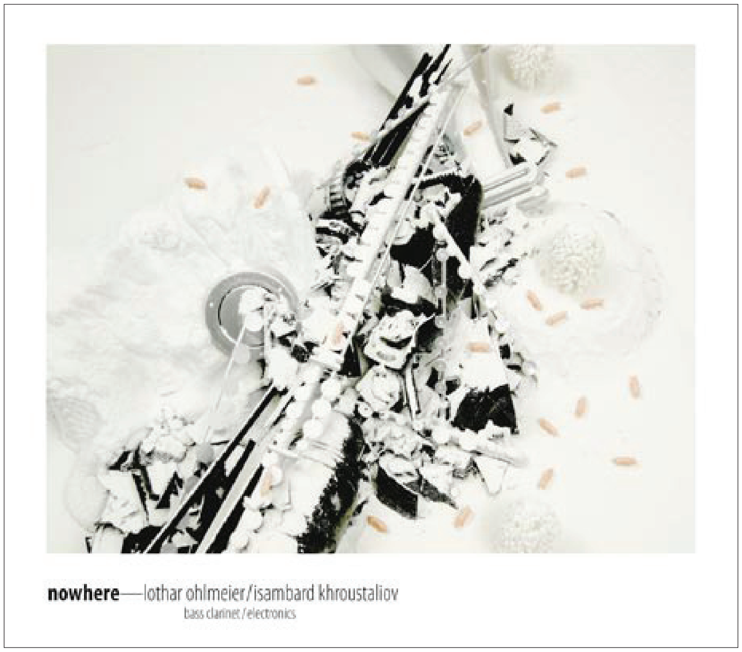
Album Description

'N/A An Introduction To Not Applicable' brings together almost and hour of film and nearly three hours of music realised and documented spontaneously since the inception of Not Applicable as an undefined method of realising work in 2002 by Ollie Bown and Sam Britton of the electronic group Icarus.

The work presented unites a core set of like minded individuals who currently define Not Applicable; Britt Hatzius, Isambard Khroustaliov, Lothar Ohlmeier, Martin Hampton, Maurizio Ravalico, Ollie Bown and Tom Arthurs with guests and collaborators; Adem Ilhan, Alice Scott, Candas Sisman, Daniel Clift, Geoff Wass, Javier Carmona, Laurent Duriaud, Oren Marshall, Tolga Tuzun and Yannig Willmann.

In spirit, the compilation tries to do exactly what the title implies; to assemble an anthology of work that is definitive without being prescriptive; to present a precise survey of moments in time and fleeting collaborations that, by definition, are often ephemeral in nature and without any specific agenda. As such, 'N/A An Introduction To Not Applicable' is perhaps best seen as a moment of pause and necessary reflection; a chance to soak up what has been created so far and read what it intuits.

Lothar Ohlmeier / Isambard Khroustaliov – Nowhere



NOT008 – Album – Release date 24th March 2008

1 – Haze
2 – After Sunrise
3 – The Vague Terrain
4 – Monkey Puzzle
5 – Dusk

Lothar Ohlmeier – bass clarinet
Isambard Khroustaliov – electronics

Album Description

Over the last few years, the combination of electronics and improvisation has steadily gained momentum, with a number of collaborations between electronic musicians and improvisers coming to light. In the spirit of an approach adopted by Spring Heel Jack's Ashley Wales and John Coxon with 2001s 'Masses', Fourtet's Kieran Hebden has teamed up with veteran free-jazz drummer Steve Reid, Leafcutter John with Polar Bear and Squarepusher's Tom Jenkinson has been collaborating with saxophone virtuoso Evan Parker.

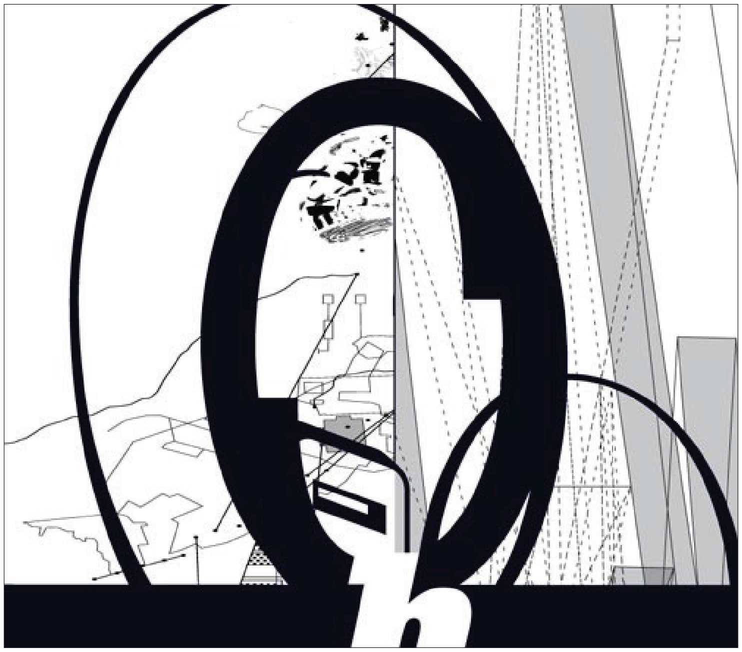
'Nowhere' arrives on this landscape at what would seem like quite a poignant moment, documenting a collaboration begun in 2005 between Isambard Khroustaliov (AKA Sam Britton from the electronic duo Icarus) and bass clarinet player Lothar Ohlmeier, and as is perhaps suggested by the title, it takes yet another very different view on the territory proposed by attempting to combine two musical worlds as dense and diverse as improvisation and live electronics.

Approaching the area as a kind of unknown 'zone' and working in a manner not too dissimilar to the central character in Andrei Tarkovsky's 'Stalker', Khroustaliov and Ohlmeier remain consciously wary of the paths of least resistance; reluctant to second-guess the various boundaries and forms that might characterise this amorphous space and, as a result, continually re-working their musical approaches.

Unsurprisingly then, it is also an exploration that has kept them occupied for a relatively long period of time. The record has been 3 years in the making and has encompassed a residency at IRCAM in Paris (working on new electronic performance software with scientific researcher Diemo Schwarz) and performances at improvised music meetings, jazz and experimental music festivals all over Europe.

The result is a record that documents a collaboration ranging in scope from tentative ideas to full blown virtuosity, from extremes of contrast to extreme lyricism, whilst never compromising its intention; to evolve an idiomatic musical language that is lyrical and rich enough to describe a path through this emerging landscape.

Isambard Khroustaliov - Ohka



NO011 – Album – Release date 12th October 2009

1 – Ping
2 – Aporia
3 – Traum
4 – Junkspace
5 – Ohka

Total running time: 55'18"

Written, composed and produced by Sam Britton.

Prepared piano on Ping, Traum and Ohka performed by Gareth Humphreys. Guitar on Aporia and banjo on Junkspace performed by Philippe Pannier. Bass clarinet on Traum performed by Lothar Ohlmeier. Tuba on Traum performed by Oren Marshall. Traum contains short passages of electronic source material by John Wall. Mastered by Will Worsley.

Album Description

Ohka is the first full length solo recording by Isambard Khroustaliov and documents five key pieces which chart the various converging practices that have shaped and informed his musical perspective; from his continuing work with the electronic group Icarus and time spent as a resident composer at IRCAM, to his involvement in improvised music and work for film and animation.

Positioned somewhere between the fictional abandon of a mashup and the contemplated purposefulness of contemporary composed music; Ohka is a uniquely bold musical statement where acoustic instruments, performance and instrumentalism are taken apart, mutated, and reassembled in an electronic zeitgeist of their former selves, in which disjunction and fracture serve as the only concrete musical guides.

Over five years in the making, it is an album that not only documents the author's struggle with the progressive riddle of our contemporary musical climate but also restlessly leaves no stone unturned in the pursuit of its discourse; from the opening utopianism of Ping via the deconstruction of Aporia to the psychosis of Traum, the post-modern lament of Junkspace and the schizophrenic euphoria of Ohka itself, it is an album whose density and attention to detail make enormous demands on the listener and reward in equal measure.

A Further Insight Into Not Applicable

NOT012 – Live Album – Release date 18th January 2010

Part 1 – 30'12"
Part 2 – 33'48"

Recorded Live on May 5th 2009 at the Stoke Newington International Airport, North London.

Andreas Willers – guitar
Anna Kaluza – alto saxophone
Isambard Khroustaliov – computer
Lothar Ohlmeier – bass clarinet
Maurizio Ravalico – congas
Rudi Fischerlehner – drum kit

Tom Arthurs – trumpet, flughelhorn

Album Description

The two tracks that compose this album are the integral, unedited documentation of a live performance, which was set up with the desire of thaking advantage of a rare occurrence of having most of the core Not Applicable sound makers in London on the same night, together with some of our dearest friends, and past guests, from Berlin. This jolly party was furtherly enriched by the unannounced last minute appeareance of Anna, another Berliner, in London for a course.

The evening is divided in two sets. The first one follows a scheme suggested by Rudi, a progression of duos alternating seamlessly on stage: R. Fischerlehner – A. Kaluza, A. Kaluza – L. Ohlmeier, L. Ohlmeier – A. Willers, A. Willers – M. Ravalico, M. Ravalico – R. Fischerlehner. With I. Khroustaliov being given the liberty of intervening throughout the set at leisure.

The second set is a collective improvvisation by all the above participants, added by the fortuitous arrival of Tom Arthurs, who, on a day off, appeared during the interval, and was forcibly driven back home by Isambard to collect his horns. Hadn't it been for this act of love we would have missed forever the dark intimations that came into existence on the last nine minutes of the set, because I have a feeling we would have probably called it a day at 24'10"

Icarus – All Is For The Best In The Best Of All Possible Worlds

NOT013 – Live Album – Release date 25th March 2010

1 – Tuning
2 – Husky Offset
3 – Specters
4 – Eulot
5 – Uke 'Em
6 – On The Sunny Sides Of The Ocean
7 – Parallax
8 – On The Sunny Side Of The Oceans

Total running time: 43'28"

Written, performed and produced by Ollie Bown and Sam Britton.

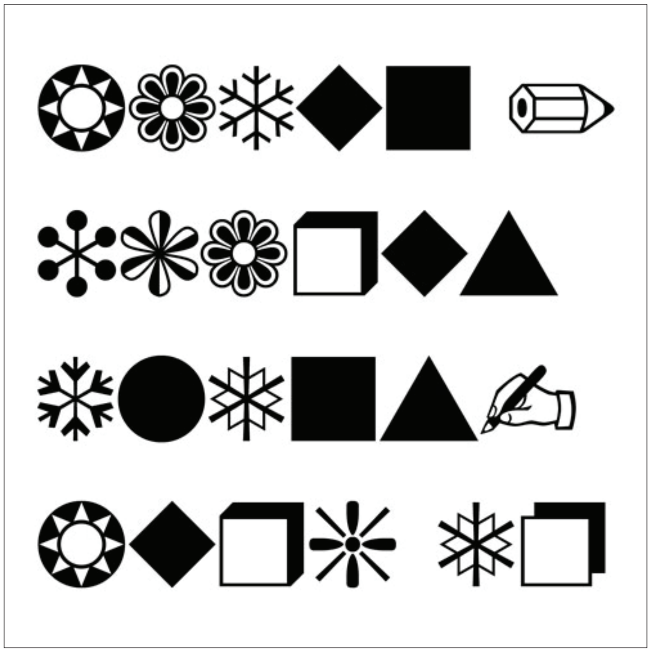
"Specters" features piano by Tolga Tuzun and 'cello by Lucy Railton. "Uke 'Em" features trombone by Robin Harris, trumpet by Steve Chadwick and euphonium by Paul Tkachenko.

Album Description

'All Is For The Best In The Best Of All Possible Worlds' documents Ollie Bown and Sam Britton's continued exploration into the world of live electronic music performance and presents new material worked up during the course of their European tour in the summer of 2009 to promote the Icarus remix album 'Sylt Remixes'.

Probably the best encapsulation of how their music has been influenced by the combined forces of improvisation (in performance) and reflection (in the sense of both compositional techniques and software development to enable such performances), the record itself is perhaps their most incisive to date.

Icarus / Badun – Flensburg



NOT020 – EP – Release Date: 27th May 2011

01 – Badun – AKO – 11:29
02 – Icarus – Vermiculite Trotter – 05:21
03 – Icarus – Sparkly Bear – 07:26
04 – Badun – KTO – 08:14

Badun are Oliver Duckert and Aske Krammer
Icarus are Ollie Bown and Sam Britton

Album Description

Icarus and Badun met in 2005 at the Elektronisk Jazzjuice Festival, in Aarhus, Denmark.

Amidst the drunken chaos, dangerous use of power tools, lost keys, stolen bikes, freezing conditions and missed flights, they bonded over a love of ecstatic, ever-changing and dizzying drum arrangements, anarchic sonic orchestration and shoplifting Hollywood chewing gum.

The friendship led to a number of shared gigs in the UK, Denmark and Holland, Icarus's release of their album 'Sylt' and the remix record 'Sylt Remixes', which included a Badun remix that also features on their 'Late Night Sleep' album. Throughout this time, the bands' output began to express mutual references, forming a conversation over time, and the idea of a joint release floated in the air.

The plan was sealed during an impromptu session of synth sampling by Sam from Icarus and Oliver from Badun in 2009, with the idea of using the source samples as the basis for tracks by both bands. The final result, cooked up over the better part of a year in live and studio sessions by both groups individually is a chameleonic manifestation, with each track following its own unique trajectory; from the fractal manipulations of AKO and freeform hubris of Sparkly Bear to the time-warp vortex of Vermiculite Trotter and legacy brain-spin of KTO.

The 'Flensburg' EP is dedicated to the myriad of Yamaha Disklavier player pianos consigned to a life of performing preloaded Elton John MIDI files on cruise ships, with the hope that this will inspire them to crash, short circuit and corrupt in pursuit of a less demeaning existence.

Philippe Pannier / Isambard Khroustaliov – CHALEUR

NOT017 – Album – Release Date: 24th October 2011

01 – Coïncidence
02 – Habituellement
03 – Arrivée
04 – Légèrement
05 – Entre des
06 – Unions
07 – Recherchées

Philippe Pannier – Guitar, Banjo.
Isambard Khroustaliov – Computer.

performances recorded by Fabrice Le Breton @ Deux Pièces Cuisine, Blanc Mesnil, Paris on the 18th & 19th November 2010.
edited by Philippe Pannier and Isambard Khroustaliov.
mixed and mastered by Isambard Khroustaliov and Will Worsley.
artwork and design by Ollie Alsop.

Album Description

Philippe Pannier and Sam Britton (AKA Isambard Khroustaliov) met at IRCAM in 2006, introduced to each other by the composer Philippe Leroux in order to realise a piece for banjo and electronics to be composed by Sam. During this period, many ideas, techniques and strategies were prototyped, fuelled in part by the fact that they were exploring a myriad of ways to play, notate and electronically process an instrument that was new to both parties (Philippe having trained as a classical guitarist) and furthermore, almost totally unfamiliar in the landscape of contemporary composed music. The final result is the composition Junkspace, as performed by Philippe, that appears on the Isambard Khroustaliov album Ohka.

Following this time spent at IRCAM, the obstacles of distance and circumstance conspired against further dialogues, but the release of Ohka in 2009 put them back in touch and re-ignited the desire to perform together again. The opportunity to do so finally arose in the winter of 2010 through the Forum Culturel de Blanc-Mesnil on the outskirts of Paris and the date was approached with a kind of guarded euphoria, with various strategies for how to proceed proposed and discussed via e-mail. Once finally in the same room however, neither of them had anticipated the abundance of musical material that emerged spontaneously in the two days spent rehearsing and performing together. Captured through good fortune by Fabrice Le Breton, the recordings have been subsequently sewn together as a kind of non-linear stream of consciousness; the fruits of parallel paths of discovery incubated over the intervening 4 years and imploded into 35 minutes of critical dialogue.

Maurizio Ravalico / Isambard Khroustaliov – The Resurfacing of an Atavistic Trait

NOT020 – Live Recording – Release date 11 November 2011.

Track 1:
The leisurely exploration of a karstic area; our curiosity leads us along a non-linear path, during the course of which we visit different types of sinkholes, put our safety through some mild risks, and make few unexpected discoveries, among which the decomposing body of a deer, previously signaled by a disturbing smell.
(28'42")

Track 2:
The heavy breathing of a huge dormant monster, lying in a cave while herds of small cohabiting animals carry on their laborious daily activities, incidentally keeping the cave clean from lichen growth, and preventing the settlment of parasitic colonies on the monster's skin and horifices.
(25'18")

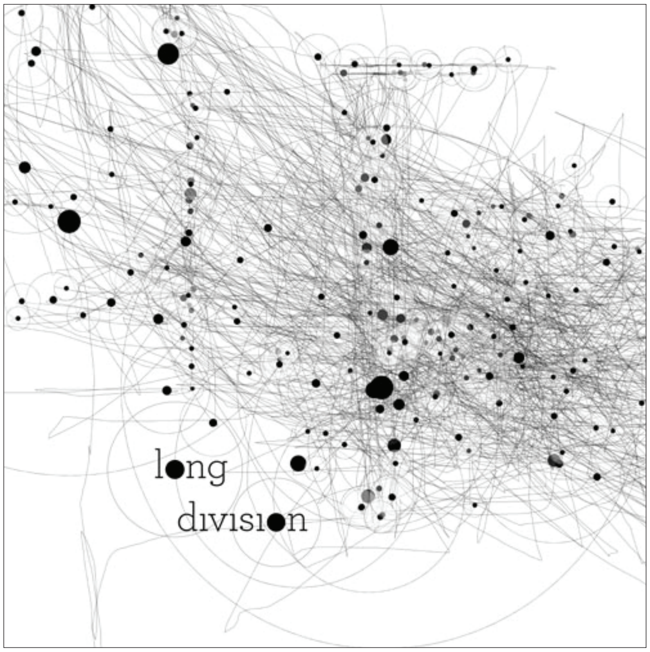
Maurizio Ravalico, percussion
Isambard Khroustaliov, computer

Artwork by Valentin Manz.
Design by Maurizio Ravalico and Isambard Khroustaliov.
Recorded live in Berlin on September 2nd and 3th 2010, during the Not Applicable Artists Festival of Experimental Music and Film.
Mixed by Isambard Khroustaliov and Maurizio Ravalico
Mastered by Isambard Khroustaliov at Trouble Studios, London.

Album Description

The two half-hour long tracks on 'The Resurfacing of an Atavistic Trait' were recorded over the course of two live concerts, held in Berlin during the Not Applicable Artists Festival 2011; they are not improvisations, but planned traverses that are nonetheless filled with the chance occurrences that populate performance environments. In keeping with the spirit of this circumstantial paradigm both the tableaux that function as titles for the two tracks and the artwork by Valentin Manz are not intended to be in any way either guides for the listener or impressions of the pieces. All three elements should be considered as separate but parallel entities, each entering into a related spirit of evocation whilst retaining an originality of purpose.

Tom Arthurs / Ollie Bown / Isambard Khroustaliov / Lothar Ohlmeier – Long Division



NOT019 – Live Album – Release Date: 6th January 2012

01 – Arthurs / Ohlmeier / Khroustaliov – NK, Berlin
02 – Ohlmeier / Bown / Arthurs – North Sea Jazz Festival, Amsterdam
03 – Arthurs / Khroustaliov – NK, Berlin
04 – Arthurs / Ohlmeier – North Sea Jazz Festival, Amsterdam
05 – Ohlmeier / Khroustaliov – North Sea Jazz Festival, Amsterdam
06 – Arthurs / Bown – North Sea Jazz Festival, Amsterdam
07 – Ohlmeier / Khroustaliov / Arthurs – NK, Berlin

Tom Arthurs – trumpet / flugelhorn
Ollie Bown – autonomous electronics
Lothar Ohlmeier – clarinet / bass clarinet
Isambard Khroustaliov – autonomous electronics

Software assistant @ North Sea Jazz Festival – Roy Carroll

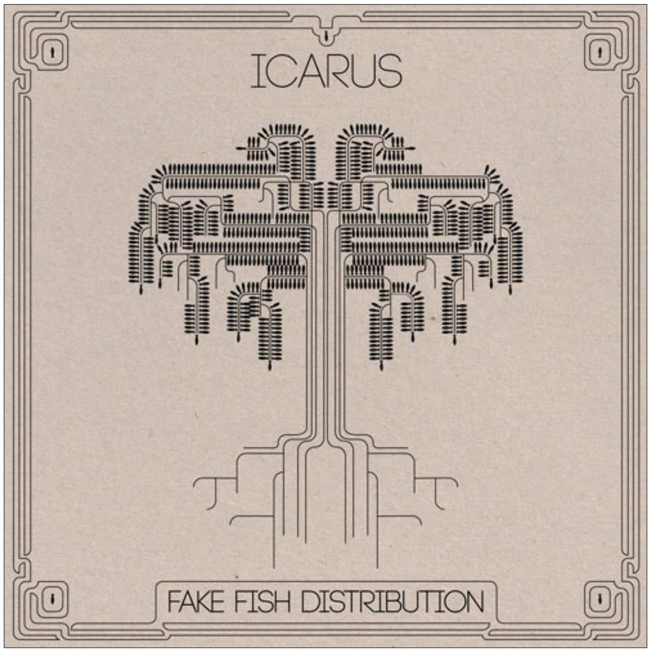
North Sea Jazz Festival performance recorded by Roy Carroll.
NK performance recorded by Isambard Khroustaliov.

mixed and mastered by Isambard Khroustaliov.
artwork and design by Vadim Charles.

Album Description

In 2010, Ollie Bown, Sam Britton, Tom Arthurs and Lothar Ohlmeier, were invited by NonFiction to play a concert at the North Sea Jazz Festival. Several factors conspired to make it an experiment in live autonomous and interactive software performance-by-proxy: the large geographical divide between participants, a buildup of previous work in live autonomous electronics, the fact that neither Sam nor Ollie could actually make the date of the show and the demands of a commission that required new and original work to be presented.

Icarus – Fake Fish Distribution



NOT022 – Album in a 1,000 Variations – Release date 6th February 2012.

01 – Dumptruck Cannibals
02 – Shallow Tree
03 – Spineez of Breakout
04 – M.D. Skillz
05 – Colour Field
06 – Old D.
07 – Three Stupidities
08 – Two Mbiras

Music, Software, Scripting – Icarus (Ollie Bown and Sam Britton)
Mastering – Will Worsley, Trouble Studios
Artwork – Harrison Graphic Design

Album Description

Icarus' forthcoming album, Fake Fish Distribution (FFD), their 9th in all, uses generative and parametric techniques to create a musical work that draws on the increasingly fruitful relationship between contemporary electronic music, algorithmic software processes and designed variation.

FFD was composed using normal electronic music production tools and uses the normal medium of music distribution — the media file download — but comes in the form of a vast array of structured variations on the album's musical content, feeding unique versions to each unique listener. FFD reinvigorates our understanding of what it means to own a 'copy' of something, in an age where the contents of our music collections are not even distinct objects, but clones of the exact same bits that belong elsewhere to others. You give somebody your phone number, not a 'copy' of your phone number; how can you experience ownership of this stuff except in a logical, legal manner, that old fashioned sense of ownership, going beyond the rights associated with its use? The motivation behind FFD is to think of how copies of something can be regain that distinction that is grounded in an individualised relationship to an entity, a relationship that is lost in the age of network-distributed music.

Alex Bonney / Isambard Khroustaliov / Tolga Tüzün – From Bloom To Bust

NOT026 – Live Album – Release Date: 9th September 2013.

01 – I
02 – II
03 – III
04 – IV

Alex Bonney – Trumpet (II & III)
Isambard Khroustaliov – Electronics
Tolga Tüzün – Piano & Bloom

Recorded at the Zoom Unit, Shelford Place, London, on the 29th June 2011, by Isambard Khroustaliov.

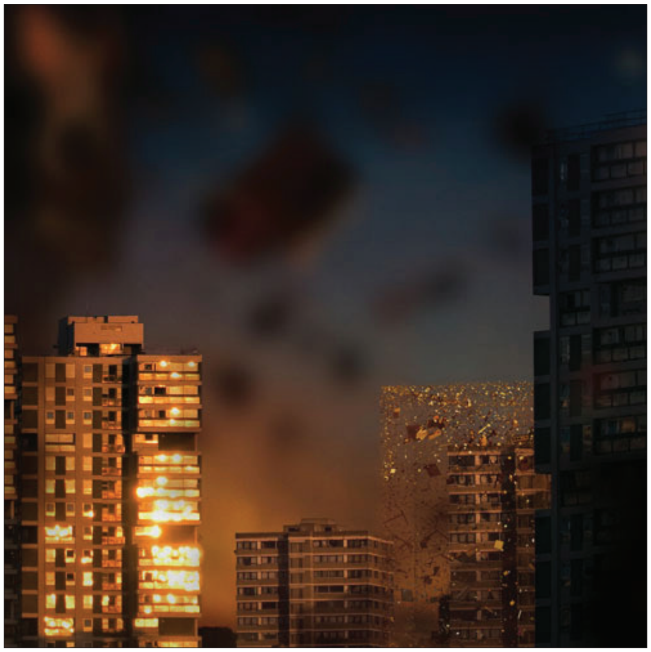
Photography by Léonie & Martin Hampton.

Bloom by Brian Eno and Peter Chilvers.

Album Description

'From Bloom to Bust' is perhaps least imperfectly described by alluding to the serendipity that shaped the warm June evening on which it was recorded; the recent arrival in London of our host's old family piano, a last minute telephone call to Alex Bonney inviting him to bring his trumpet, the fortuitous design of the curved case of Tolga Tuzun's iPod touch that functioned so well as a slide and preparation device inside the piano, and its incidental extended use as a musical instrument in its own right thanks to Brian Eno & Peter Chilver's 'Bloom' app. Prepelled by the small group of friends who gathered to stoke the eloquently homespun proceedings, the music that unfolds is at once indebted to the intense multifariousness of our information rich musical epoch and yet in its open inquisitiveness, unencumbered by it.

Lothar Ohlmeier / Isambard Khroustaliov – Lady Fairfax



NOT030 – Live Album – Release Date: 18th November 2013.

01 – Vermont
02 – Hellespont
03 – Beatrice
04 – Avenue

Lothar Ohlmeier – Bass Clarinet
Isambard Khroustaliov – Electronics

Recorded live at the Bethaniënklooster, Amsterdam on September 16th 2012 by Concert Zender, Recording technician Joost Kist, recording produced by Kees van de Wiel. Mixed and mastered by Will Worsley and Isambard Khroustaliov at Coda-Cola, London.

Artwork by Ollie Alsop.

Album Description

It seems that no science fiction movie is quite complete without some form of musical reminiscence in its soundtrack; think Vangelis' love theme in Ridley Scott's 'Blade Runner', or Andrei Tarkovsky's quotation of Bach in 'Solaris'.

With this in mind, it is perhaps apt that around the mid point of this live recording, which finds our protagonists reunited in Amsterdam for a performance, Lothar Ohlmeier spontaneously reaches for the melody from the verse to George Gershwin's 'But Not For Me' to weave into his dialogue with Isambard Khroustaliov's electronics. It is in a curious way a defining moment; as if the ghost of Sonny Rollins fleetingly enters the room, a spectre from another time and place sent to confound our predicament as defined by the arrow of time. The presence is registered only to vanish, enveloped by the brooding non-linear digital counterpoint, a fog of musical DNA which signals the vortex that unfolds here as 'Lady Fairfax'

From our perspective after the event, this recorded trace is all that remains, complimented by the plumes of debris levitating from Ollie Alsop's imagined future in which gravity has become a commodity expelled by some electromagnetic storm. In this indistinct future place and time, one might do well to remember Marcellus's call to action from Hamlet; "Thou art a scholar; speak to it, Horatio."

Tom Arthurs / Isambard Khroustaliov – Vaucanson's Muse

NOT033 – Album – Release Date: 19th September 2016.

01 – On a Carpet of Leaves Illuminated by the Moon
02 – Vaucanson's Muse
03 – Grace Jones
04 – Trajets
05 – Can't Unsee
06 – Irina Piperin
07 – Isländisches Fishtank
08 – Sea Interval

Tom Arthurs – Trumpet
Isambard Khroustaliov – Electronics

Recorded by Isambard Khroustaliov at Coda-Cola Studios, November 2013.
Mixed by Isambard Khroustaliov & Tom Arthurs at Coda-Cola Studios, February 2014.
Mastered & cut by Alex Wharton at Abbey Road Studios on a Neumann DMM lathe, November 2014.
All compositions Tom Arthurs and Sam Britton [PRS/MCPS].

Original artwork by Will Alsop.
Liner Notes by David Toop. recording produced by Kees van de Wiel. Mixed and mastered by Will Worsley and Isambard Khroustaliov at Coda-Cola, London.

Album Description

Evolving out of a ten year friendship, spanning their involvement in the label and collective Not Applicable, and catalysed by a UK tour of Graphic Scores in 2013 (featuring Joanna MacGregor and Ollie Coates among others), 'Vaucanson's Muse' is a seminal document of the collision between improvised acoustic and electronic music in the hands of two of the most eloquent practitioners in their fields.

Set alongside specially commissioned artwork by maverick architect Will Alsop and liner notes by esteemed musician and author David Toop, the LP as a whole consolidates themes hinted at in the music of unknown worlds constructed through symbolic and geometric abandon.