



# COLLABORATION IN SONIC DESIGN

*frameworks for designing interactive sound environments*



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2006



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*frameworks for designing interactive sound environments*

An exegesis submitted in fulfillment of the requirements  
for the degree of Master of Design

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B. Design Studies

SCHOOL OF ARCHITECTURE AND DESIGN  
PORTFOLIO OF DESIGN AND THE SOCIAL CONTEXT  
RMIT UNIVERSITY

March 2006



## DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the exegesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Jeremy Yuille



## ABSTRACT

This exegesis investigates two interactive sound design projects, describing each one in terms of techniques, concepts, and processes that went into their realisation. It describes how collaborative processes helped me become better at working on solo projects, how technical skills helped me to apply conceptual knowledge, and how Pierre Schaeffer's theories of the sonic object can be applied to the design of interactive sound environments. In the process I explain some unique aspects of interactive sound design, suggesting a suite of methodological, technical, and conceptual tools for the interactive sound designer. I then reflect on the ways I combined these tools, and propose a methodology of *transcoding systems*.



## ACKNOWLEDGEMENTS

I would like to acknowledge and thank the following people for their help with this exegesis:

RMIT School of Applied Communication, for funding me to undertake part of the research in 2003. The Communication Design program, for supporting my research, particularly in its final stages.

The Lifesigns team. Software development: Nicholas Sandow, Shee Zon Chen, Leng Hou Tan. Sound design: Steve Law. Database design/coding: Steve Taylor, Harry Lee. Photography: Greg Ford. Video: Matthew Perkins

Lisa Grocott, for prodding me to start, helping me to finish, and the inspiring conversations in-between. Laurene Vaughan and Tim Kreger for advice and proofreading. Peter Downton, for that coffee when I *got it*. Paul Doornbusch, for the musicianly conversations, the *Solfège*, and making the complex understandable. John Dack, for filling a *massive* gap in the lexicon, and letting me read it before he was finished.

My supervisors: Pia Ednie-Brown, for reintroducing me to phenomenology, and letting me write sci-fi. Lawrence Harvey, for guiding me through this first landing, with insightful advice, encouragement, and confidence.

Troy Innocent, for his support, friendship, and collaborative vision.

and Maria, for proofreading, unwavering support, and giving me the best reason of all to finish.



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*“Music, insofar as it is an inclusive activity which cuts across many specific disciplines, is the privileged area for interdisciplinary research.”*

Michel Chion, describing  
Pierre Schaeffer's *Traité des objets musicaux*  
in *Guide des objets sonore* p39

*“... (the) object of study is a system, either constructed, or so abstracted from a physical assembly, that it exhibits interaction between the parts, whereby one controls another, unclouded by the physical character of the parts themselves.”*

Gordon Pask in *An Approach to Cybernetics* p15  
via Ranulph Glanville's summary of the book



## INTRODUCTION

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For over a decade I have worked with music and sound design in the fields of theatre, performance, computer games and advertising. Although my ability to produce successful work has increased, I found I was less connected to the sonic event, and the work containing it. In one sense I had lost the ability to *listen*. The work I was doing with sound design started to resemble the work I was doing elsewhere in web design, and freelance programming. It was abstracted, concerned with problem solving, and divorced from the experience of hearing. As software replaced hardware, the physical connections between equipment were now increasingly becoming virtual and intellectual. I undertook this research in an effort to regain the act of listening, to explore my practice, and to generate more interesting, sophisticated and ultimately more rewarding ways of working with sound and systems.

When I reflected on my career to that point, all the works that I thought represented *me* best, were collaborations. These collaborations were with fellow musicians, performers, programmers, visual artists, directors, producers, actors, academics, and importantly, different software systems that I had created.

I was also very interested in the differences between sound design and composition. There was a tendency for my sound designs to sit on the limits of perception, in the background, in synergy with other

elements of the collaboration. I can still remember one particular theatrical work (which I think is still one of my best) *Fathom*, from 1995:

*an actor, immersed in water on the stage, emerges from the pool. The sound of the water dripping from her body is imperceptibly augmented by the sound of a gurgling stream, while a claustrophobic low frequency noise that had been slowly introduced to the space is then released...*

This memory still brings a smile to my ears because it represents a near-perfect moment of theatrical gestalt. Actions, lights, dialogue, space and sound came together and moved the emotional balance of the auditorium. Later that night, the Director of Drama at Victorian College of Art told me it was the best sound design he had ever seen produced at the school. I wasn't a student there.

I am including this anecdote, not to say "I am a great sound designer" as I believe it was a lucky fluke that I was fortunate enough to stumble across at the time. I tell it here because it describes in a frozen instant the aesthetic values that drive me to be passionate about music and sound design, namely synergistic collaboration and the incredible emotional potential of subtlety.

This document describes two projects. The first project, *lifesigns*, was a collaboration where I designed the sound engine for an interactive installation by Troy Innocent. In this project I was working with a team of three programmers, another sound designer, and Troy, the artist. I was responsible for designing the way the work would sonically interact with people, both in the immediate sense, as they were playing the work, but also as an installation where people could move around inside the space of the gallery.

The second project, *Tixeerif*, is an electroacoustic composition for four or more speakers. I was responsible for every aspect of this project, from the conceptual approach to the sonic production required to realise those concepts.

This exegesis investigates these projects, describing each one terms of techniques, concepts, and processes that went into their realisation. An analysis of how they were designed and produced will explain how they relate to one another and my practice as a whole.

I describe how collaborative processes helped me become better at working on solo projects, how technical skills helped me to apply conceptual knowledge, and how theories of the sonic object can be applied to the design of interactive sound environments. In the process I explain some unique aspects of interactive sound design, suggesting a suite of methodological, technical, and conceptual tools for the interactive sound designer. I then reflect on the ways I combined these tools, and propose a design methodology of *transcoding systems*.

## AN OUTLINE OF THE PROJECTS

In the summer of 2000/2001 I was approached by Troy Innocent to help with a research project. We spent the next year building a prototype system for mapping gestural input onto audiovisual transformations of 3D objects in real-time. This work, the Transmutational Meta Processor (TMMP) (Innocent, 2002b) was the first step in a much longer collaboration with Troy that would culminate in the premiere of the *lifesigns* project at ACMI in June

of 2004 (Innocent, 2004). Later that year, *lifesigns* was exhibited at ARS Electronica, the international festival for electronic arts held annually in Linz, Austria.

*Lifesigns* is an interactive installation by Troy Innocent, commissioned by Film Victoria and the Australian Centre for the Moving Image. It uses digital game technologies to represent an interactive virtual world inhabited by artificially generated entities, or *lifesigns*. Each *lifesign* is unique, passing on some of its electronic DNA when reproducing with other *lifesigns*. People can navigate the world using a physical interface to manipulate individual *lifesigns*, or view a large floor-projected map of the space while moving around in the installation space.

On beginning my candidature, the *lifesigns* project was beginning to move focus from what kind of hardware we would use, to the description of the underlying software relationships between the elements. Over the next 18 months *lifesigns* grew from a concept and software requirements specification into a sophisticated, robust, fully operational networked environment able to travel and be installed without expert help. I learnt many things along the way, some in order to achieve a design outcome, some as a result of having done it. This exegesis will describe that period of *lifesigns*, particularly concentrating on the relationship between the theoretical underpinnings, conceptual design and technical execution.

Because it is so general and wide-ranging in its scope, *lifesigns* forms the conceptual core of the research reported in this exegesis. The other project *Tixeerif* is a specific exploration of the sonic medium, informed by and relating back to works like *lifesigns*. The knowledge

generated in *Tixeerif* folds back into any future work of *lifesigns* scale. The two projects specifically address different ends of the structure–object continuum, more of which I will discuss later.

Throughout 2003 and into 2004 I worked for small concentrated periods on *lifesigns* – usually in response to either a deadline in the project or some free time in my schedule of other projects. As my work on *lifesigns* became more specific and detail-focussed, I was keen to keep feeding the expansive, performance driven side of my practice with new projects.

I had designed a number of techniques for gesture-driven sonic processing and had used them to produce live performances throughout 2003 at events like *Liquid Architecture3*, *What is music?* and the *Australasian Computer Music Conference (ACMC)*. While these performances were successful, I was frustrated with the way these pieces were so ephemeral and transitory – their sonic product was relevant for the duration and context of the performance and then never really worked later as a recording.

In early 2003, Pia Ednie-Brown from RMIT suggested that I explore the ideas I had been researching in a composition. This led directly to me composing a linear version of *Human Beings are Animals Too (Humans)* – from a recording I had of a performance of the same name. The process was entirely liberating; I was able to move into working with music and sound in a way that had a very different relationship to code or systems of interaction. Working with the concrete sound object, I was listening to sound again and loving it! During 2003 and 2004 I worked in this way on the piece *Tixeerif*, of which *Humans* makes up the first section. The work was premiered at the SIAL Sound Studios concert *SPECTRUM 01* in late 2004 at Horti Hall in Melbourne.

This explains the chronology and some relationships between the two projects of this exegesis, *lifesigns* and *Tixeerif*. In order to better understand how they relate to one another and, more importantly, what I learned by doing them, I will now describe each one in detailed separation.



## LIFESIGNS

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In this section I will describe *lifesigns*, giving a brief overview of the artwork, how it works, and how people can interact with it. I will describe aspects of the *lifesigns* project with particular reference to its broad design goals and the theoretical antecedents. I will then outline my role and responsibilities within the design and realisation of the work, specifically referencing Pierre Schaeffer's theories of *sonic objects* and Denis Smalley's *spectromorphology*.



Figure 1. *lifesigns* installed at the Australian Centre for the Moving Image in 2004

## DESCRIPTION

*Lifesigns* is an interactive installation combining two separate views of a virtual world, hereafter referred to as the *player* and *map* views.

### *Map View*

A flattened map of the world is projected on the floor of the gallery space, with a spatial soundscape that communicates a sense of the world's state.

### *Player View*

Up to four workstations placed around the edges of the map, enabling individual navigation and play of the world. These workstations include a screen with a first-person view of the world, stereo speakers, and an interface with a trackball for navigating the world and a set of touchpads for selecting and manipulating individual lifesigns.

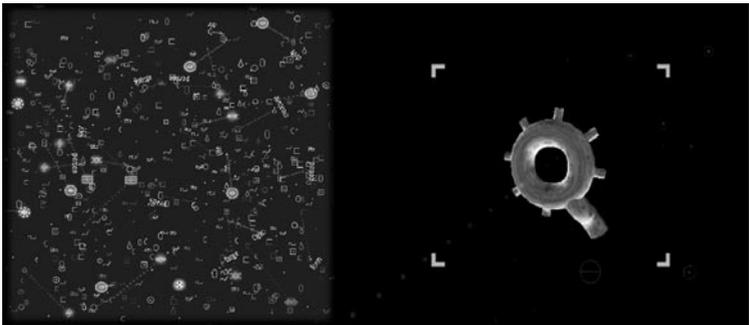


Figure 2. Screenshots of map and player views

Living signs or lifesigns inhabit this virtual world. They have been generated by a system of rules that govern features typical of signs,

symbols and icons such as symmetry, form, colour and sound. Each lifesign is built from primitives, described as *atoms*. Rules for the combination of atoms into larger structures are described in the system as *structural constraints*. The process of building a lifesign from geometric primitives is determined by a grammar that defines relationships between the primitives in terms of *build rules*, weighted by probabilities. More rules also determine how lifesigns interact with one another. They may attack, mutate, leech and join with other collections of lifesigns, they can also communicate by sending messages or commands. The game world is a network of living entities, or lifesigns, whose actions and behaviour shape the activity of the simulated ecosystem.

There are three types of lifesigns; *Ambient*, *Language*, and *Beatbox*. These types are analogous to species, each type reacts differently to input from users and other lifesigns. This difference is achieved through strategies for mapping interface touchpads onto the lifesigns structure and the way signals propagate through the lifesign. The following list outlines a high level design specification for each lifesign type: (Innocent, 2004)

*Ambient*     Four parameters are mapped to four individual atoms in an icon.  
By default the icon makes no sound.  
Sound events are discrete events, triggered by the touch pad inputs.  
Individual atoms are animated in sync with inputs.  
Signal is propagated up and down the icon structure, depending on the rules of propagation.

*Language* Four parameters are mapped to single root atom in an icon.

By default the icon makes no sound.

Any input turns the voice of the icon on.

No input turns the voice off.

Inputs received while the icon voice is on modulate the current voice.

Signal is propagated down the icon structure, depending on the rules of propagation.

*Beatbox* Four parameters are mapped to four individual atoms in an icon.

By default the icon makes no sound.

Sound events are discrete events, triggered by the touch pad inputs.

Individual atoms are animated in sync with inputs.

Signal is not propagated up and down the icon structure, but transferred immediately to the icon's join points.

Features such as *structural constraints*, *build rules*, *behaviour* and *meaning* of each lifesign are stored in what came to be called their DNA. Lifesigns can reproduce, creating offspring that uses a genetic algorithm to combine features of both parents DNA, so that each new lifesign is a unique entity.

When the virtual world is started, a random batch of lifesigns are generated. Over time, lifesigns that are best adapted to their world will survive and reproduce. In this case the parameters for survival include their successful mix of behaviours, significance in terms of the meaning system within the world, and ability to gain energy by being aesthetically appealing to the people playing the system.



Figure 3. Detail of physical interface in operation.

People use the workstations to move through the world and observe the emergent behaviour and form of lifesigns in their natural habitat. Each of the four workstations provides a unique and navigable window or field of view into the virtual world, allowing users to see and hear nearby lifesigns. Users navigate the space and can select individual lifesigns. Once selected, these lifesigns can then be manipulated or *played* using four touchpads included in the interface to trigger the lifesign with energy input. That energy then propagates through the lifesign, creating visual and sonic behaviour. The touchpads communicate velocity and polyphonic aftertouch, so users can hold a note and manipulate up to four qualities of the sound at the same time. For example: filter cutoff frequency, pitch, modulation depth and speed.

## ROLES & RESPONSIBILITIES

In a project of this complexity, it is very difficult for one person to do everything. Specific skills are needed in many different discipline areas. The artist, Troy Innocent, had commissioned me to build software elements for TMMP, a conceptual precursor to *lifesigns*. After the successful completion of that project Troy engaged me to advise on the design of the sound engine for *lifesigns*. The process of defining the scope of the role took some time, and eventually the following set of responsibilities was drafted (Innocent, 2002a), outlining what I would do.

Advise on software and hardware solutions to meet the specified requirements of the sound engine for the project.

Advise on music and sound issues in relation to the project, and where required compose and design sounds for the project, as directed by the artist.

Programming work in accordance with any specifications required by the artist from time to time, in order to develop the sound engine for the project.

Completion of programming work on the sound engine of the project following work performed by other programmers.

Provide reports to the artist on a regular basis as to the my progress in providing these services.

Production of all ancillary programming documentation, including sufficient commentary in code to allow another programmer to take over the my work.

Where instructed to do so by the artist, production of design documentation, testing documentation, user manuals or any other type of document.

Assistance with acceptance testing and unit testing of the project.

Assistance with the installation and integration of the sound engine and hardware system of the project following its delivery.

These responsibilities were distributed throughout the project, but the timely completion of any project requires a plan for when different elements of the project will be delivered, and evaluated. To address this issue, the following four milestone stages were drafted (Innocent, 2002a).

- Stage 1*      Integration of software synthesis system into the Project, including test patches.
- Stage 2*      Working sound engine identified, developed and integrated. Refined software synthesis system to include all parameters, play system variables, programmable instruments, and programmable sequences as specified by the Principal.
- Stage 3*      Installation sound environment, including all lifesigns behaviour sounds for the world/server view as specified by the Artist. Completion of recorded icon sample output, primarily for web site upload.
- Stage 4*      Refinements, changes, and sound engine optimisation based on testing and feedback from the Artist. Delivery and integration of final sound engine, including all documentation.

## CONCEPTUAL APPROACH

*lifesigns* exists in the context of previous projects using artificial life to create and manipulate audio/visual worlds, these include *Feeping Creatures* (Berry, 1999) and *Eden*. (McCormack, 2000) In this sense, characteristics and properties usually associated with living systems and natural environments are applied to information systems and virtual worlds. Autopoietic ideas such as self-organization were fundamental in the conception of the work as an enclosed world of living entities. On closer examination, the world can be seen as an example of the complexity possible within a structurally coupled environment. (Maturana et al., 1987). Troy Innocent, the artist, was specifically interested in the ability of digital systems to *encode processes* and theories of digital media:

“*lifesigns* investigates five properties of digital media described by Lev Manovich - (i) numerical representation, (ii) modularity, (iii) automation, (iv) variability, and (v) transcoding (Manovich, 2002). Numerical representation is the basis of all processes and interactions within the system. *lifesigns* generated by the system are built from simple atoms, and this modular approach is applied at all levels as the work evolves through multiple iterations autonomously, utilizing the capacity of digital media to encode process. *lifesigns* that evolve from these processes display a high degree of variability in their representation, resulting in an *emergent language* rather than a language that is explicitly designed or constructed. They are represented as image, sound and motion through the transmutation of the digital code from which they originated.” (Innocent, 2004)

### *My conceptual approach*

To this mix of ideas I brought theoretical frameworks from the work of Pierre Schaeffer, particularly his theory of the sound object put forward in the *Traité des objets musicaux* (Schaeffer, 1966a) and *Solfège de l'objet sonore* (Schaeffer, 1966b) via a translation of Michel Chion's *Guide des objets sonores* (Chion, 1995), Denis Smalley's theory of *Spectromorphology* (Smalley, 1997), and ideas on the perception of musical time from Curtis Roads' book *Microsound* (Roads, 2001).

### *Sonic Objects*

In 1966 Pierre Schaeffer published the *Traité des objets musicaux*, in which he:

“...develops the main part of his new musical theory of the sound object. It is based on two principal ideas, making and listening, and explores the first two levels of this theory: typo-morphology and classification of sounds. He uses various disciplines such as acoustics, semiotics and cognitive science to demonstrate his explanation of sound and, in particular, the musical object within musique concrète.

Michel Chion's *Guide des objets sonores* is a very useful introduction to this voluminous work.” (EARS)

Neither Chion's *Guide* nor Schaeffer's *Traité* have ever been officially translated into English. I was fortunate to not only become aware of the work John Dack and Christine North were doing in translating Chion's *Guide des objets sonores* (Chion, 1995) but for John Dack to send me the translation for study purposes. It is through this unofficial translation, together with a translated reissue of Schaeffer's

*Solfège de l'objet sonore* (Schaeffer, 1966b), and Carlos Palombini's PhD Dissertation, *Pierre Schaeffer's Typo-Morphology of Sonic Objects* (Palombini, 1993) that my knowledge and understanding of this important aspect of 20<sup>th</sup> Century musical thought is based.

In the *Traité*, Schaeffer builds a theory of formidable depth and sophistication from the first principles of the *acousmatic* situation and the *abstract–concrete* dialectic. I will explain the concept of *acousmatic* in the later section on working in the studio, but before we move on an understanding of the *abstract–concrete* dialectic is required. Chion states that in using the two terms, Schaeffer refers to Lalande's *Vocabulary of Philosophy* (Chion, 1995)

*Abstract: every notion of quality or relationship considered in a more or less general manner without reference to any of its representations. In contrast, the complete representation as it is or could be given is called concrete.* (Lalande et al., 1947)

Schaeffer calls these the *two isotopes of reality* because they represent the dual ways everything can be perceived; as the qualities something exhibits (*concrete*) or its place in a symbolic system (*abstract*). Schaeffer goes on to build many more specific concepts using this dialectic, from the far-reaching *object–structure* to the more sonically specific *context–contexture* and *musical–musicianly* (Chion, 1995). Some of these pairs will be examined later in the context of *Tixeerif*, where these conceptual approaches were applied.

### *Spectromorphology*

The term *Spectromorphology* refers to:

“the interaction between sound spectra (spectro-) and the ways they change and are shaped through time (-

morphology)... A spectromorphological approach sets out spectral and morphological models and processes, and provides a framework for understanding structural relations and behaviours as experienced in the temporal flux of the music.” (Smalley, 1997)

Although the term was conceived to aid in the listening and description of electroacoustic works, it also functions (like any other system of classification) as a way of conceptualising the creation of sonic events. In other words, spectromorphology can be used to describe what has been made, and to create new work. John Dack states that spectromorphology...

“...emphasises the benefits for the composer in classifying and describing the varieties of ways in which spectral energy can be shaped and how this supports the listening processes as the mind searches for meaningful musical structures.”  
(Dack, 2002)

A student of Schaeffer, Smalley states that the theory “owes most” to the *Traite des objets musicaux*, and in many ways it can be seen as extension of Schaeffer’s work, made accessible to the composer because of advances in technology that afford a view of a sounds spectra. These advances include the Fast Fourier Transform (FFT) algorithm that significantly decreases the processing needed in order to measure the level of energy across the sonic spectra of a sound, CPU speed increases making this calculation even more possible in conjunction with other processes, and possibly most importantly, the ability to display and manipulate the spectrum of a sound in realtime (spectrogram) or as a function of time (sonogram)

Within these frameworks, *lifesigns* can be conceptualised as a manifestation of the concrete–abstract dialectic; the player

soundscape uses an abstract language of mathematical rules often associated with the serialism and subsequent musical movements, an account of which can be found in Chapter 2 of David Cope's *New Directions in Music* (Cope, 1993). In *lifesigns*, these rules create midi streams which trigger instrumentally driven audio samples. The map soundscape is inspired by a phenomenological approach to the experience of sound in space, moving from the abstract concepts of instrument and note to the concrete sound object. I will now look in more detail at the sound designs for the Player soundscape and the Map soundscape in separation, before returning to the methodologies behind their integration.



## LIFESIGNS PLAYER VIEW

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The *lifesigns* player view presents a first-person view of the virtual world, allowing users to navigate the represented space, select *lifesigns* and manipulate them for audiovisual effect. This section will describe how the player view software achieves these sonic interaction aims, and why some solutions were chosen over others. It will examine the use of algorithmic composition techniques in the design of a system for producing typologically driven aesthetic behaviour, and some effects of collaboration on these design processes.

### RESEARCH QUESTIONS

In a complex project like *lifesigns* there are many specific research questions to answer. These range from aspects of the direct interface with users, eg:

*How can simple user interaction be applied as transformations on a sound?*

*How can this be done in realtime, synchronising with transformations of 3D objects in virtual space?*

To the technical interface with galleries and non-experts, requiring robust software design and production:

*How can this all run simply in a gallery with no specialist supervision?*

To the conceptual interface between the artist, me the designer, and the programmers:

*How can an intended aesthetic be reproduced by a system?*

Of the first two questions, tight synchronisation of animation and sonic events is essential to the synaesthetic relationships that Troy Innocent wanted to convey in the work. The solutions to this question were arrived at iteratively, and are interspersed through the next section on the player view sound model. The third question is addressed more specifically in the reflective section on content and systems in the second half of this exegesis. I will talk here about the last question, as it relates strongly to the key finding of this research and is expanded upon in the later sections of this exegesis.

*Designing for behaviour*

Design of a system that demonstrates aesthetic tendencies is a complex undertaking. In this case, the sound engine has to be general enough to support many different experiences and configurations of sonic processing, but specific enough to produce those experiences within a certain musical genre. Troy Innocent, the artist, was very interested in the sound design communicating characteristics of “electro” music. This game makes a large use of the “bleeps” and electronic drum sounds found in that genre of music, revelling in a “low-fi” retro aesthetic founded in the musical technologies of the early 1980’s.

The process of designing this system was further complicated by the interrelated nature of the system and content. For example, I needed to know *how* to play whatever sounds we would eventually produce

because this knowledge would affect the way those audio samples were produced, particularly because the choice of synthesis would have ramifications on the format and type of file we would need.

One such set of values are the rules governing how a lifesign responds sonically to user input. Through research and many conversations with colleagues, this sonic interaction was abstracted into behaviours for generating melodic and rhythmic information. Homogeneous *build rules* create harmonic melodic phrases and heterogeneous *build rules* create dissonant melodic phrases. The size of a lifesign (ie. The number of constituent *atoms*) determines how long these phrases will be, and the lifesign type (*Ambient, Language* or *Beatbox*) determines the proportional relationship of notes to silence and how long or short these rhythmic phrases will be. Values for these musical parameters are generated and stored in a lifesign's DNA. The techniques used to generate a unique musical DNA for each lifesign are described below, and include Markov chains (Franz, 1998), weighted stochastic determinacy and basic lookup (hash) tables. MIDI is used to communicate this information to a sound card, where stored samples are processed. I will now explain how the player view sound system generates these different behaviours, while a thorough technical documentation of the algorithms used can be found in Appendix 1.

## AN ALGORITHMIC ENGINE

The player view workstations use the DownLoadable Sounds (DLS) or Soundfont format to synthesise sonic output. The decision to use DLS was driven by a need to minimise load on the central processing unit (CPU). The player view workstation CPU was already

very busy running the visual and logical aspects of the world. The DLS engine can be run on relatively inexpensive consumer sound cards leaving more CPU cycles for this other processing. MIDI is used to communicate between the player's control pad, the system, and the sound card. When a lifesign is acquired by the player (or comes within earshot) its relevant soundfont is loaded into one of 32 available banks on the DLS engine.

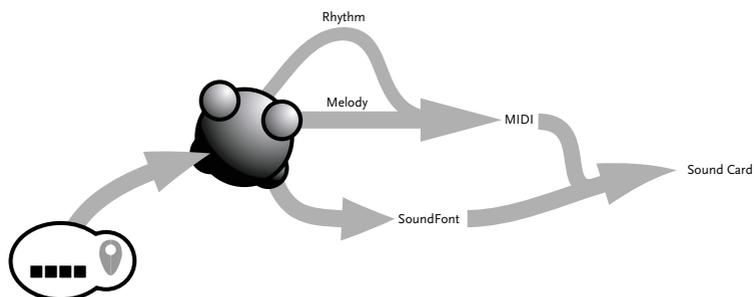


Figure 4. Player view sound system diagram

Using MIDI and DLS had the added benefit of being able to run production and development in parallel, because the sound designer could place a 'dummy' set of sounds into a Soundfont and systematically replace those sounds later with more up to date audio samples. This allows the programmers to test audio behaviour before the final set of sounds are created, while the sound designer can test a Soundfont by merely playing recorded MIDI files, without needing the game to be compiled or having to mess around with the usual production requirement of specific filename structures. The overly general, standardised and well documented specification and widespread implementation of MIDI makes programming and tweaking the system relatively easy for people with non-musical backgrounds. Sound cards designed to the Soundfont specification

also provide rudimentary wavetable (Roads, 1996 p 90) and subtractive synthesis (Roads, 1996 p 184), which means that in addition to being able to change the speed a sample is played, and thereby changing its pitch, you can also control filtering, dynamic level, stereo positioning and basic effects like reverberation to each voice. More in depth information on the background to these aspects of the system and its relationship to sound design for Digital Games can be found in a paper titled *Smearing Discontinuity :: In-Game Sound that* I presented at the *Digital Arts and Cultures Conference* in 2003.

To describe how these technical and conceptual ideas were integrated I will now examine each of the different subsystems of the player view sound engine. Each sound event in the lifesigns player view is made up of the following sub-events:

*Pitch*            what MIDI note number is used to create a note-on message?

*Duration*       how long before a corresponding note-off message is sent?

These two types of events generate the abstract qualities of rhythm and melody, whereas the next two types of events are required to generate the concrete phenomena of sound itself.

*Processing*     which parameters are effected to change the way the soundfont is modulated?

*Timbre*           which soundfont is being played?

The typologically driven musical behaviour of the lifesigns player view is generated by a system comprised of an *abstract generator*, incorporating melodic and rhythmic elements which outputs

MIDI notes, and *voice allocation*, which chooses how the player view workstation sound engine will respond to these MIDI notes and subsequent user modulation.

### *Pitch*

Each *player* has four touch-sensitive pads for manipulating a lifesign after it has been acquired. The four pads can be conceptualised as *inputs* that cause an audio–visual *output* from the lifesign.

- ⦿ Please view the PEOPLE PLAYING section of the DVD to see the touchpad interface in use

Lifesigns are built from *atoms*, starting with a *root atom*. When a lifesign is created it generates pitch information for each *atom* it contains. This process begins by determining the *root* pitch of the lifesign where the scale of the *root atom* (range 0...3) is mapped to the octave, where larger *atoms* give lower values. The colour of the *root atom* (range 0...11) is mapped to the pitch class, or which note inside the octave. An offset of 36 (three octaves) is added to yield a number between 36 and 83 (range C1...B4).

The colour and scale of each subsequent *atom* is analysed to determine how different it is from the *root atom*, this difference (range 0...8) is used with a lookup table included below to derive an interval of pitch, or how far from that atom's pitch parameter is from the *root* pitch, the result being that homogeneous lifesigns create melodic relationships, heterogeneous lifesigns create dissonant relationships.

Difference	0	1	1	2	3	4	5	6	6	7	7	8
up	0	4	7	5	10	9	3	2	8	6	11	1
down	0	5	8	7	2	3	9	4	10	1	6	11

Figure 5. Harmonic/dissonant difference tables

These harmonic / dissonance values were based on experiments I did in the studio, mapping musical intervals onto a perceived scale of dissonance.

When a player hits one of the buttons to manipulate an acquired lifesign the velocity and note-on message are passed to the software, triggering it to send the *root* pitch at that velocity to the DLS engine, and to hold that note for as long as the player keeps the pad depressed.

### Duration

When the touchpad is released, the events triggered by the player travel through the hierarchy of geometric primitives within the lifesign, causing further musical-visual events. In the *lifesigns* player view this is referred to as *signal propagation*.

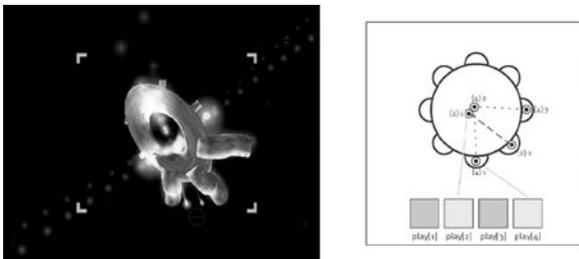


Figure 6. Propagation of input through hierarchy of lifesign geometry.

When a lifesign receives some *input* from a player it triggers a note that represents the *root* atom. When the player releases the note a signal propagates out through the hierarchy of geometric forms that comprise the lifesign, further triggering notes and animations that correspond with these individual atoms.

For example, a lifesign may have three levels of hierarchy with one atom on the first level (ie *root atom*), two atoms on the second level (ie directly connected to the *root*) and six atoms on the third level (ie directly connected to the second level atoms).

When an input arrives it begins by playing the *root* (level 1) and then in turn travels to level 2 and 3 playing notes associated with those atoms. This creates melodic and rhythmic output based on the atomic pitch values derived from the homogeneity of the atoms, described previously, and the lifesign rhythmic values derived from lifesigns size and typology (*Ambient, Language, Beatbox*). These rhythmic values are generated using a combination of Markov chain (Franz, 1998) for the rests and notes, and stochastic tables for the durations. The three lifesign types use differently weighted tabled and Markov chains, creating the following typological tendencies:

*Ambient* lifesigns have fewer notes and longer durations.

*Language* lifesigns have medium numbers of notes and medium durations.

*Beatbox* lifesigns have more notes and shorter durations.

For example, if we choose an *Ambient* lifesign: it will be made up of between 1 and 16 *atoms*. This number of atoms is used to define how many elements will be in the musical phrase associated with that lifesign. Using a probabilistic function, a random number between 0.25 and 4 is chosen. In the case of *Ambient* lifesigns, this

number is weighted towards the smaller end of the scale (0.25). By multiplying this number (called the phrase length coefficient) with number of atoms in the lifesign a musical phrase length is obtained, this length has a minimum of 1 and a maximum of 4 times the number of atoms in the lifesign. *Ambient* lifesigns have weightings towards smaller coefficients, *Language* towards the middle where the coefficient equals 1, with *Beatbox* lifesigns weighted towards the higher end, producing phrases that tend to be longer than the lifesign. If a musical phrase is longer than the number of atoms, the signal cycles around to the root atom for pitch values.

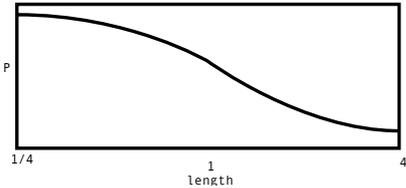


Figure 7. Phrase length coefficient table for Ambient lifesigns

Duration information is derived using a similar weighted probabilistic function, this time the scale is in *ticks*, or unit measures of the world time. The outcome of this function is a number between 1 and 16. *Ambient* lifesigns are weighted towards the larger (ie longer durations) end of the scale (see Figure) while *Language* and *Beatbox* are weighted toward the middle and smaller end respectively.

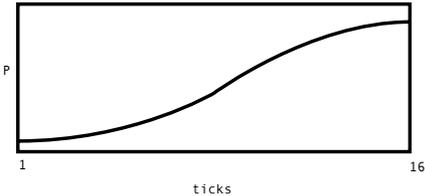


Figure 8. duration table for Ambient lifesigns

Whether the duration is applied to a played note or period of silence (ie rest) is derived using a Markov chain with different weightings given to the probability of a rest occurring in the three types of lifesigns (Franz, 1998). This technique lets the composer set probabilities for either a Note or Rest happening after either a Note, or up to 3 consecutive rests. These tables generate a tendency for *Ambient* lifesigns to have fewer rests than *Language* ones, while *Beatbox* lifesigns tend to cycle between rest and note.

### *Processing*

Musical-visual events triggered by the player may be modified in realtime by continuing to apply pressure to the touchpads.

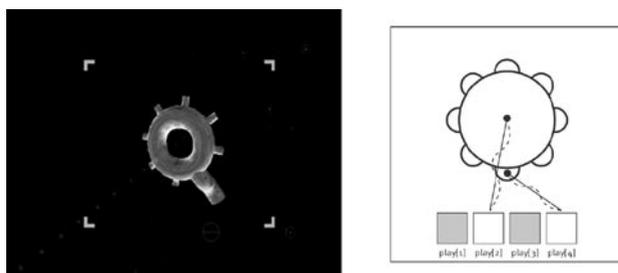


Figure 9. Modulation of a lifesign (scale parameter).

When a player selects a lifesign the four interface touchpads are randomly mapped to modulate different parameters of the DLS engine. These may be LFO (1 or 2) depth or frequency, Low Pass Filter frequency or resonance, Pitch Bend, Chorus level etc. The hardware interface is capable of sending polyphonic MIDI after-touch messages (individually polling each button to see how much pressure is being

applied to it). The effect of this is that the player can hold down one or more of the pads to modulate the lifesign’s sonic output while pressing other pads to trigger notes.

Ambient		N	R
N		0.7	0.3
R		0.7	0.3
RR		0.9	0.1
RRR		1	0

Language		N	R
N		0.5	0.5
R		0.5	0.5
RR		0.8	0.2
RRR		1	0

Beatbox		N	R
N		0.7	0.6
R		0.8	0.2
RR		1	0

Figure 10. Rest/note Markov chains for all three types

*Timbre*

So far, all these processes have only created a stream of MIDI notes; meaningless without knowledge of what sample will be played. This MIDI stream triggers audio samples that are saved in the soundfont format. One major question that arose in this stage of the design was: *how do we limit the number of soundfonts required?* With a potentially infinite number of different lifesigns, we did not want to be producing an infinite amount of audio samples for use in soundfonts. Some strategy was needed to limit the amount of production needed, while not losing the important concept that each lifesign is unique.

To this end, a diagram of the possible soundfonts was created, using a grid with axes of complexity and artificiality. Soundfonts are defined in a grid of 5x5 for *Ambient & Language* lifesigns and 4x4 for *Beatbox* lifesigns. The axes of the grid are scales of ‘pure ... complex’ and ‘natural ... artificial’. These scales are mapped to the lifesigns appearance using its *build rules* and *behaviour* difference as follows:

Natural & Pure sounds				Natural & Complex sounds
Artificial & Pure sounds				Artificial & Complex sounds

Figure 11. How to pick a soundfont

The *Pure ... Complex* axis is mapped to the standard deviation of the lifesigns behaviours. When a lifesign is created it is assigned a core associated behaviour, each of the lifesigns atoms are also assigned a behaviour.

If  $B_n$  = the behaviour of  $Atom_n$ , then  $D$  = standard deviation of  $(B_1, \dots, B_n)$  or the amount of difference in that lifesign's behaviours.  $D$  is scaled between 0 ... 4 for Language and Ambient lifesigns, and between 0 ... 3 for Beatbox lifesigns. This is then used on the horizontal axis of the soundfont matrix; so if ( $D=0$ ) the behaviours are all very similar and a *Pure* sound is chosen, if ( $D=4$ ) the behaviours are very different and a *Complex* sound is chosen.

The *Natural ... Artificial* axis is mapped to the build rules of the lifesign. Each lifesign has a subset of *build rules* which determine its

physical uniformity. These rules regarding uniformity are distilled to a single number where the minimum (0) represents very uniform build rules, and the maximum (4 for *Ambient & Language*, 3 for *Beatbox*) represents very non-uniform build rules.

This number is then used on the vertical axis of the diagram above; so uniform build rules (0) select *Natural* sounds, and non-uniform rules (in this case 4) select *Artificial* sounds.

For example, integrating the two concepts in the context of a lifesign that was extremely homogeneous in its *build rules*, but extremely heterogeneous in its *behaviours*, I would choose a *Natural & Complex* sound. If, on the other hand I had an lifesign whose *build rules* were disparate and *behaviours* were uniform, I would choose an *Artificial & Pure* soundfont.

This matrix creates a descriptive framework that sits between a system and the content that system will use. This framework helps the system designer to specify what characteristics the content must exhibit, which aids in the production of that content. A second iteration of these matrices was made to describe the different types of sounds used by *Ambient*, *Language* and *Beatbox* lifesigns. These more specific diagrams were used to commission a sound designer to build the individual sounds that would be put together to make the soundfonts.

Bells				Clicks
		Satellite bleeps : morse code etc		
Drone				Modemesque digital noise

Figure 12. Ambient matrix with more specific descriptions

### *Programming*

To design interactive sound processes for *lifesigns* I used a rapid prototyping environment called Max/MSP (Puckette et al., 1997) in which objects representing processes are connected together to form systems that can interact with a user in realtime. This kind of environment makes prototyping of complex interactive systems relatively simple as the relationship between conceptual and technical design is quite strong, as the document (patch) is a visual representation of the flow of signals and control.

The final version of *lifesigns* that would be installed into galleries was being developed by a team of graduate programmers in C++ with the help of a middleware library of software routines called

*Renderware*<sup>TM</sup>. This meant that my initial interactive sound designs all had to be translated into this development environment. This translation was not a trivial task, and the process included many months of getting to know the team of 3 programmers individually in order to put my ideas to the right person in the right terms. It also included me teaching the programmers the technical underpinnings of MIDI, digital audio and realtime interaction in order to build a shared understanding of terminology and techniques.

This invisible aspect of the task is, on reflection, something I have always done, evidenced in past biographical statements where I had described myself as *a digital media designer often asked by artist and programmers to make ideas work* and the fact that I have on many occasions bridged the gap between artist and programmer.

One direct effect of this collaborative relationship is that I eventually eschewed Max/MSP in favour of a similar visual development environment, CPS. The key factor in this choice was that CPS would automatically generate C++ code from its visually constructed patches. This meant we only had to work on one integration of my code into the larger project. Thereafter I could replace my code with new files as I made changes and everything could be automatically re-compiled. This modular approach was very liberating to me, although CPS had a limited set of functionality (compared to Max/MSP) it integrated in an almost seamless way.

### *Waterfall vs Prototyping*

While working with a group of computer systems engineers I found one fundamental difference in our methodologies. I favoured an iterative approach, where I would build a subset of the final design and slowly add functionality as needed. This often meant the 'final

design' was very different from the originally specified or imagined, because I had run up against issues during the prototyping that made me change the conceptual approach. The engineers on the other hand had what I now know is a *waterfall* methodology where the entire solution is first specified in terms of function, down to the most minute detail. This is called a functional specification. Then, in the terms of the metaphor, over the next waterfall a Software Requirements Specification (SRS) is derived that describes how the software will do what the functional specification describes. The SRS is usually a large document (the lifesigns SRS is 58 pages and over 15,000 words long) with legal style numbering in order for remote team workers to coordinate the development effort. It is not until after the SRS is decided that the code writing part of the development begins.

Collaboration with this kind of methodology forced me to re-evaluate and change the way I did things – eventually opting for something in-between my prototype led design interaction and their waterfall type linear process. Because the key factor in the success of our collaboration was the interface between my code and theirs, so we sat down and formatted a fixed interface taxonomy for use which meant we would only have to integrate code once, and I could then make any change to the rest of my code base, keeping the interface section untouched. This fascinated me and I soon became aware of how this methodology could be applied to other collaborative projects where multiple people were working on a single codebase.

Incidentally, the synthesis elements that I was coding were eventually dropped because they weren't as efficient as the soundfont engine

running on external hardware. So even though this section was never realised in the final version of the work, I took a lot of valuable lessons from it into subsequent collaborations.

## CONTENT DESIGN

The production of the audio samples for lifesigns soundfonts was commissioned to Steve Law, a prolific producer of popular and experimental electronic music. In addition to the matrices described previously, a comprehensive specification for the audio samples used for each type of lifesigns was created. This creates yet another level of conceptual application, and communication between collaborating designers. I now describe this specification, while the effect of this kind of separation of production and design is examined in the second half of this exegesis.

### *Language sound files*

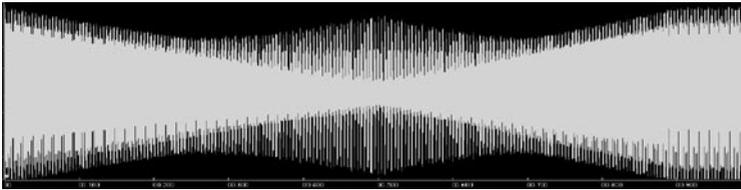


Figure 13. A Language type audio sample

Language lifesigns use short looped monophonic samples that are modulated by envelopes and user input. Language sounds are a lot like instruments, they use looped waveforms modulated for the duration of the note event by user input and envelopes 1 & 2 built into the soundfont specification. The sounds are typically shorter

that other types, and the entire sound loops in attack, sustain and release. Language sounds are monophonic, and only one sound plays at any time. If another note event overlaps a preceding event, the preceding sound is stopped to let the new sound play. Language lifesigns modulate their sample by applying user input and envelopes 1 & 2 to the filter frequency, amplitude and pitch.

*Ambient sound files*

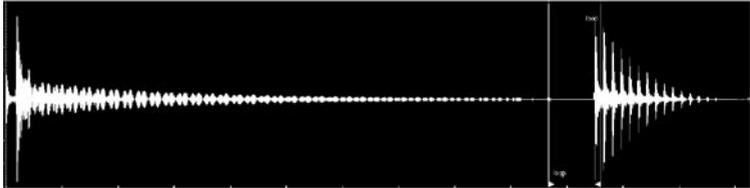


Figure 14. An Ambient audio sample

Ambient lifesigns use samples that are more complex than language lifesigns. These samples range from realistic bells and clicks to morse-code bleeps, repetitive drones and at the complex extreme, digital noise (like modem carrier signals etc). Ambient sounds have discrete envelopes and loops inside the sample. the loop point is contained within the sample – creating a rhythm that loops while the sample is held, then a different part of the sample is played when released. They are, in a sense, mechanical. Not lifeless, but more about patterns and modulations of patterns within a single sample. Ambient sounds are played back polyphonically – ie more than one instance of the sound may be playing at the same time. These different instances of the sound may have different pitches, filter settings etc. Ambient lifesigns use LFO 1 & 2 to modulate the pitch,

filter frequency & amplitude of the sample playback. The amount that these sources affect the aspects of the sound mentioned above is mapped to play parameters and the target type of the root atom.

*Beatbox sound files*



Figure 15. A Beatbox audio sample

Beatbox lifesigns use sets of separate samples on individual keys – set out a little like a General Midi Drum kit. Beatbox sounds have discrete envelopes inside the sample, there are no loop points and every sound has its own distinct envelope. Beatbox sounds are not affected by amplitude envelopes and are played back polyphonically.

SUMMARY

This section has described the conceptual approach used to design the *lifesigns* player sound environment and how that design was produced. The techniques described include algorithmic and stochastic composition, standardised content formats, interdisciplinary collaboration, and the analysis of musical genres to inform the design of systems demonstrating aesthetic behaviour. It highlights how the *lifesigns* player sound design is conceptually driven by the heterogeneous nature of individual elements in the world. I will

now contrast this with an account of the map environment, where a conscious attempt to homogenise the soundscape lead to very different design strategies being adopted.



## LIFESIGNS MAP VIEW

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*lifesigns* exists not only as a virtual 3d world to be navigated and manipulated, but as an installation to be physically experienced within the real space and time of the gallery. This Map soundscape complimented the Player soundscape by generating a sense of the *lifesigns* presence in the physical space of the installation (Innocent, 2004). The following section will describe this Map environment, giving a detailed account of the contributing concepts and technical skills required for its realisation. These include Pierre Schaeffer's use of the structure-object dialectic, John Cage's anecdotal report on silence, the acoustic properties of space, and synthesis methods that exploit psychoacoustic phenomena. I will explain how I used methods of sonic representation as tools for the creation of a homogeneous voice for the *lifesigns* world.

In the *lifesigns* installation, a plan of the virtual world is projected into the space, accompanied by a soundscape that represents the activity or 'state' of the world at any time. This soundscape was designed to let visitors *feel* the activity and *life* of the *lifesigns* world as much as see its actions and behaviour on screens. This was achieved by linking the soundscape elements to the occurrence of behaviour, energy levels and other properties of the world while homogenising the representation of those events so as to draw attention to any changes in macro-level activity rather than the behaviour and appearance of individual elements.

## BEHAVIOUR & OBJECTS

There are 8 types of behaviour a lifesign can exhibit:

*attack, befriend, leech, message, command, mutate, reproduce & join.* (Innocent, 2004)

When a lifesign anywhere in the world performs a behaviour, a discrete sound is played in the mapsoundscape. There are 8 families of behaviour sounds, and each family contains 10 audio samples that are variations on the same sonic typology. These short samples or microsounds (Roads, 2001), being no longer than 300 milliseconds, were produced by sculpting white noise with a spectral filter that was controlled by a user defined envelope function.

The *lifesigns* mapview uses four speakers to spatialise these behaviour sounds. When a lifesign performs a behaviour, a sound of the corresponding type is chosen at random and played at the x–y coordinates of that lifesign. Because this activity happens about two or three times a second, the effect is that the individual sounds remain singular while also blurring into a spatialised cloud or unity. The more activity in the world, the more the individual sounds overlap one another to form a cloud.

These sounds were designed as a related set of *échelles* using the Schaefferian concepts *Profile of Mass* and *Melodic Profile* (Schaeffer, 1966a) and Smalley's theories of *Spectromorphology* (Smalley, 1997).

### *The échelle*

An *échelle* can be described as "...a graduated series of different states of a criterion or a dimension." (Chion, 1995) or discrete expressions of a continuous phenomena. Schaeffer proposed the idea of *échelles* using

non-traditional parameters (ie not pitch) like *grain*, *allure* or *Profile of Mass*. (Chion, 1995) Technically, this would have been an exciting prospect in 1960, and is commonplace among today's Digital Audio Workstation software environments. Examples abound in popular music anywhere a parameter is manipulated through a discrete set of values over time for musical effect.

The *écbelle* is an important concept in the formulation of a methodology for designing systems that produce a range of responses to user input because it represents a framework for the specification and graduation of that range of responses. In this way, the *écbelle* also provides a conceptual bridge between an abstract idea and its concrete realisation, helping the designer to cross the chasm that seems to develop between theory and practice.

### *Objects & Structures*

The 8 sets of behaviour sounds and their use in the map soundscape are a concrete example of the *object–structure* dialectic put forward as one foundation for Schaeffer's theory of Sonic Objects. In characteristically complex fashion, this dialectic can be paraphrased as the state where every object has a context, every context has objects and everything we perceive is both a context and object at the same time (Chion, 1995).

In the *lifesigns* map soundscape, we hear a cloud of noise but can also perceive individual molecules of sound that make up that cloud. These aspects of Schaeffer's research resonate with later theories of Second-Order Cybernetics (Heylighen et al., 2001), particularly around the dialectics of context–contexture, description–identification and continuity–discontinuity. These concepts have been very widely examined in a number of disciplines, including the aforementioned

cybernetics, music and more commonly, philosophy. One part of my research is interested in the application of these conceptual models to the design of interactive sound environments, particularly how the designer can use these models of *splitting the universe* to produce more sophisticated and rewarding work. I will give examples of further aspects of these theories, with concrete applications of these concepts in a later section. A more thorough examination of these concepts is undoubtedly integral to any further research I would undertake in this or any related field, it is to that further research that I now leave the dialectics of system and object... there be expansive plains, dragons, and treasures.

#### CONTEXT & CONTINUA

The map soundscape design borrows heavily from John Cage's anecdote on silence: on entering an anechoic chamber, which should have been sonically isolated and silent, he reported hearing two sounds: one, his central nervous system (CNS) was a high frequency buzzing, the other, his cardio vascular system (CVS) was a low frequency roar (Cage, 1961). This metaphor was applied to the virtual world of *lifesigns*; the CNS corresponding to behaviour undertaken by individual lifesigns and the CVS being the total amount of energy in the entire *lifesigns* world at any one time.

As identified by Cage, the deep roar of our cardiovascular system is our constant companion, indicating activity and vitality. In humans the sound is created by blood and air cycling through the body. In *lifesigns* a deep throbbing sound is introduced into the space

to represent the *heartbeat*, or amount of energy in the world at any point in time. At this scale, the lifesigns world is treated like a single object.

This continuous sound is produced using the psychoacoustic phenomena of *beating*. When 2 or more sine waves of similar frequency are added together a third tone will be heard at the frequency of their difference. For example, if a 100Hz tone and 102Hz tone are mixed together, a 2Hz tone will be created in addition to the original frequencies. 2Hz is extremely low (human hearing perceives approximately 20Hz - 20kHz) so this frequency is perceived as a swelling and diminishing of the mixed tones that happens twice a second.

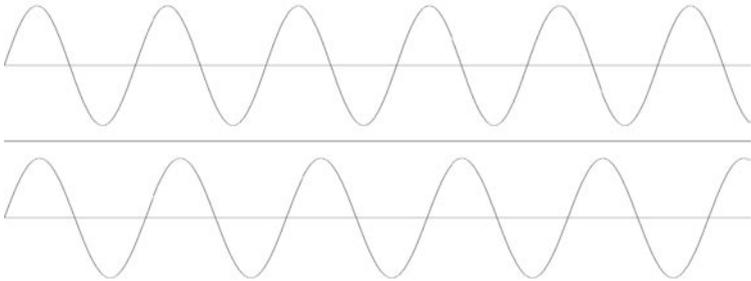


Figure 16. Two sine waves of close, but different frequency.

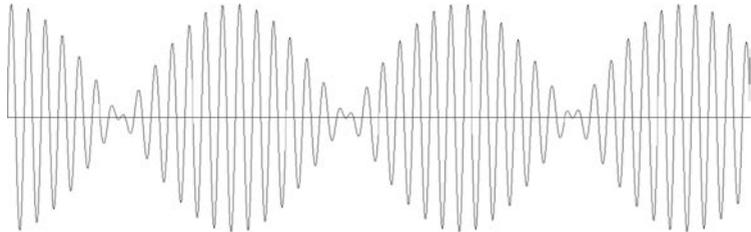


Figure 17. Produce a 'beating' effect when summed.

The method for producing the cvs *heartbeat* is: generate a sine wave at a *fundamental* frequency that is almost inaudible (around 30Hz). Add another instance of it into the mix, but raise the frequency of the second instance as the energy level of the world is raised. Scale the maximum world energy to a sonically interesting maximum frequency for this second sine wave.

Low frequencies are chosen for a number of reasons. Generally, humans can perceive sound from somewhere around 20Hz to 20kHz. Sound at the lower limits of this scale is *felt* as much as it is *heard*, because the sonic pressure waves resonate in different body cavities like the bowels or chest. Human sonic perception is weighted toward the middle of our hearing range, where speech and other indicators of danger occur, in this mid-range we are very attuned perceiving the source location of a sound in physical space. Low frequency sounds are more difficult to localise, and hence are perceived as more diffuse. This diffusion is enhanced by the acoustic environment into which these sounds are introduced, where reflections of sound waves can create a complex arrangement of interference patterns, similar to those created when the surface of an enclosed body of water is disturbed.

These nodal points of interference create a dynamic sonic environment in the space of the installation, where people can literally walk around and experience areas in the room that are louder, quieter, static or highly active. This effect is further psychoacoustically enhanced by 'tuning' the *fundamental* frequency to resonate with the physical volume of the installation space. The effect is to have a *pulse* to the room that changes almost imperceptibly with human and lifesign activity.

*Immediate continuity*

These clouds, blurring the immediate short behaviour sounds, in juxtaposition with the infinite continuous beating tones was inspired in part by Curtis Roads' diagram of time vs. musical function (Roads, 2001).

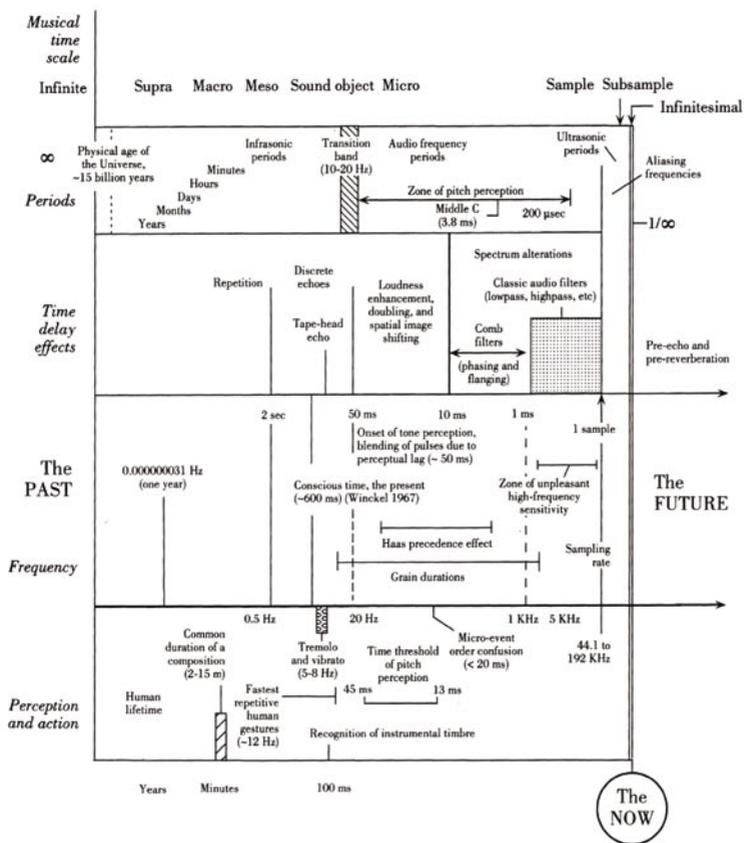


Figure 18. diagram of time vs. musical perception

The design intention was to situate the Map soundscape on the limits of auditory and kinaesthetic perception, hovering between being *heard* and being *felt*, so that the player view sounds could sit in the middle, at the spectral range analogous to *speech*. When we analyse the spectral and temporal composition of the entire installation, a complimentary relationship between all the soundscape elements can be perceived on multiple levels. By distinctly separating the high frequency behaviour sounds from the low frequency world pulse, a spectral *gap* is left for the instrumentally driven sounds of the individual lifesigns created by the player view workstations. In the final installation of the work, this gap was exaggerated by using in-house equalisation and careful tuning of the *heartbeat* fundamental frequency to the gallery space.



Figure 19. conceptual diagram of the lifesigns installation space, illustrating how the map soundscape of blue waves and ambient cloud mixes with the immediate player view soundscape.

## SUMMARY

This ends the description of this project, one that ran for more than 3 years, and involved the application of what were for me many new skills and concepts. The theoretical foundations of Schaefferian *sound objects*, Smalley's *spectromorphology*, and Road's *Microsounds* helped me to integrate heterogeneous discrete behaviours within a homogeneous, polyphonic, immersive environment. I built software environments for interactive musical creation using abstract mathematical algorithms, as well as tools for spectral synthesis of typological content objects. All of this was done while working within a multidisciplinary team, including music producers, artists, and programmers. I will talk more about the collaborative side of this project in the second half of this exegesis, but now I want to move from this abstract approach, where a system and content are designed to create a range of possibilities, to where these kinds of environments are used to produce a linear concrete work.

## BACK INTO THE STUDIO...

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I had been researching interactive sound design for over a year and realised I had spent just about all my time working with computers and digital systems. Sooner or later, I thought, I'll want to actually make some sound. This wasn't the first time I'd faced this kind of dilemma of being caught in the abstract. In fact, it was for these very reasons that I undertook my research at RMIT, an institution well known for its standards and examples of practice-led research. The University had just commissioned the new SIAL Sound Studios, and back into the studio I went, eager to listen and pore over the intricacies of working in a linear format.

The following section looks at this stage of my research, best exemplified as a project in the 14 minute work *Tixeerif*, composed, produced, and performed during the second half of my candidature. While the format for this work is linear, I will highlight some of the similarities drawn across from the *lifesigns* project, particularly where I have sought to extend my practice and expertise in the application of theoretical frameworks and concepts. Pierre Schaeffer's *sonic objects* (Chion, 1995) appear frequently in the ideation of this project, and methods for their translation from concept to application are discussed alongside Smalley's theories of *sectromorphology* (Smalley, 1997) *indicative networks* (Smalley, 1995), and Roads's concepts of *microsounds* (Roads, 2001). I will describe each of the sub-elements of *Tixeerif*, and finally return to the relationship between linear and interactive formats in an attempt to integrate these two larger

projects, *lifesigns* and *Tixeerif* into a single framework. Before we begin with an analysis of interactive and linear sound formats, we must revisit Schaeffer's *Traité* to explore that which binds them together, the perception of sound, or listening.

## THE FOUR MODES

In September of 2003 I had made contact with John Dack, an academic in the UK who had, among other things, done his PhD with Denis Smalley. John and Christine North had been working on a translation of Michel Chion's *Guide des objets sonore* (Chion, 1995), an excellent piece of secondary research on Pierre Schaeffer's work into the phenomenology of sound. In his *Solfège de l'objet sonore* (Schaeffer, 1966b) and *Treatise de l'objet Musicaux* (Schaeffer, 1966a), Pierre Schaeffer introduces the concept of the *sonic object*, and with it the idea of an *acousmatic* context for sound and music.

“The acousmatic situation changes the way we hear. By isolating the sound from the “audiovisual complex” to which it initially belonged, it creates favourable conditions for a *reduced listening* which concentrates on the sound for its own sake, as *sound object*, independent of its causes or its meaning” (Chion, 1995; Schaeffer, 1966a)

One key to this understanding is an examination of the way sound is perceived, in another important section, Schaeffer famously describes 4 distinct modes of listening, outlined as:

*Mode 1*      *écouter* is to lend an ear to, to interest oneself in. I actively direct myself towards someone or something which is described or signalled by a sound.

- Mode 2*      *Ouir* is to perceive with the ear. In opposition to *écouter*, which corresponds to the more active attitude, what I *ouis* is that which is given to my perception.
- Mode 3*      From *entendre* I shall retain the etymological sense only: 'to have an intention'. What I *entends*, what is *evident* to me, is a function of this intention.
- Mode 4*      *Comprendre*, to grasp, has a dual relationship with *écouter* and *entendre*. I *comprends* what I aimed at in my *écoute*, thanks to what I have chosen to *entendre*. But, reciprocally, what I have already *compris* directs my *écoute*, informing what I *entends*.  
(Palombini, 1993)

Other methods of describing these are:

- Mode 1*      *indexical* or information gathering (to listen to)
- Mode 2*      passive reception (to hear)
- Mode 3*      appreciating and responding to attributes of sound (to listen out for)
- Mode 4*      responding to a musical language (to comprehend).  
(Palombini, 1993)

These four modes are perhaps the most well known aspect of Schaeffer's research, and in-depth descriptions and comment on them can be found in the publications referenced above. My interest here is in the application of these ideas onto my practice. For instance, within the context of what Schaeffer calls *Solfège* or a *Programme of Musical Research*, a methodology of 'rocking back and forth' between mode 4 and 3 to generate *suitable objects* for use in acousmatic music is described (Chion, 1995). This idea drove a major change in my

practice and I will come back to explain the process and what is meant by *suitable objects* in the next section when I examine the works and my processes in detail.

Exposure to works like Gaston Bachelard's *The Poetics of Space* (Bachelard, 1969) during my architectural education, and work with Pia Ednie-Brown at RMIT in the previous year had primed me for phenomenological approaches but nothing could have prepared me for the effect these notes by Chion on the work of Schaeffer would have on my practice. All of a sudden here was a way of conceptualising sonic perception, and negotiating what had previously been very difficult, namely the relationship between intellectual abstraction and material practice. I now believe this is mainly because Schaeffer was as adept and experienced with the practice of sound engineering and production as he was with the description of its perception. He could *do* as well as he could *think*.

### *Making work*

In context of this newfound knowledge I was given the opportunity to present a work at the 2004 ACMC in Wellington NZ. I had begun work on a short piece of music titled *Human beings are Animals too* – based on a performance work I'd composed a few years earlier:

In 2001, I designed and built a performance system for myself using a bi-directional USB game controller for gestural control of audio processing.



Figure 20. gestural control of musical parameters using a game controller

I composed a number of pieces for this system, one of these compositions, *Human Beings are Animals Too*, has a number of conceptual levels, one is the concrete – manipulating sounds of one kind with a gestural interface so as to bring about another kind of sonic behaviour, purely for the reason of creating new sound objects in realtime. in. In *The Listening Imagination: Listening in the Electroacoustic Era* (Smalley, 1995), Denis Smalley discusses the concept of sonic *gestural activity*, categorising it in terms of a sonic objects link to an imagined activity, or gesture that might have produced the sound. Throughout the following descriptions of these works I use the term *gesture* to widely describe sonic objects that exhibits what Smalley describes as an *energy-motion trajectory* (Smalley, 1995), or whose *spectromorphology* (Smalley, 1997) indicates a gestural source.

On another level, *Humans* is about the way human beings can be animalistic, both in sonic form, or by doing stupid things like 9/11 and the ensuing war, or really stupid things like thinking that economics would save the environment. Whatever the ideas,

*humans* is a piece that asks the performer to skate the edge between recognition of the source material (sound recordings of human's having sex) and letting the monkeys out of the cage.

### *Linear systems*

I took the files I had from the performance and rehearsals and began to edit them together into a work that would stand on its own in a linear context. At once I had to face things that were more difficult, and far more easily accomplished in this new linear medium. It's easier to apply theory to a linear work of time based media, because the work is exactly the same every time it's played. The opposite is true for an interactive work, where the composer or designer is defining a field of possibilities with which people can play. The linear works that make up *Tixeerif* can be thought of as *etudes* or studies for future interactive environments. They are also soundscapes collaged from recordings that have been generated in interactive production environments.

*Humans* had always been a performance, in that it never really existed in any definitive state or duration as a sonic work, but rather as a set of files that were manipulated in realtime by a certain configuration of a combination of software (Max/MSP, LiSa) and hardware (game controller). The work was always about the moment that is now, never about setting up a larger compositional structure.

What was more difficult about making a linear version was having to decide how a structure that was larger than phrasal length might be established from a work that was purposefully general and open in its architecture. I had been reading Curtis Road's *Microsound* (Roads, 2001) at the time and was particularly interested in the table showing relationships between time and musical perception

(included in the lifesigns map section). I decided to use the ideas communicated in this table to introduce a temporal element to the conceptual mix.

One thing I realised after a week or so was that there was an infinite amount of variational potential in the composition of such a linear work and that this variation could be *folded back* to reflexively inform how I might design systems for performance. One example of this is to examine the way a system treats time: my initial performance system for *Humans* was built around the timescales of phrases – anything from 1 to 8 seconds. What began as an exercise in semantic and textural manipulation or what Schaeffer refers to as *Profile of Mass* (Chion, 1995; Schaeffer, 1966a), eventually took on the form of a linear composition with a traditional structure of beginning, middle and end. Working in a linear format let me pay close attention to structural time, or larger than 1 min, and in extension think about how a system might be designed to play at these meta time-scales.

In addition to these new temporal concepts, I had also opened the work up to space. *Humans* had always been strongly spatial in its attempt to make sound ‘jump around’ the stage. Until now it had been constrained to stereo, but with this new work I wanted to jump into composing in surround, specifically the newly ubiquitous multi channel 5.1.

### *Generative projects*

Once I had finished *Humans* I was definitely hooked on linear composition. It may sound strange, but as a musician using digital

tools it had been over 5 years since I'd crafted a linear work. With *Humans* I had kept working, slowly paring things back until I had what I thought to be the essential aspects of the piece.

I soon began on more works, and as the SIAL Sound Studios opened and I was able to work in the creatively conducive environment there, I quickly built a palette of sketches, some of which would later become elements of *Tixeerif*.

Meanwhile I was reading more of Chion's notes, and was beginning to make some headway in understanding them better, helped by regular listening to works inspired by Pierre Schaeffer's theories. These included works by Schaeffer, Chion, Parmegiani, Ferrari, Xenakis etc (essentially the GRM archive). Listening to the works of composers like Parmegiani had both an inspiring and sobering effect. New Schaefferian ideas mixed with the experience of producing *Humans* made me acutely aware of the amount of work compressed into a piece like *La Création du Monde* (Parmegiani, 1982-84) or *Sonare* (Parmegiani, 1996). If I was going to embark on the creation of an electroacoustic work, some part of me could not help but hold it up against these examples for comparison.

Listening can be a difficult art. finding time to listen is problematic in today's busy culture. To this end I enthusiastically recommend an iPod or similar and investment in a good set of headphones. I found the ones manufactured by Future Sonics to be excellent for prolonged listening and rudimentary production work in noisy environments, like aeroplanes or walking through Melbourne's CBD.

The following section will explain these processes, concentrating on a unique aspect of each works conceptualisation and production. It examines how I translated a performance work into linear format using Schaefferian concepts with *Humans*, and how these concepts

were honed and focussed in *Keycaps* to create more sophisticated discrete sonic objects. I will look at the use of production tools as instruments for drawing out indexical contrasts within *hyprethun*, or creating the polyphonic continuities of *earkleanr*. Finally, I will return to the non-linear via Smalley's visual indicative network, and it's part driving the narrative of *Fire Eater*.

#### TIXEERIF

Armed with new knowledge, inspiration, and most importantly, the new SIAL Sound Studios, I plunged in to the fray and began work on a number of sonic and musical experiments. Like all experiments, some failed and were put into the back of the conceptual cupboard for later recycling, others blossomed and became works in their own right. After *Humans*, of the four remaining sections within *Tixeerif*, two were complete accidents that I stumbled across while trying to do something else (*hyprethun* and *Fire Eater*), and two were long drawn-out production exercises whose finished form closely mirrored their initial conception (*Keycaps* and *earkleanr*).

#### *Human Beings are Animals Too*

Most of the sounds occurring in *Humans* are derived from processed vocal utterances – particularly the sounds of people having or simulating sex. The work was my first attempt to use what I'll refer to as the Schaefferian modes 3 - 4 method of composition. This is derived from Schaeffer's description of how to recognise and create sonic objects that are suitable for musical use. Chion states that these types of sonic object must be simple, original, easily memorable, and of medium duration. In order to work in the acousmatic

situation, they must lend themselves to *reduced listening* by not being too anecdotal or loaded with meaning. They must be able to be put together with similar sound objects to produce an identifiable musical value, or what Schaeffer refers to as the musical Law PCV2. Finally, Chion suggests a relative suitability, where objects could be deemed suitable only when they are part of a group of other objects. (Chion, 1995)

Here the term *reduced listening* refers to the act of listening to a sound for its own sake without intellectual attachment to a source or meaning (Chion, 1995). This concept, fundamental to *acousmatic* music is one foundation on which Schaeffer's theory of the sound object is built. The Law PCV2 referred to in this list represents a complex composite relationship of Permanence of Characteristics with Variations of Values which balances the *abstract–concrete* dialectic within the musical context (Chion, 1995). A very thorough examination (in English) of this is available in John Dack and Christine North's translation (in progress) of Michel Chion's *Guide des objets sonore* (Chion, 1995).

Chion goes on to describe that the creation of suitable objects involves:

- a toing and froing between doing and listening
- first in *musicianly* listening which is limited to the most simple, least anecdotal objects, which have a spontaneous, albeit minimal, musicality;
- next by *musicianly* invention which should create suitable objects for a musicality which remains to be defined;
- lastly by *musical* listening which seeks to discover the potential musical values in these sound objects.

(Chion, 1995)

In Schaeffer's lexicon, *musical* refers to reductive methodologies, whereas *musicianly* refers to expansive ones. (Chion, 1995) This methodology is rather like the concept that *musical* theory analyses existing *musicianly* experiments, or as a colleague once noted, that *design* theory analyses *designerly* provocations. It describes a cycle in which you iterate between the musicianly (mode 3), and refine via the musical (mode 4).

The important aspect of this method is that a framework for the selection of suitable objects is proposed, and the criteria under which an object is deemed suitable are explained. This then gives the composer new conceptual tools with which to create new work. For example, this may be done by editing *suitable objects* from recordings of performances and then collage them together with synthesised sounds to form a sense of coherence and continuity. This is exemplified in *Humans* by the use of different production techniques, including:

- Collage* adding a quiet continuous soundscape to a loud raucous one and then cutting the loud one to reveal that which had been there all along.
- Diffusion* the original sound files were mixed into stereo format, which was augmented with front-back mixing in a subsequent quadraphonic version.
- Tempo* drawing out the intervals between musical gesture to build a narrative of temporal expansion and compression.
- Dynamics* extreme differences were used to further mark juxtapositions such as claustrophobia and space, violent and gentle to mark time and accentuate musical gesture.

### *Compositional structure, a narrative*

The work begins with a repeating low-fi cry or squeak joined by a low growl. We then hear the “noise” that had marked the recording as low-fi grow and accelerate from a point behind our head to the front speaker in an intense crescendo tapered off with a trail of reverberation. This announces the work, and sets up the two main voices that are heard throughout the piece.

As the reverberant tail fades, a tone or chord can *just* be heard, rising in a slow movement. Over this sits a two-part call and response of gestural sound objects sourced from performance recordings.

The chord gets louder and seems to break up just before it abruptly ends followed by some more gestures and another loud crescendo of noise, followed by a cacophony of complex sine waves, and various squawking, flapping, screeching etc.

The vocal sounds are all very processed so their original identities aren't immediately apparent, but an inkling can be 'felt' because they share internal spectral qualities and morphologies to those of speech. This second crescendo fades as we hear the sound objects move to their point of originality, before they are transformed into bird calls and other minimalist gestures, scampering, flapping etc.

We then hear a loud, deep, grown like a lion's dominate the sound field, interspersed with a singular voice gesture, creating a single duet before the fades out, gasping for air and the other is cut off in a large space.

In the quietest parts of the work, there can be heard the sound of typing on a computer keyboard. As *Humans* ends, this keyboard can be heard again, rising in volume to make a processed transition into the next section, keycaps. While I was making *Humans* I searched

for something that would provide an *indexical* counterpoint to the animalistic utterances and gestures of the piece. I settled on the sound of typing on a computer keyboard – to me this represented not only a socially contrasting commentary on bland modern human habitats and a spectral compliment of the wild, dynamism of the vocal gestures, it was also something immediately recognisable.

*Human Beings are Animals Too* represent my first attempt to apply Schaefferian theories to a linear work, something that I would take further in the next section, *Keycaps*.

- ◉ Before we go on, please listen to *Keycaps* on the DVD

### *Keycaps*

This work explores the ideas applied in *Humans* and attempts to extend them by focussing on sonic gestures created from a single original source. A recording of typing on a keyboard was processed in musicianly ways to create a wide range of sonic objects and gestures from which the work was constructed. Musicianly listening (mode 3) aids in the identification and editing of suitable objects, as defined by Schaeffer and Chion, from the processed sound file. Musical listening (mode 4) helps to compose these gestures together to create musical structures.

While working on *Humans*, I started to apply *musicianly* processing to the original field recording of typing. I decided to use this work as a way to practice what I described earlier as *modes 3–4 composition techniques* and began to listen for suitable musical objects while I was processing the original recordings.

I used many software environments to process the sound recordings and create new musical objects. Some environments (Max/MSP,

live) afford real time control of granular synthesis processing. This allowed me to play the controls in real time, listening for musically suitable objects and then exploiting these musical qualities.

These experiments produced a set of audio files that I then listened to and cut into different *suitable objects*. Most of these objects were eventually discarded but this close evaluative listening was an important part of creating an overview of the works structure, particularly of the kinds of sonic objects available to begin the formulation of a musical language.

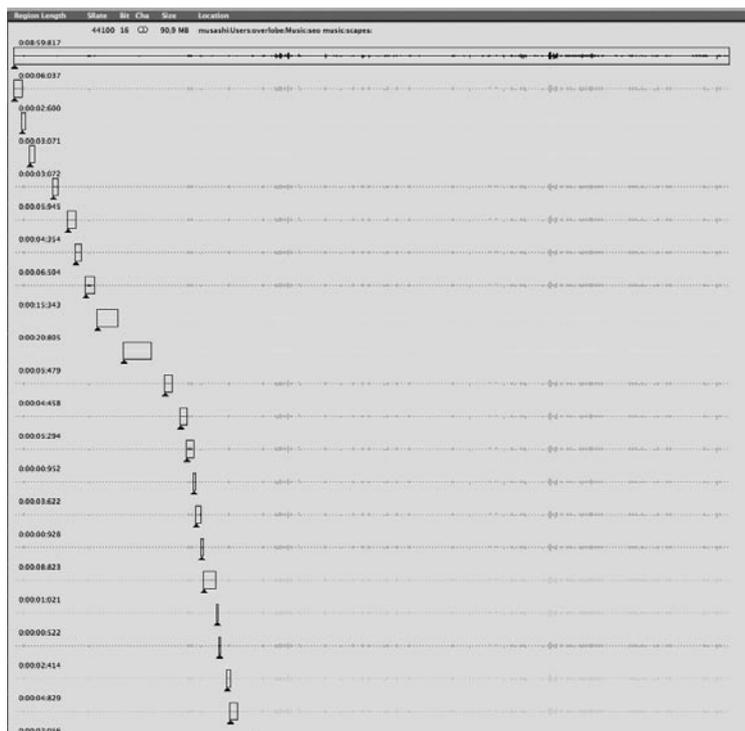


Figure 21. diagram of a processed file cut into *suitable objects*

Schaeffer's *modes 3–4 technique* helped me to focus ideas and draw creative distinctions between what could sometimes be a very large number of possibilities. I was able to quickly decide on high level issues, like compositional density or the duration of a period of silence, and like any good framework or conceptual tool, this technique didn't dictate any one object or aesthetic over another. Rather, by reducing the number of criteria for selection, and increasing the sophistication of those criteria, I found that ideas were more at my fingertips, helping me make more sophisticated work, faster. That's not to say that I could just apply the theory as a conceptual plugin. Only through months of diligent study of Chion's notes was I able to even attempt this kind of application of Schaeffer's theories. Their conceptual shorthand was completely opaque to me until I spent an extended period of study reading, taking notes of my own, and supplementing them with forays into Carlos Palombini's PhD thesis (Palombini, 1993) and Denis Smalley's research around *Spectromorphology* (Smalley, 1997). These elements worked together to build my understanding of Schaeffer's *solfège* up from first principles of the *acousmatic* situation and the *abstract–concrete* dialectic.

*Keycaps* is not, however, just an *étude* for exploration of Schaefferian methodologies. It had a number of conceptual underpinnings that also drove the work. I was interested in extending the gestural approach to sounds used in *Humans*, contrasting the raucous shrieking in that piece with gestures derived from human–machine interaction. The computer keyboard posed possibilities as an instrument, with its restricted palette of possible sounds, and the highly *indexical* nature of those sounds. I also wanted to make a piece of music that was very minimalist, concentrating on the possibilities of a single voice in the way Paul Klee described drawing as “taking a line for a walk”. Modern digital production environments afford incredible control

when it comes to the crafting of sonic objects, and *Keycaps* can also be seen as a way of exploring these possibilities in a compositional framework.

*Keycaps* is the first work I produced in the SIAL Sound Studios, and the first work composed completely from scratch for 4 speakers. The minimalist monophonic nature of the sonic objects let me concentrate on the way these sounds would be played in the virtual space defined by four speakers. After a number of experiments to ascertain how these sounds worked in this kind of physical arrangement, I chose to use a combination of phase manipulation and level adjustment to move the sounds around between the speakers.



Figure 22. Stereo Adjuster plugin: You can adjust the stereo spread of an existing stereo recording using this MS matrix. Setting the slider in the middle means that the stereo is unchanged. Move it to the right and the sound becomes distant (by mixing in a left-minus-right signal). Move it to the left and the sound becomes close and mono. (Stuck, 2003)

The following screenshots show an arrangement where identical copies of a stereo file are played in the front and rear stereo pairs of speakers. The software automation of an audio effect was used to enhance

or reduce the perceived width of the stereo signals separately. This effect, coupled with automated changes of level created perceived movement of the sound in the front/back direction.

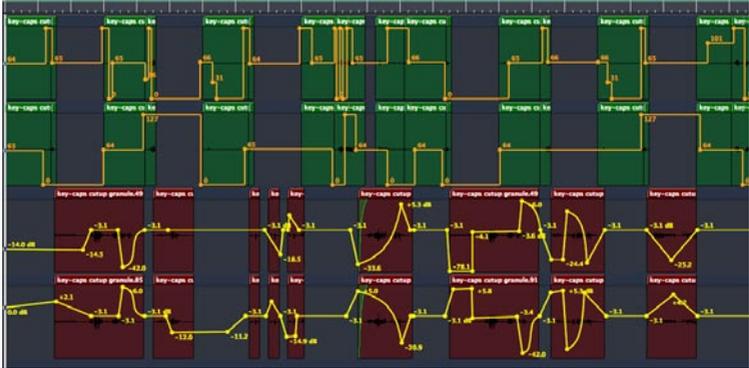


Figure 23. diagram of keycaps automation. Front & back Stereo Adjuster settings on the top tracks, levels on the bottom tracks

There are many methods for spatialising a sonic object within multiple speakers. The techniques described here are aligned with those of panning or the relative loudness of the sound in each speaker; and phasing, a more complex relationship between the waveforms of a sound in each speaker. Both these techniques are suited to realtime control, because they are already well documented and require relatively less processing than other methods. Therefore these techniques would be suitable as methods for immediate reaction in an interactive sound environment.

These first two works, *Human Beings are Animals Too* and *Keycaps*, share notions of discrete sound objects that communicate gestures, either in their spatial arrangement or their spectromorphology. The next two works, *hyprethun* and *earkleanr*, move into more continuous

and *indexical* concepts of the soundscape, contrasting highly synthesised sonic objects with field recordings of nature and acoustic instruments.

- ◉ Now that I have described the processes behind the work, please listen to *Keycaps* on the DVD again. You can use the `SETUP` menu to turn a visual representation of the waveform on or off while listening.

*byprethun*

Conceptually, this work is both a continuation of the call and response structure heard in *Humans* and an exercise in *indexical* contrasts. A high frequency synthetic tone is played against a field recording of a tropical thunderstorm. Highly abrasive synthetic gestures build over a counterpoint of rolling thunder. The piece ends in a crescendo of deep noise that is abruptly cut to reveal the next section, *earkleanr*.

One of the abrasive gesture voices is worth mentioning here, its production being complex but hinting at possible interactive uses: A short period of broadband noise is run through a percussive dynamics shaper.

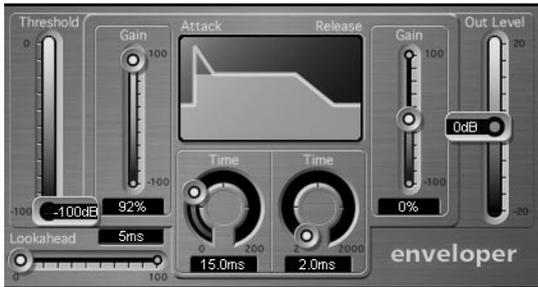


Figure 24. percussive gate effect

Ubiquitous production tools can be split into a number of types. *Dynamics* is one that affects the morphology of a sound's volume, commonly called its *envelope*. Pierre Schaeffer noted in his *Solfège de l'objet sonore* that a sound's envelope or profile of loudness is an extremely important factor in its perception. He called particular attention to the attack section of the envelope stating that it gave important indicative clues to the source of a particular sound (Schaeffer, 1966b). This leads to the experiments in Schaeffer's *Solfège* where a change in the attack section of the envelope changes the listener's perception of what produced the sound.

*Hypretbun* uses a percussion compressor/gate effect to shape the profile of a composite harsh noisy sound. This psychoacoustic effect also makes it possible for the sound to be perceived well above the already loud rumble of thunder as the section builds to a claustrophobic crescendo.

### *earkleanr*

*Earkleanr* is a work that applies the minute spatial gestures relationships of *Keycaps* in a continuous fashion. Where *Keycaps* gestures are discrete, almost monophonic, *earkleanr's* sonic objects overlap into a continuously diffuse sound field. This continuity is further supported by an underlying bell tone made by recording a brass bowl played with a timber rod.

I will now move the mode of discussion around the following set of images. These illustrate how the spectrally similar synthesised sounds were initially made from synthetic bell tones, which were then reversed and affected with a ring modulator before being granulated with large window sizes to generate a more diffuse sound field.

- ⦿ these files can be heard on the DVD in the  
EARKLEANR PRODUCTION section

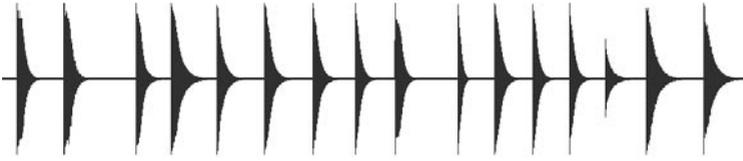


Figure 25. initial chimes...

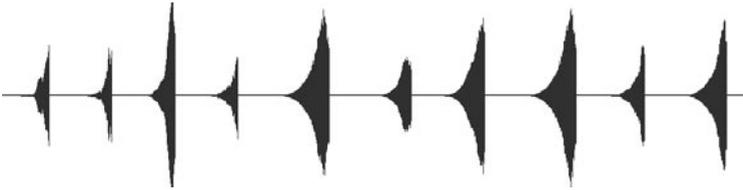


Figure 26. are reversed and...

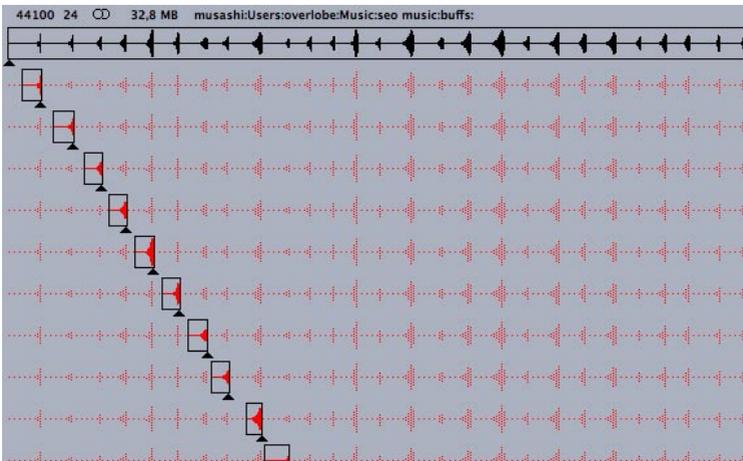


Figure 27. run through a reverberation effect, from which *suitable objects* are edited

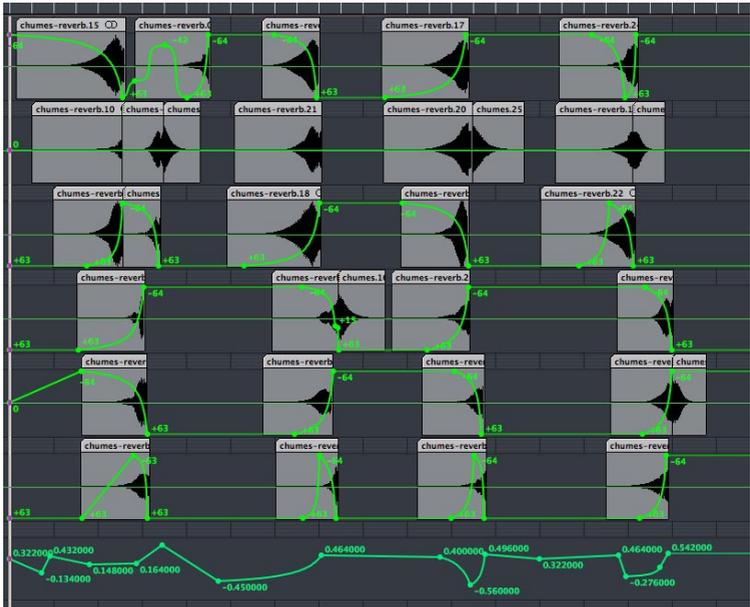


Figure 28. these elements are sequenced together and mixed to create a stereo file that has a lot of *spatial* dynamism. Automation on the files above shows panning and ring-modulation frequencies



Figure 29. which is then run through a *granulation* process to spatially and temporally diffuse the soundscape even more



Figure 30. these granulated soundscapes are then mixed together to create a multi-layered spatial composition

### *Fire Eater*

Fire Eater is a work driven equally from narrative and technique. While experimenting with a pair of bi-directional loops of the tails of cymbal hits I applied Doppler Shift (Roads, 1996 p 463) effects to the sounds. Doppler effect is best explained by the example of an ambulance siren. As the ambulance passes you the pitch of the siren drops. This is a physical phenomena: because the ambulance is moving it *squashes* the sound waves together as it approaches the listener and *stretches* them as it recedes. Longer waves sound lower in pitch, so the characteristic doppler effect indicates the passing

of a sound source through space. Because doppler is a indicator of movement of a sounding source in relation to the listener, I then applied spatial modulation to the resulting sounds, moving them in arcs between 4 speakers.

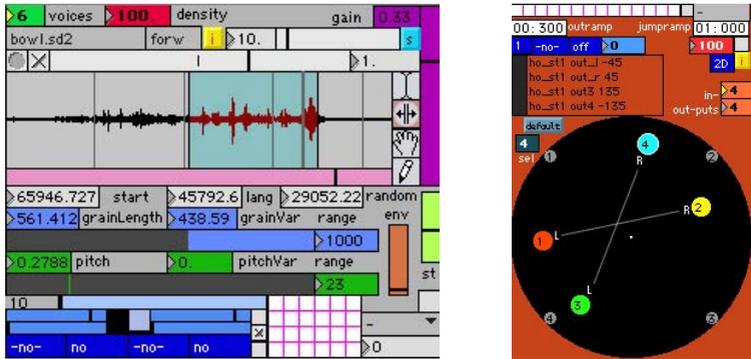


Figure 31. some images of the software environments used in the production of *earkleanr* (granular synthesis module on the left) and *Fire Eater* (spatialisation module on the right)

One interesting outcome of this experiment was the realisation that a relationship between the spectromorphology of the original sound file, the Doppler effect and the spatial movement did not need to be fixed or synchronised to achieve the desired narrative affect of a pair of loud objects swooping down on the listener, in the centre of a vast plain. I became interested in the possibilities of extending this visual narrative further.

Smalley refers to this relationship between a sonic gesture and its visual correlation as the *visual indicative network*, stating that:

“This would imply that music, and electroacoustic music in particular, is not a purely auditory art but a more integrated, audio-visual art, albeit that the visual aspect is frequently invisible.” (Smalley, 1995)

I was intrigued by the possibility of applying narrative notions to a work, as this is something I had not really thought of in my practice before. Ordinarily, my works were more concerned with the concrete qualities of sounds rather than any narrative or visually referenced potential in the mixing and relationships between sounds. In many ways this was leading me back to the interactive sound designs of *lifesigns* or other digital games, because I was composing the soundtrack for an imagined visual environment.

In an interesting development, a colleague referred to this section of the work as “the part with all the traffic noises” which surprised me, as I had always imagined the less urban image described earlier. This highlighted to me how important the initial state of the listener is in interpreting the work, and that there might be ways to lead the listener into sharing the visual indicative network, if not absolutely and literally, then at least in the same ballpark. On the other hand, a multiplicity of readings, particularly where there are strong correlations towards what seem to be diametrically opposed situations, seems to me to be the hallmark of an interesting work of art, but therein lies another expansive field of research to which I will defer my travel for another time.

## SUMMARY

This concludes the sections directly addressing the two projects of this Masters research. *Lifesigns*, an installation for which I designed the interactive sound engine, and *Tixeerif*, an electroacoustic composition that I composed and produced. I have described the theoretical approaches I used to design these works, particularly Pierre Schaeffer's theories of *sonic objects*, Denis Smalley's theories of *spectromorphology* and *indicative networks*, and Curtis Roads theory of *microsounds*. I have also outlined some skills and methods that enabled me to realise these works, including algorithmic composition, programming, production skills and interdisciplinary collaboration. I will now reflect on the process of designing and making these projects, identifying what I learnt by doing them, and how this knowledge is used in the practice of interactive sound design.





I began this exegesis thinking it was about the design of interaction, because the two previously described projects represent both ends of an interactive scale, one being linear and the other infinitely generative. But in writing these chapters, my strongest memories were not of interaction between users and systems, but between designers, artists and engineers. I deemed these aspects most important for my practice, and subsequent discussion within this exegesis. Reflection on these aspects of the projects helped me to understand different components of my practice and begin to manipulate them individually, with conscious intent and what one supervisor called

*“higher degrees of resolution”*

In undertaking this exegesis, my position has shifted from considering interaction as only occurring between code, sounds, and machines, to focussing on its play between methodologies, ideas, and disciplines.

It was, in fact, all about collaboration.



## WHAT I LEARNED

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In the next section I explain some unique aspects of interactive sound design, describing how it differs from other forms of interactive design. I categorise the knowledge and abilities used in the collaborative design of the projects detailed in the previous chapters, suggesting a suite of methodological, technical, and conceptual tools for the interactive sound designer. I then propose a methodology for their integration, described here as *transcoding systems*.

### INTERACTIVE SOUND DESIGN

Throughout this exegesis I use the term *interactive sound design*, to describe my practice. It is important to define what I mean when I use this term. One fundamental defining factor of my practice is that it occurs in the digital environment, so when I talk about interactive sound design, I'm not talking about interaction with acoustic instruments, but rather, with software that may interface with the physical environment via hardware. I'm talking about computers, digital sound software environments, like Max/MSP, digital game engines, and Digital Audio Workstations.

At the formal level, a work of interactive sound may have a number of final outcomes, or expressions. Different aspects of the work are usually subject to control during the performance of the work. These aspects might include: what notes are played, what samples

or digital instruments are used, how these instruments interpret the notes played, how the system playing the notes interprets control signals coming from users (or other software). This differs from other forms of sound design, for example film sound design, where the final outcome is already determined and always the same. Interactive sound shares the structural qualities of other non-linear media, where the final outcome can be described as a product of multiple simultaneous processes, controlling aspects of the final form.

Techniques for generating interactive sound works include using large palettes of individual sound files that are triggered by a software engine, this could be as simple as putting a cd of many small tracks on shuffle play mode. Another approach is the creation of synthesis engines with parametric control driven by users or software, or more usually a combination of the two. Suitable synthesis engines can range from pre-existing systems like SoundFonts, mentioned in the preceding chapters, to custom designed DSP software built in environments like Max/MSP. In the latter case, the role of the interactive sound designer begins to take on aspects of software engineering, or at least programming.

Another way for me to further narrow the definition of interactive sound design is to ask the hypothetical question:

*How does interactive sound differ from other interactive media?*

At the level of the medium, a fundamental difference is that digitised sound has a sample rate many times higher than that of visual or physical modes of interaction. The standard sample rate for playback of sound is 44,100 Hz as opposed to the 25 Hz for visual media or 1000 Hz for control data. Sonic events need to be tightly synchronised in order to maintain the integrity of the waveform, and

to create the illusion of spatial sound. Similarly, the latency of an interactive sound system is a significant factor in how *connected* the user feels to the system (DiFilippo et al., 2000). Latency is a measure of the amount of time between user input and the perception of the event that is triggered by that user input. All of these factors mean that sonic interaction has a temporal granularity far smaller than other modes of interaction.

Another key distinction between sonic and other modes of interactive design is in the use of what I will describe as *structured objects*. Within the fields of music and sound technology researchers have built standards and formats for structuring many separate elements of content into a single object that can be easily transported between machines, people and contexts. These objects include the midi files, audio samples and soundfonts used in this Masters research. The medium of digitised sound, and the technologies associated with it, help describe what makes interactive sound design different from other modes of interactive design.

The projects presented in this exegesis also differ from some examples of interactive design because they aren't driven by a concept of current user needs. They are, however, provocative experimental solutions for possible future needs and exponents of possible media artefacts.

For example, *lifesigns* does not address a current need to view, manipulate and communicate systematic relationships in an artificial life universe but does have direct application to current research in interactive sound and artificial life in digital games. It may have application in the future if generative methodologies are applied in more domestic situations.

*Tixeerif* is both a linear collage of the output from many individual specific environments, and a sonic sketch for the design of other

interactive environments. It is also a specific attempt to integrate technique and an aesthetic inside a conceptual framework. In this way it suggests one way to bridge technical aspects of interactive sound design, concerned with systems and content with more theoretical aspects, examining users and concept.

This bridge between ideas and application is the focus of the next section, where I examine methodological, technical, and conceptual knowledge that helped me to move between the theory and practice of interactive sound design.

## KNOWLEDGE & ABILITIES

The medium of sound has a temporal structure distinctly different from other modes used in the design of interaction. This suggests that interactive sound design requires unique combinations of skills to address the technical and theoretical aspects of this temporal granularity.

My experience from these projects also revealed the importance collaboration plays in the realisation of these projects. interactive sound designers often need to operate at many different levels within interdisciplinary teams. These levels are not only the technical and conceptual mentioned previously, but also those of discipline and methodology, where working with others often requires the designer to adopt new theoretical approaches and acknowledge different ways of doing things. It also includes the levels of structure and object, where the system and the content that system use might often be designed and produced by different team members.

## *Technique & Concept*

Examples of the integration of these two kinds of knowledge are apparent in the projects discussed here. When they evidence technical knowledge it is very likely that conceptual knowledge played a part in its application. Similarly, their application of conceptual knowledge is usually achieved by technical means. This is not an unusual mix of requirements in any discipline, nor is it unique to find these kinds of knowledge integrated in a single practitioner. What is important in this case is that in order to demonstrate mastery as a interactive sound designer, I believe you must have a strong ability to integrate conceptual and technical knowledge. I'll support this statement with a number of examples drawn from the projects I've described in this exegesis.

In *lifesigns*, because I knew what was possible within the MIDI protocol and the Soundfont specification, I was able to conceptualise and design a system of player view rules derived from Schaefferian theories of the sound object. In this case my technical knowledge helped me to apply a concept. In another example, while designing algorithms for real time interaction in the *lifesigns* player, the homogeneous-heterogeneous dialectic was a helpful conceptual framework. I was then able to apply this concept using techniques of statistical analysis & algorithmic composition, including Markov Chains and weighted stochastic indeterminacy. In this case, knowing how to conceptually frame a technical problem in order to choose between a range of technical opportunities demonstrated integration in the opposite direction, or how a conceptual framework helped to solve a technical problem.

*Tixeerif* is a linear sound file, not a generative system, making it open to close scrutiny and well suited to demonstrate specific and general

examples of the integration of technical and conceptual knowledge. One example continually found in the making of *Tixeerif* is the relationship between audio production skills and sonic expression of concepts.

### *Audio production skills*

Audio production encompasses many skills and areas of knowledge: from electronics, because many production processes are based on electronic phenomena (even if they are digitally simulated these days), to acoustics (essentially sound is just waves travelling in a medium) to psychoacoustics, or the way perception affects an acoustic situation. While the act of listening is inherently perceptual, and sonic perception is undeniably subjective and contextual, there is no denying that sound also follows the laws of physics.

“It is a well established fact that our approach to music is generally twofold: this is the physicists’ as well as the musicians’ doing.

On the one hand, music is considered to be based on acoustics or even mathematics, which ought to give it the status of a science ; on the other hand, it is acknowledged that it proceeds from psychological and sociological phenomena which, over the ages, have developed in to an art, itself depending on various crafts.” (Schaeffer, 1966b)

In 14 minutes, the 5 sections in *Tixeerif* represent over 12 months of production. Each sub-section has been systematically structured, built, edited, pruned, pulled apart, evaluated and put back together differently to form the larger work. Putting these sections together necessitated the creation of transitions between the individual pieces.

A great deal of this production work is technical, for example: knowing how to automate a certain setting to create a desired sound precisely the way I wanted. Knowing how to produce a sound heard on the street, or imagined in the head is a necessary aspect of electroacoustic composition. In this way the technical production environment requires an instrumental dexterity.

For instance, the spatialisation of the first voice in *Keycaps* as achieved entirely by altering the phase relationships between front and back stereo signals. In *hyprethun* the percussion gate becomes an important instrument creating an 'edge' on the harsh noisy sounds, while the mixer is used to sequence discrete sonic objects from a continuous stream of noise. In *earkleanr* the synthetic voices of the work are built up using simple production methods, adding complexity in each step. The acoustic results of spectral polyphony and spatial layering are both a conceptual goal and an exploration of possible interactive applications.

### *Structures & Objects*

Interactive sound design is concerned with systems and the content those systems use. I observed that both projects required me to repeatedly traverse these levels of object and structure.

An example of this ability can be seen when deconstructing an aesthetic in order to design a system. Early in the *lifesigns* project, Troy had described to me the genre of music he wanted *lifesigns* to use for sonic inspiration, by lending me some CD's of electro music. I studied the works, listening for the structures that had been used by the different composers and then described them as a system that our programmer could build, and a set of sounds that another sound designer could produce.

Moving in the opposite direction, another example can be seen in the soundfont samples for the *lifesigns* player view. The individual sound files are the base element of this system, but we can break the sound file down into even smaller elements. For instance, each sound file will have an *attack* section or beginning of the sound, the *loop* section where the file will loop while held and a *release* section that is played after the note has been released. The format of these sound files also saves the loop points of the sound. What this means is that the sound file itself can be conceptualised as a mini system which contains embedded structures for interaction.

These relationships reoccur in the soundfont format itself. A soundfont can be conceptualised as a content object because it is stored as one binary file that includes all the audio samples and programmatic structuring. These soundfont files can be transported and used across a number of environments because the format is standardised and implemented on hardware via the Sound Blaster chipset in sound cards, and software through the inclusion of DLS Soundfont support in the QuickTime™ format, available on Windows, Linux and Mac OS.

Soundfonts can also be conceptualised as a system, because they use audio files as content, arranging them in a way that can be accessed by the defined standard.

This means that audio files and soundfonts are *structured objects*, because they are transportable objects that adhere to standardised descriptions of systems. This allows other systems to plug in and offload processing onto these objects simply by interfacing with these standards. This modularity is usually achieved by the public

documentation of a structured objects' *Application Programming Interface*, or API. Another way of describing these structured objects is as *formats*.

An example of how the interactive sound designer can use structured objects is seen in the specifications for *Ambient*, *Language* and *Beatbox* types of audio samples used in the *lifesigns* player soundscape. In the *Language* type, the entire sample loops seamlessly, in the *Ambient* type, a small section of the file loops and actually has a rhythm in the envelope of this loop, and in the *Beatbox* type there is no loop and the entire envelope is embedded inside the sound.

There are many processing jobs that can be offloaded onto standardised formats of today. This implies that one key skill of the interactive sound designer is knowing when to *not* program something, because that functionality is better supported in a format.

### *Generalising the specific*

This ability of a designer is two-way. That is, the ability to generalise the specific also implies the ability to specify the general. I suggest a method of interaction design that borrows from Schaefferian modes 3–4 compositional technique where the designer rocks back and forth between generalising specificity and specifying generality.

For example, a specific problem might be that when playing a certain lifesign I realise that the pitch values generated by its DNA are too low for the soundfont that it's triggering. This makes the sound either inaudible or overly deep or it doesn't mix very well with others. Instead of changing the specific sound file or maybe adding

rules for that specific case, I need to be able to generalise the issue in order to then make changes to the entire system that has generated this issue.

While working on *lifesigns*, I began formulating a diagram to aid in the description of this relationship between generality and specificity. In it, an aesthetic intention is drawn at the top. In *lifesigns*, this represents the world as Troy imagined it. At the bottom of the diagram are elements that represent individual rules. These are the systemic elements or components that generate the system's outcome. If we join these together, this diagram shows how general rules can have a specific outcome, or that a specific outcome can imply a general set of rules.

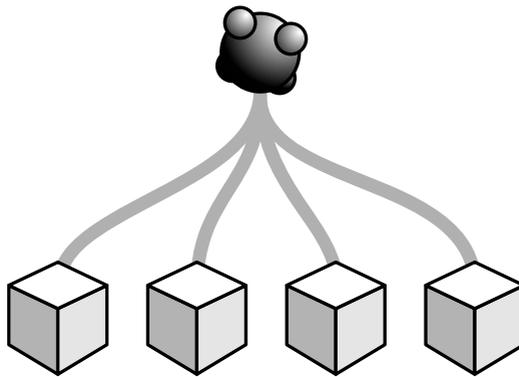


Figure 32. general & specific diagram

I used this diagram to communicate with other members of the *lifesigns* team in order to locate where on this axis between specificity and generality we were working. I would actually point to this diagram, use it as a map in order to say, “At the moment, we’re

working generally about this specific issue.” or “right now we’re actually working with something that has more general ramifications and so we need to move down and think about it in that sense.”

Troy, as the artist with the original concept, was working from the top down, from the object or aesthetic outcome. I was working from the bottom up, designing a general system to generate the specific outcome. This allowed me to begin to formulate a strategy where we work from both ends to meet somewhere in the middle.

I realised at this point that I was simplistically putting Troy in the *aesthetic concept* role and myself in the *general rules* role. What becomes obvious when I reflect on the projects is that these roles aren’t mutually exclusive. On the contrary, their traversal was key to what I consider to be the success of that project. As I became able to describe to Troy what the specific outcomes of changing a general system were, he became more able to explain to me a general way of producing the specific outcomes he wanted. We both got better at doing each other’s job, and we could move back and forth between both sides of the problem quite easily.

## WORKING WITH OTHER DISCIPLINES

A few months after working with the programmers on *lifesigns* I was asked to consult on a similar project at the *University of Technology Sydney* (UTS). While there, I had the chance to meet Tim Mansfield of the *Distributed Systems Technology Cooperative Research Centre* (DSTC). Tim introduced me to the Extreme Programming methodology (Beck, 1996) and through that I became aware of software Design Patterns (Gamma et al., 1995). It was here that I recognised the waterfall vs prototyping experience I described earlier in the section

on the *lifesigns* player view was formally addressed in the literature of computer science, albeit under different and far more generically applicable terms. The introduction to Design Patterns also resonated with me because early in the *lifesigns* project Troy had given me Christopher Alexander's book *Notes on the Synthesis of Form* (Alexander, 1964).

Computer Science has drawn a number of theories from Architecture and Planning research, most notable among these being the *Design Patterns* methodology inspired by Alexander's book *A Pattern Language* (Alexander et al., 1977) and Rittel and Webbers' concept of *Wicked Problems* (Rittel et al., 1973), which I found to be a powerful reflective tool for analysing a complex interdisciplinary project like *lifesigns*.

#### *Wicked problems*

Wicked problems are described as unique situations that have no definitive formulation or success criteria. Attempts at a solution change the understanding of the problem, generating consequences whose follow on problems are impossible to foresee. Wicked problems lack clear evaluation criteria, making it difficult to know when the solution is finished, or even correct, yet the designer does not have the luxury of failing (Poppendieck, 2002; Rittel et al., 1973). It's not possible to turn up for a performance and not perform, nor would it be possible for me to deliver an interactive sound design that didn't work

Methods suggested for dealing with wicked problems include *identifying that the problem is wicked*, or not treating a wicked problem like a tame problem that is clearly defined and formulated (Rittel et al., 1973). This can be combined with the concept of *taming the*

*problem* through discussion and collaboration with stakeholders (Rittel et al., 1973). In the case of *lifesigns*, these stakeholders were the artist, programmers, and sound designer. This discussion involves formulating shared understandings of the problems context, acceptable solution spaces, and possible follow-on consequences. These techniques are implicit in the act of collaborating with others.

### *Collaboration*

While writing about the works, and reflecting on their similarities and differences, I also observed a common thread of collaboration. The first project, *lifesigns*, was an extended collaborative work where I was a subcontractor to the artist. I was engaged to realise Troy's vision. With *Tixeerif* I was entirely responsible for everything, but often I would find myself in the studio wondering:

*...what if I was asked to do this for X? How would I do it?*

In these cases X would be someone I had worked with previously, or someone I wanted to work with in the future, or someone I had received feedback from.

These projects represent either end of a continuum of collaborative models. Starting from interdisciplinary teams where each person has a discrete role, to the other extreme – collaboration with(in) oneself, or “oneself acting as another” (Glanville, 1998 p9). These polarities suggest a number of models in between, from those where process might be as important as the solution, to ones where the solution to a problem drives collaborators to jump between disciplinary boundaries.

These kinds of collaborative experiences help develop mastery in interactive sound design, both while working with others, and also when working solo. The processes set up in collaborative teams require design thinking to be externalised or communicated to all stakeholders. This gives a space for those ideas to be critiqued, both by the team, and also in reflection, exposing the designer to different methodological approaches and solution spaces. Paul Carter refers to this aspect of collaboration as a process of *dismemberment*, where...

“The process of making the work becomes inseparable from what is produced. The often fiery exchanges between the collaborators and the collisions between the *technes*, as the resistance to intellectual manipulation of the materials used, means that collaboration is always, first of all, an act of dismemberment. This is the first, critical phase of creative research. In the second, the stories, ideas, locations and materials thus dismembered are put back together, but re-membered, in a way that is new.” (Carter, 2004)

In this *re-membering* the new models, methods and evaluative criteria travel with the designer long after the project in which they were exposed to them has finished, sometimes triggering new collaborative or solo projects.

Based on my experiences with the projects described here, I can now identify four distinct modes of working as a interactive sound designer. These modes define points on a methodological landscape, implying a larger number of possible combinations.

*Designing for a user*: this way of working is not evidenced in these projects, but when situating my research within the field of Interaction Design, it becomes apparent that a interactive sound designer could use human-centred methodologies to drive a design agenda.

*Singularly driven projects*: working as part of a team, or solo, to realise someone else's vision. Closely related to:

*Collaborative projects*: working as part of a team to achieve a shared vision.

*Self initiated projects*: working solo to achieve one's own vision.

The projects described in this exegesis fit between the last three modes. *Lifesigns* was as a singular vision, but due to the complexity of the problem it had to be tamed by using more collaborative models. *Tixeerif* was a solo project, where I brought the knowledge from *lifesigns* and other collaborations to bear on the problem.

On reflection, this process of moving from one mode to another resonates with the previous section on technique and concept, because they both describe the act of traversing a set of abilities or ways of understanding a situation. I propose this as a meta-skill for the interactive sound designer, describing it as the ability to *transcode systems*.

## TRANSCODING SYSTEMS

The term transcoding is usually applied to digital content, where it refers to the process of converting information from one format into another. This is achieved by decoding from the first format, then encoding the result into the second format (Wikipedia). The process is often applied in realtime, for example, a DVD player will transcode an MPEG2 movie file into an audio/visual stream that standard hardware can understand.

I use the term *transcoding systems* to describe the process of moving between ways of describing and understanding a situation. As

outlined in the previous section, via collaboration the interactive sound designer can transcode systems at many different levels of a design. These include applying theoretical ideas via technical means, recreating an aesthetic in a generative system, solving technical problems using conceptual knowledge, and using knowledge gained from interdisciplinary collaboration in a solo context. I also use the term here because it implies this process occurs in realtime, meaning that the interactive sound designer must be able to hold two or more systems of understanding in their mind simultaneously.

I observed that the traversal of these different levels and abilities meant that I was able to work effectively in a greater number of situations and roles. This was possible because I made more agile use of the well stocked conceptual, technical and methodological toolbox I described in the chapters on my projects. This ability helped me to reflect on more aspects of the projects by giving me more frames of reference to reflect through. In both projects this created wider solution spaces for me, and my collaborators.

When I now reflect back on my reasons for undertaking this research, I see how the experience of collaboration, designing and realising these projects led me to a greater understanding of the elements that make up my practice. The previous section categorises these elements into a suite of different abilities, and this section describes how I put them together to generate the projects I have described in this exegesis.

In examining these abilities, I find uses for them in many of the fields where I am currently engaged. In academia they can be used to define graduate capabilities that lead to curriculum design and assessment criteria. In research management they can help me

facilitate collaboration within interdisciplinary teams of researchers. In composition, they can help me to regain the act of listening, by understanding it is but one of the important processes required in that activity. In my work with sound and systems, the combination of these abilities has changed the way I practice, because I have not only developed methods for integrating different approaches, I am also more aware that other approaches exist. I believe the work I make now has greater depth and more layers of sophistication than the work I made before undertaking this research, because it synthesises a broader range of conceptual fields.

These abilities, and the experience of discovering them has also changed the way I understand and undertake research. As the boundary statements in the preceding chapters suggest, there are many avenues of further exploration open to me. With this new knowledge, and a rediscovered passion for making work, I feel well armed to begin that next phase of my collaborative practice.



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