Using Real-Time Data Flux In Art – The Mediation Of A Situation As It Unfolds:
RoadMusic – An Experimental Case Study.

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Abstract

The practice driving this research is called *RoadMusic.* The project uses a small computer based system installed in a car that composes music from the flux of information it captures about the journey as it unfolds. It uses a technique known as sonification that consists of mapping data to sound. In the case of *RoadMusic*, this data capture is real-time, external to the computer and mobilised with the user. This dissertation investigates ways in which such a sonification can become an artistic form.

To interrogate the specificity of an art of real-time it considers philosophical theories of the fundamental nature of time and immediacy and the ways in which the human mind 'makes sense' of this flux. After extending this scrutiny via theories of system and environment, it proceeds to extract concepts and principles leading to a possible art of real-time flux. Time, immediacy and the everyday are recurring questions in art and music, this study reviews practices that address these questions, essentially through three landmark composers of the twentieth century: Iannis Xenakis, John Cage and Murray Schafer. To gain precision in regards to the nature of musical listening it then probes theories of audio cognition and reflects on ways in which these can apply to real-time composing. The art of sonifying data extracted from the environment is arguably only as recent as the computer programs it depends on. This study reviews different practices that contribute towards a corpus of sonification-art, paying special attention to those practices where this process takes place in real-time. This is extended by an interrogation of the effect that mobility has on our listening experience.

RoadMusic is now a fully functional device generating multi-timbral music from immediate data about its surroundings. This dissertation argues that this process can be an alternative to mainstream media systems; it describes how *RoadMusic's* programs function and the ways in which they have evolved to incorporate the ideas developed in this thesis. It shows how *RoadMusic* is now developing beyond my own personal practice and how it intends to reach a wider audience.

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RoadMusic Presentations

September 7 – 27 2009 Residence at "Rizome" Arts Center in lijiang China – Development of oriental scale generator, adaptation of interface for a 20 year old Chinese jeep, road-trip to Zhongdian (Tibet), production of a documentary video with Peggy Arraou: *RoadMusic from to ZHONGDIAN TO LIJIANG*. http://rhizome-lijiang.org/

October 9 2009 Presentation of Work (*RoadMusic*) to members and board of the PNEK network (Production Network for Electronic Art Norway), Bergen Art Academy, Norway. Debate concerning art and research. http://www.pnek.org/archives/tag/peter-sinclair

February 10-13 2010 Presentation of *RoadMusic* in at "Mois Multi" – Quebec (Organised by Avatar). The public were taken for 20 minute drives (roughly 80 people over 4 days). See Documentary Video of circuit and video interviews. http://www.lenomdelachose.org/

March 4 - 5 2010 Organisation of the LocusSonus symposium *Sonification (what, where, how, why)* – During which I drove guest speakers from one venue to another with *RoadMusic* in the car. The link is to video documentation made by artist Victoria Vesna (one of the participants in the symposium). http://vimeo.com/10001023 Documentary Video: Interviews with artists participating in the symposium concerning their practice of sonification. http://locusonus.org/w/?page=Symposium+sonification

July 12 2010 Presented *RoadMusic* programs at "Code lab" an informal forum for artists, developers, researches and amateurs focusing on the artistic and creative use of computer code. http://codelab.fr/1487

September 19 2010 "Poptronics" features an article about *RoadMusic* by Annick Rivoire (in French). http://www.poptronics.fr/Avec-Road-Music-Peter-Sinclair-en

September 22 2010 Presented by "Chateau de Servières" Marseille, during the exhibition: *20 Years 20 Artists 20 Companies*. http://www.chateaudeservieres.org/

November 17-27 2010 *Memory(ies)*: 2nd "Biennale Figures Of Interactivity" – Poitiers: "Questioning the place of "Memory" in the age of new technologies". Ecole Nationale Supérieure des Beaux-Arts of Poitiers: Demonstrations of *RoadMusic* driving in and around Poitiers during the festival.
http://www.figuresinteractives.com/2010/pages_fr/index.html

February 5 2011 Presentation of *RoadMusic*: Conference on "Electronic Devices and Intellectual property" « Dispositif électronique et droit d'auteur » at Avatar, Quebec.
http://www.moismulti.org/programmation/colloque.html

February 7 2011 UQAM (University du Quebec à Montréal): Lunchtime conference at NT2 (Research into Hypermedial Artworks) : *RoadMusic a Dynamic Sonifcation in Art*
MIDI Rencontre du NT2 (laboratoire de recherché sur les Oeuvres Hypermediatiques): La *RoadMusic*: Une Sonification Dynamique en Art. http://nt2.uqam.ca/

June 27 2011 Tests using Newcastle University's Electric car with Dr Phil Blyth, Director of TORG (Transport Section) and Dr Atau Tanaka, Chair of Digital Media (Culture Lab). http://www.ncl.ac.uk/ceg/research/transport/
http://www.ncl.ac.uk/culturelab/

October 14 2011 Participation in Conference Ops/IN (Observatoire des Pratiques de la création de l'Image Numérique) at Ecole Nationale Superieure de la Photo de Arles.
Paper title: *Transcodage: l'Art de La Sonification*.
www.observatoireimagenumerique.com

November 30 2011 Presented research at the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications - Workshop *Subliminal Perception In Cars*: University of Salzburg Austria.
http://www.pervasive.jku.at/AutoUI_subliminal/

February 2 - 4 2012 Workshop GMEM: Atau Tanaka, Marine Quiniou et Mathias Isouard , Charles Bascou. Conference and demo of *RoadMusic* program during "Reevox Festival".
http://www.gmem.org/index.php?option=com_content&view=article&id=522&Itemid=13595

April 12 - 13 2012 Workshop GMEM.

September 17 - 21 2012 Workshop GMEM.

November 12 - 16 2012 Workshop GMEM.

May 23 - 26 2012 presentation of *RoadMusic* at Electronic art festival "ElectroPixel" in Nantes, France. Public were driven in and around Nantes during four days of the festival. http://www.electropixel.org/

November 28 – 29 2012 International Conference "Einstein/Duchamp, et Après? La recherche dans l'enseignement supérieur artistique". Paper title: *L'art de la Sonification*. Académie royale des Beaux--Arts de la Ville de Bruxelles. Federation Wallonie Bruxelles

December 11 2012 Ministry for Culture (Direction générale de la création artistique) Annual seminar of the scientific council and research units: Presentation of doctoral research.

December 17 2012 Conference: Back and forth : from life to art "JOHN CAGE ET LA PÉDAGOGIE EXPERIMENTALE". Paper title: *John Cage – Indeterminism in composition and Performance: from score to routine*.

January 12 2013 The Contempory Art Museum in Toulon for an exhibition entitled "l'automobile dans tous ses etats" (the car in a state). Conference presentation of *RoadMusic* research. Demonstration drives.

February 9 2013 Presentation of *RoadMusic*, Reevox Festival: Marseille La Friche de la Belle de Mai (including versions by composers Atau Tanaka, Marine Quiniou, Mathias Isouard , Charles Bascou and Andrea Cerra). Roughly four hundred participants. http://www.gmem.org/index.php?option=com_content&view=article&id=5580017&Itemid=35

June 2013 The DVD Peggy Araou *RoadMusic, de Zhongdian a Lijiang* presented in the festival "Croisements" 2013 in Chengdu, China.

Publications

Sinclair, Peter. "L'art de la sonification en temps réel." *Obs/in.* l'obs/in, 2011. 121-131.

Sinclair, Peter. "Living With Alarms." *AI & Society* (Springer) 27, no. 2 (05 2012).

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Sinclair, Peter, ed. "Sonification - What Where How Why." *AI & Society* (Springer) 27, no. 2 (05 2012).

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Gresham-Lancaster, Scot, and Peter Sinclair. "Sonification and Acoustic Environments." *Leonardo Music Journal* 22 (2012): 67-71.

Sinclair, Peter; Dr Hubner, Yvonne and Dr Tanaka, Atau "*RoadMusic*: Music For Your Ride From Your Ride" Special Issue *Presence*: *Teleoperators and Virtual Environments: Subliminal/unaware cues and perception of presence in virtual, tele-presence, and automotive environments.* MIT Press (to be published). TBP.

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Introduction

As an artist I have often felt that it is preferable to strive towards and promote a heightened consciousness of our surroundings and ourselves, rather than to impose an interpretation of these same. This, however, inevitably poses the question: what becomes of the artwork? I have always been more interested in the flux of the creative process than in the end result. In fact, often there is no identifiable end to a work but rather successive versions, which from a computer programming point of view is completely normal, and leads me to ask "Why does an artwork stop?" and "Are there not ways in which the art could be more faithful to the creative process in its form and functional mode?"

Although my background and education is in the visual arts, sound is and has always been my principal medium. My practice has evolved over the past decades from machinist sculptures and performance to computer programming –creating experimental situations through real-time-audio processing. Recent technology is changing the conditions under which my practice can occur. This thesis is an investigation into the time and the place in which the artwork unfolds and the role that it fulfils.

Real Time?

The possibility of making real-time based art is a recent development, simply because, at least in the sense in which it is used in my practice, it is dependent on computer technology. Indeed, the term itself is related to programming jargon which opposes real-time to non real-time. In computer music, real-time is defined as the capacity of a computer to 'complete the calculations for a sample within the duration of one sample period' (Roads 1996, 102) or more loosely to generate sound at the rate at which it is played, rather than rendering a file in differentiated time which is then played back[1].

[1] This is one of several existing definitions of real-time for a more in depth discussion see Stuart Jones' contribution to our special edition of AI&Society (Jones, Now 2012)

Much of what we might today call real-time art (interactive installations, hypermedia or augmented reality) finds its origins in media based arts of cinema, video and recorded music. In the context of this research I will propose a different approach, one that involves the automated production of form from immediate data that places the present moment at the centre of the artwork. The ambition of *RoadMusic* is to generate music for the car that adapts to the journey. To do this I have developed a program that runs on a dedicated mini-computer equipped with sensors and placed inside the car. The sensors collect information about the drive as it evolves and the music is derived solely from these fluxes of data.

Immediacy in itself is not art –it is just life (or in computer terminology just raw data) and the central question posed in this thesis is: how is it possible to mediate the situation as it unfolds in such a way that it constitutes art?

Flux Art

Notions of flux in art are not new: art that becomes is as old as music itself and furthermore, until the recent advent of recording technologies, music or other forms of performance unavoidably took place as you experienced them. However, such works are traditionally dependent on the live presence of the performer rendering the piece before an audience and are consequently shaped by the constraints and particularities of the performance situation. Most importantly this implies that the rendering of the artwork becomes a special occasion, which in itself, arguably distinguishes it from the flux of the everyday.

With fine arts comes the idea that intuition can be in some way fixed in time and subsequently rendered to an audience; the artwork gains an existence independent of its author that offers possible advantages such as critical distance and permanence. Painters have long been motivated by a desire to capture the instant, Giacomo Balla's 1912 *Dynamism of a dog on a leash* is a historical example. However, most often, even if such an artwork tells of flux, it detaches itself from it through a process of sublimation. A more recent example might be found in work by British land-artist Hamish Fulton who considers his art to be the solitary walks he makes, but who nevertheless proposes still photographs as a public interface to this activity (D. Brown 1985).

In 2002 Nicholas Bourriaud in *Relational Aesthetics* advocates a process-based art:

> Unlike an object that is closed in on itself by the intervention of style and a signature, present day art shows that form only exists in the encounter and in the dynamic relationship enjoyed by an artistic proposition with other formations, artistic or otherwise. (Bourriaud 2002)

There is a generation of artists influenced by such ideas. For example Gonzalez-Torres' 'removable' installations evolve over time by inviting visitors to take part of the installation away with them. In one such installation the public were invited to help themselves to a pile of sweets which weighed the same as the combined body weights of Gonzalez-Torres and his lover[2].

Interactive installations involve the spectator, changing the paradigm of the art 'object' or fixed media. Jeffrey Shaw's 1989 *The legible city* allows the spectator to cycle through virtual cities (based on maps of real cities) where walls and buildings are constituted of three-dimensional letters and words. The bike interface allows the user to choose his route through this textual world (Shaw 1989). If these works undeniably include the flow of time, the sanctification of the process through its insertion into a space dedicated to art, operates the same type of transformation on our perception of it, as does that of the performance. In this thesis I will consider the possibility of an art produced in and for the everyday and non-consecrated space.

It could be argued that the Internet offers just such a non-consecrated space and art theorists have shown interest in social networking for some time. In his seminal paper *The Cybernetic Stance: My Process and Purpose*, first published by Leonardo in 1968, Roy Ascott proposes an art of social networking, predicting public access to communications systems:

> They contain nothing but the possibility for future action; that is to say they exist only in so far as the spectator participates in their evolution by, on the one hand, interacting with other people within a complex social situation, and on the other hand by conducting a private interior dialogue. (Ascott, The Cybernetic Stance: My Process and Purpose 2007, 105)

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[2] Félix González-Torres (1957 - 1996) An American artist of Cuban origins, known for his minimal process based installations (felixgonzalez.com).

I am actively involved in collective networked projects of a type that Roy Ascott could have been describing (Locus Sonus's open microphone project (Locus Sonus 2013)). *RoadMusic* however adopts a different approach, which consists of considering mobility (as opposed to social geography) as the cybernetic motor behind the creation.

Sonification

RoadMusic is a sound based piece that relies on computer-music techniques. With mainstream principles of real-time computer music such as algorithmic composition, electronic instrument design or the interactive manipulation of pre-recorded media, music is created either by human gesture or (with algorithmic composition) by processes that are disconnected from the world outside the computer. The functioning principle of *RoadMusic* is a process known as sonification, which is driven by data external to the device.

Sonification is a recent term that does not yet figure in the Oxford English Dictionary. The definition of sonification most commonly cited is that proposed during the ICAD[3] conference in 1999: 'Sonification is the use of non-speech audio to convey information (Kramer 1999)' or in other words the mediation of (most commonly digital) data through sound. Scientists involved in sonification research, in particular Thomas Hermann, have in the past suggested that the definition should exclude artistic usage (Hermann 2008). In a special edition of AI&Society dedicated to artistic sonification that I guest edited (Sinclair, Sonification - What Where How Why 2012), several artists contradicted this position and Hermann himself has revised his point of view since his contribution to the review starts with: 'Sonification today is an interdisciplinary practice ranging from scientific applications to sound art and composition(Grond et Hermann 2011).'

Sound Art

> 'Reproduction' is to the digital world what the hot-air balloon once was to aviation. Using digital technology artists are now able to introduce new forms of 'production,' not 'reproduction' (Rush 1999, 168).

[3] International Community for Audio Display

Sound, in the context of digital media has found new terrains, which confound categories hitherto dedicated to 'spatial' art and 'temporal' music. Music and voice have become mobile, with social consequences that go far beyond the music reproduced. Sound can now be installed, spatialised, generated or continuously captured. More importantly in the context of this research, digital sound production can take place in real-time and on apparatuses small enough to be carried in the hand; thus sonification, which as a technique incarnates this notion of 'new form of production', can take place in real-time and in real-place.

Mobility

The miniaturisation of computers is a very new phenomenon[4]. This leads me ask whether the fact that a media system can share its users' mobility might modify the very nature of that media and whether as a consequence there might be a new way of approaching media based on this mobility. This applies in the case of *RoadMusic* but this question is gaining pertinence and becoming more generalised as smartphones enter into this category of miniaturised computers.

[4] To the extent where they have become truly portable and sufficiently inexpensive to be dedicated to a specific task while remaining powerful enough to accomplish complex real-time calculations.

Introduction To Practice

The original idea behind *RoadMusic* is to create music adapted to a car journey, by generating it from the journey itself. It came from a drive across Pennsylvania, along one of those seemingly endless straight roads dominant in the USA. There was, or so it seemed at the time, a fusion between the relatively featureless, monotonous route and the music playing on the car stereo. The music was "Deadbeat" (Monteith 2012), minimal, slowly evolving electronica with lots of grainy ambient sounds. The comment was made that it would be even better if the music could 'really' adapt to the journey. When I started thinking about this it struck me as being a challenging but achievable project.

Mapping data about the cars' movements to sound was a relatively simple process, however this rapidly became uninterestingly tautological (one simply hears what the car does). Developing ways in which to expand this as music has proved much more thought-provoking since the 'real-time' nature of the audio production required is (at least at first view) in contradiction with 'traditional' methods of composition that often involve either defining overall structure in advance of musical execution or spontaneous human intervention.

The first question that this sonifying of environmental data evokes is: if data is informative of the current circumstances, does the perception of the resulting sound become modified to acquire an other-than musical status (at least if music is taken as form, representation or expression)? Another way of formulating this is: do the music's 'real-time' and 'real-place' qualities effect our relation to it, making it an intrinsic part of the audio environment, independent of aesthetic considerations? A consequential second question is: in such a case, where audio production is based on real-time, indeterminate data (as opposed to human intervention), is it possible to consider the result as artistic? Thirdly, supposing that data sonification can be considered as art, what structural and aesthetic concepts or conditions might be applied, considering that this form must be dynamic and without determined duration (which also means that in musical terms beginning and end are indeterminate)?

As I will show, stochastic composing techniques and other concepts that incorporate incidental or naturally occurring sound as music can open this space conceptually. Equally important is the study of audio and musical perception where a kinetic syntactic

approach to listening provides a basis for thinking of music as an on-going process as opposed to an overall structure.

Description Of *RoadMusic* In Brief

The current version of *RoadMusic* runs on a dedicated and autonomous mini PC that is fixed to the interior of a car's windscreen (like a GPS device) and connects to the car's stereo via a standard audio input. The computer is equipped with sensors and a camera.

Figure 0-1: *RoadMusic* hardware installed in a car. (Photo Sinclair)

The sensors gather information about movement (accelerometers on x, y, and z axes): vibrations from the car body and the road surface; and on a larger scale bends, bumps, accelerations and braking. The camera gathers information about the visual field: moving objects and colour.

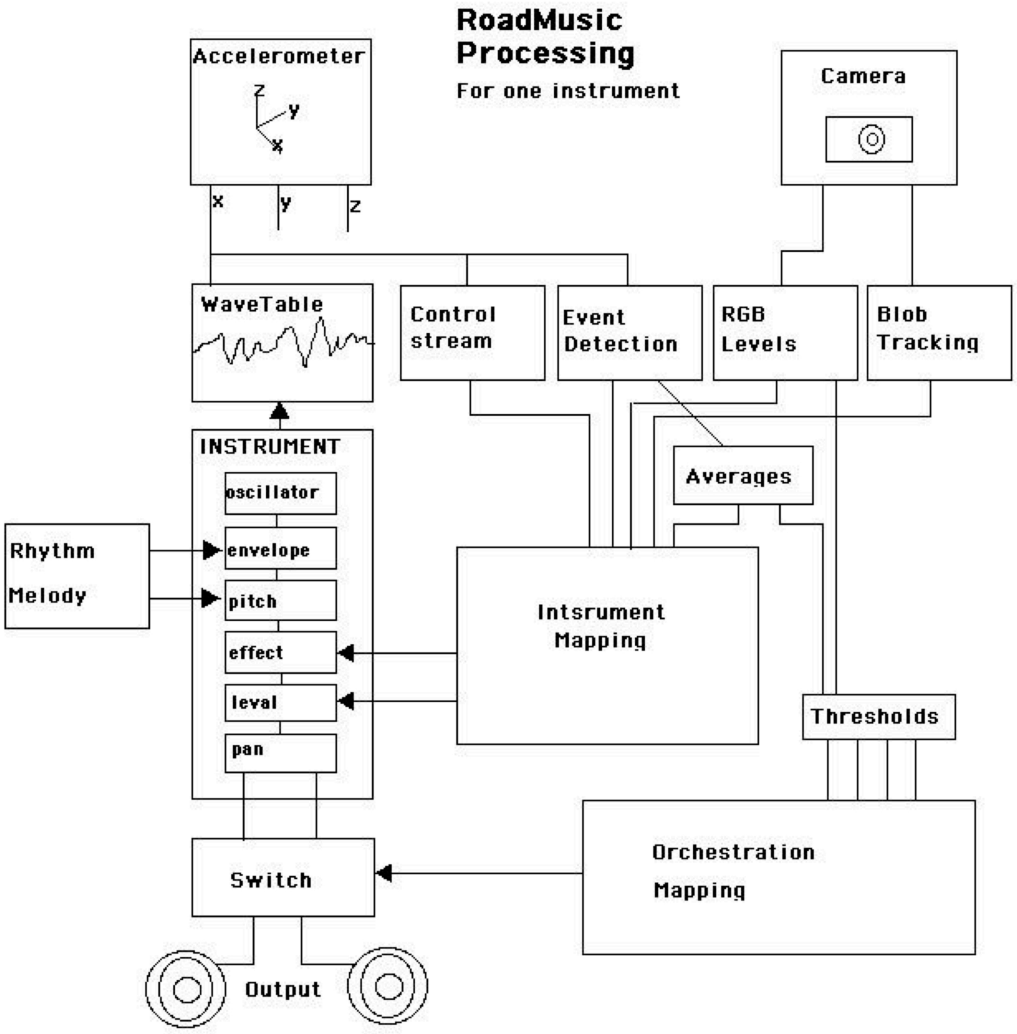

Figure 0-2: Schema of *RoadMusic* analysis and audio processing

Possibly the single most important (sonic and conceptual) feature of the *RoadMusic* program, one that has particular bearing on the theoretical research which follows, is that at the outset there is no pre-recorded audio in the system[5]. It does not use playlists or samples; rather audio synthesis is based upon the incoming raw data –the forms of the

[5] There is an exception to this: a recorded voice which gives feedback information about user navigation.

road and the cars movements. This data is written into wavetables[6] and read at audio speeds, meaning that the sounds evolve as data updates.

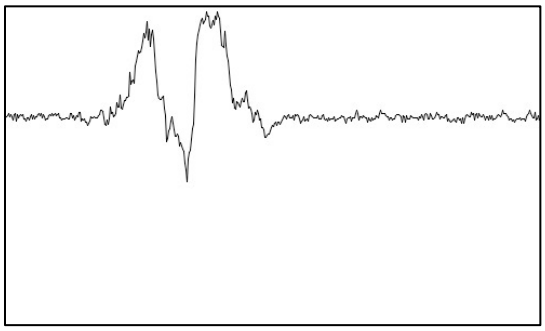

Figure 0-3: A wavetable

This might immediately conjure up the idea something very noisy in the auditory imagination of the reader, however since this is just the starting point of the synthesis (the wavetable is then read by oscillators and numerous other processes are applied to it), it essentially affects the sound on a micro-sonic scale, modifying timbre or texture. The influence of this on the end result is subtle and not necessarily consciously quantifiable to the untrained ear but it eliminates the monotonous nature of many synthesised sounds and importantly *is* the audio 'imprint' of the journey itself.

Instruments Or Streams

At the next level of complexity up from the wavetables described above, audio synthesis is accomplished by a number of modules generating what will be described later in this thesis as multiple streams[7] –separate audio identities, which for the moment are most easily thought of as instruments. Each of these 'instruments' has basic parameters that can be varied in real-time such as pitch, amplitude and pan and some have more

[6] Indexed memory or array of values used in computer music.

[7] See Chapter 3.3 : *Auditory Scene Analysis*.

distinctive qualities such as frequency spectrum (tone filter), echo, delay, and 'Doppler'[8] effects that can simulate physical space or movement depending on the instrument.

Data Analysis And Mapping

Data from the accelerometers is processed in different ways:

- Each data stream is rescaled and smoothed so that it can be used as a continuous controller by any parameter of any instrument. For example, the varying force of acceleration and deceleration or g-force as the car goes round bends or over bumps, can be mapped to change pitch, level or harmonic spectrum.
- Events are detected within these same streams by measuring difference against time, so it is possible to discern a bump, a bend, an acceleration or a deceleration. These events are used to trigger sounds directly, to introduce or remove notes from melodies, or to switch signal processes on or off.
- These events are also used to calculate statistics about the road –measures of bumpiness, bendiness, stops and starts– that in turn produce new streams of data (moving frame averages). Like the rescaled data, these can be mapped to any parameter of any instrument, causing slower variations that mediate the drive on a macroscopic scale.
- A last level of analysis applies threshold values to the statistical data, producing a new set of events which are typically used to orchestrate the ensemble – switching different instruments on and off according to the type of road, for example: straight, some curves, winding; flat, bumpy, very bumpy.

The Landscape

A camera captures the visual field of the road ahead. This capture is analysed in two ways:

- Blob tracking is used to distinguish large moving objects, most often cars in the opposite lane. An object detected in the video frame is translated as coordinates: horizontal and vertical position and size. As with data from accelerometers, these

[8] Phenomena whereby, when a sound source is moving rapidly towards or away from an auditor (for example a siren or train horn) the perceived pitch is modified.

can be mapped to sound parameters. In practice, they are employed to create the impression that a sound is moving correlation with an object outside the car by using psycho-acoustic cues (phase difference, amplitude and Doppler shift).

- Colour of the overall scene is analysed by extracting varying RGB (red, green, blue) component levels, typically used to vary harmonic elements in an instrument. Here too an event is extracted when there is a change in the dominant colour of the landscape and used to bring about changes in the music.

Global Inactive

A last but important detection is the non-event: the program provides a signal when no event has occurred for a few seconds, typically when the vehicle marks a stop (there is a mechanism which prevents this from recurring more than once per minute to cater for traffic jams and suchlike). This is used to define parameters of a new piece, for example, to re-generate melodic and rhythmical patterns. The compositional process, once the actual code for instruments has been completed, consists of deciding which input parameters are to be routed to which instrument parameters.

As I will show this principle of elaboration, from the lowest level of real-time, upwards or outwards and indeed backwards on scales of time and sophistication (albeit via the compositional routines conserved in the algorithms of the program) has simultaneously been the focus of this artistic practice and the theoretical research of the following chapters.

Structure Of Chapters

Chapter One: Theories Of Flux – Time And Perception

In Chapter One, I consider theories of time and perception. Bergson identifies a dimension that is unique to immediate time (duration) on which he constructs the multiplicity of Élan Vital. If Bergson is essentially concerned with the fundamental nature of time, Daniel C. Dennett builds his theory of consciousness by deconstructing the narration that we relate to ourselves. Dennett's mechanistic view of this real-time, ever updating, editorial process provides me with a possible basis for a method of automated, dynamic composition.

RoadMusic is external to human consciousness; it is an interface between the human user and environment. This connection is fundamental to my research and defining the position that the real-time flux produced by the device occupies is one of the major points of interrogation of this thesis. Thus, I prolong the theories of time and perception of Bergson and Dennett to include environment through Gregory Bateson's extended version of Cybernetics and Henri Lefebvre's Rhythmanalysis.

Chapter Two: Precursors To Sonification: Iannis Xenakis, John Cage, Murray Schafer

In Chapter Two, I consider the work of three composers, whose work constitutes the theory and techniques that historically lead to the premises of an art of sonification of environments. Engineer and architect as well a composer, Iannis Xenakis employed stochastic mathematics in order to model sound and symbolised music to extract it from the fixed time domain of the linear score. John Cage, on the other hand, introduced chance into the compositional process, opening music to indeterminate sounds of the world. Subsequently, Murray Schafer developed a concept of soundscape; a multi-disciplinary approach that considers sound environment as a composition.

Chapter Three: Music And Audio Perception

In Chapter Three, an extension to Chapter One, I specifically consider audio perception and its relation to musical listening. I pay particular attention to Leonard B. Meyer's explanation of the way in which musical emotion and meaning evolve in real-time and develop this further to include perception of environmental sound, with Albert S. Bregman's *Audio Scene Analysis*. Between them, these provide me with a theoretical basis for composing in real-time.

Chapter Four: Artistic Sonification And Environments

Chapter Four starts by considering the state of the art of sonification design in the technical domain. This leads on to my original research: a survey of artistic sonification that took the form of an international symposium and the subsequent editing of a special edition of *AI&Society*. I discuss the different ways in which artists attribute signification to the data they use, focusing on real-time and real-place sonification. The final section of this chapter considers perceptual and artistic consequences of making audio mobile.

Chapter Five: *RoadMusic* – Review of Practice

RoadMusic is an in-car device and a program, which generates music in real time from data about the road. In Chapter Five, I start with a subjective description of a journey. I then discuss the way in which the ideas emerging in the previous chapters gather together within my practice. The second section deals with the practical functionality and evolution of the program, relating this to compositional and sonification strategies. Finally, I comment extracts from interviews conducted with people who have experienced *RoadMusic*.

This Thesis is multidisciplinary and practice driven. The research presented in Chapters One to Four has been carried out simultaneously and in a reciprocal exchange with the development of *RoadMusic's* compositional programs. It is preferable to consider these chapters as different, albeit related and intersecting approaches that converge on the practice as described in Chapter Five; rather than as a path leading progressively towards that practice.

1. Chapter One - Theories of Flux – Time and Perception

1.1. Introduction To Chapter

The question of real-time in art necessitates questioning the nature of immediacy itself. If I have chosen to begin this thesis by a description of the fundamental nature of time, as developed by Henri Bergson, it is because Bergson's invention of a dimension specific to time and of a different nature to space makes thinking in terms of flux possible.

Rather than comparing this with ensuing philosophies such as that of Edmund Husserl or Gilles Deleuze, I preferred to jump forward and sideways and balance this with the contemporary writing of Daniel Dennett. Reliant on modern cognitive science and computer science, Dennett's work on consciousness provides an articulation with my practice of programming sound. Bergson's theory of time consolidates my reasons for wanting to construct an art of real-time flux but it does not, in itself, provide a model on which I might construct a working method. Daniel Dennett's theory on the other hand provides me with the starting point for such a method since he concerns himself, primarily, with the way in which immediacy is 'interpreted' by consciousness. Throughout this chapter I will seek to understand the way in which, through consciousness, we structure the raw data of our environment into something which 'makes sense' and in the last section, the way in which this might be applied to the construction of a form of art.

Bergson and Dennett are both primarily concerned with human perceptions of time and thus leave some of my questions unanswered since with *RoadMusic* I am working towards an artistic method that is simultaneously outside of and interacting with human consciousness. It exists as connectivity between the exterior and the interior rather than being either consciousness itself or a representation of exterior. This leads me to extend my research to include two historically intermediate thinkers: Gregory Bateson and Henri Lefebvre. Bateson makes use of cybernetics to place informational as opposed to causal concepts at the centre of his theory, which enables me to place human, machine and environment in a single system. Henri Lefebvre's rhythmanalysis supports this extension to the exterior by abolishing the discrimination between self and the environment. His

vision of ‘everyday’ is one of self, inextricably extended through physical, social and historical rhythms.

1.2. Flux And Self

1.2.1. Henri Bergson (1859 -1941)

> Science has to eliminate duration from time and mobility from motion before it can deal with them. (Bergson, Time&Free Will 1913, 115)

In *An Introduction to Metaphysics*, Henri Bergson introduces the idea that it is impossible to know the nature of things through measurement or analysis. There exist he says, two possible ways of knowing something: from the inside or from the outside. If you consider something from the outside, you adopt a point of view that will define the way in which the thing is described: a camera angle so to speak. If you change your point of view, by the same token you will change your way of defining or describing. If, on the other hand, you are within something then you will know, immediately, all there is to know about that thing in that instant of its existence.

Intuition

Scientific measurement is opposed to experience itself since it consists of symbolizing and contextualizing a thing, while the actual experience of that thing is a flux, without symbols, without measurement. By using symbols, we create a representation that is necessarily incomplete, because only the original is complete –or *absolute.* Applying this idea to self, Bergson explains that the description of a character in a book, however detailed, can never correspond to the knowledge of that character experienced from within, whereas if it were possible to actually be that person if only for an instant, one would know everything there is to know about the character immediately:

> The character would be given to me all at once, in its entirety, and the thousand incidents which manifest it, instead of adding themselves to the idea and so enriching it, would seem to me, on the contrary, to detach themselves from it, without however exhausting it or impoverishing its essence. (Bergson, Metaphysics 1912, 22)

Bergson calls this simultaneous experiencing of something from the inside 'intuition'. From this he surmises that: 'Metaphysics, then, is the science which claims to dispense with symbols (Bergson, Metaphysics 1912, 24).'

Duration And Mobility

Bergson extends his criticism of the analytical method to include the notion of duration. If you take the trajectory of a moving object from the outside and divide it into measurable entities, each entity will be considered as stationary. The movement is artificially stopped, creating successive points. However, there is neither stopping nor points but rather continuous mobility. Again, increasing precision of the unity of measurement does nothing to approach us to the reality of the moment being measured, since each additional division simply creates two new entities that need to be considered independently. However, our experience of passing time is a continuum that each passing moment incorporates. Things are in a state of permanent becoming from which it is impossible to extract a measurement or a symbol through a concept, to do so would be to suppose that the object of our analysis could be immobilized.

If the trajectory of an arrow is plotted from the outside, because the system of measurement and notation of the trajectory in space will consist of points, it might be thought that actual movement or mobility cannot exist. This is one of the four paradoxes formulated by Zeno of Elea[9] and which has troubled philosophers ever since. Bergson's response to this question is that if you were to be inside the arrow you would immediately appreciate the nature of being that arrow in that instant. The mistake is to try to explain flight from the trajectory or movement from space, rather than the opposite. From this Bergson develops his theory that there is a dimension of pure time that has to be considered separately from time of which we are conscious, which we can measure or about which we can communicate.

[9] 5th century BC, Greek philosopher.

Time And Space

Mobility then is key to Bergson's thinking and incorporates time and space in a flux of becoming. He criticizes Kant's theory of separate dimensions of homogenous time and homogenous space as it appears in 'Transcendental Aesthetic' *Critique of Pure Reason* (Kant 1781), proposing instead that the symbolisation of time (as opposed to time itself or duration) takes place within the dimension of homogenous space (Bergson, Time&Free Will 1913, 92). We necessarily spread a symbolic measurement of time in space in order to perceive it; otherwise each instant evaporates as it passes.

> If this point were conscious of itself, it would feel itself change, since it moves it would perceive a succession; but would this succession assume for it the form of a line? No doubt it would, if it could rise, so to speak, above the line which it traverses, and perceive simultaneously several points of it in juxtaposition: but by doing so it would form the idea of space, and it is in space and not in pure duration that it would see displayed the changes which it undergoes. (Bergson, Time&Free Will 1913, 103)

This is an important part of Bergson's theory were he identifies a false problem, which arises through considering that pure duration (or becoming) and perceived time are of the same nature and then trying to articulate them with space. For Bergson there is the dimension of space: an empty homogeneous medium (Bergson, Time&Free Will 1913, 95) within which we distinguish different sensations. These distinctions are quantitative in nature but the sensations are fundamentally of the same kind – past and indeed future time participate in this dimension. Then there is duration, our mobility, which is another dimension, of a different nature or kind. Bergson's definition of real time (pure duration) is quite different to the computer music definition that I cited in the introduction to this thesis. Yet this distinction between flux itself, the representation of that flux and the articulation between the two is germane to the central question of this research and the possibility of creating an art from real-time data.

Memory

Bergson's theory incorporates an articulation between real time, duration and perceived time: the flux of our mind is not homogenous since each moment is influenced by the weight of the moment that precedes it and will in turn be modified by the moment that follows it. Thus our consciousness, with its passage in time, gathers the weight of

memory and can never be linear. The possibility of simple and isolated sensations cannot exist due to this juxtaposition of the present moment and past experience. Without this, there would be no duration only instantaneity. The quality of duration is also variable and in flux and cannot be symbolized by the abstraction which we call time (measured time). Multiple strands exist simultaneously, they have different durations, they are different sensations and they cannot be extracted from one another without an effort of abstraction that removes them from the reality we perceive.

Multiplicity

Thus juxtaposition of memory with perception of the present combines as multiplicity, and multiplicity is simultaneously unity –Deleuze's description of this as a 'composite' is perhaps easier to visualise (Deleuze 1988, 18-19). Simply, it is not possible to separate this unity out into its component parts in order to define them as symbols, since doing so effectively destroys the unity. Bergson starts by explaining that numbers are simultaneously unities and multiplicities. Since each number contains the numbers that precede it, it is a multiplicity. However, since it is possible to perceive a number without unfolding it into its constituent elements it is also a unity. Similarly, our perception of the instant is a unity in the sense that everything is contained within that instant, the moment itself and everything that precedes it is multiplicity because it contains the past and because it is made up of a multitude of simultaneous sensations with differing evolving dimensions. We create *false* categories, divisions and measurements in order to extract elements from this multiplicity to render them into consciousness.

In *Time and Free Will*, Bergson uses this now famous metaphor to explain multiplicity:

> Let us assume that all the sheep in the flock are identical; they differ at least by the position which they occupy in space, otherwise they would not form a flock. But now let us even set aside the fifty sheep themselves and retain only the idea of them. Either we include them all in the same image, and it follows as a necessary consequence that we place them side by side in an ideal space, or else we repeat fifty times in succession the image of a single one, and in that case it does seem, indeed, that the series lies in duration rather than in space. (Bergson, Time&Free Will 1913, 77)

Bergson's multiplicity comes in two kinds, quantitative and qualitative (objective and subjective). Quantitative multiplicity is applicable to material objects that can be counted

whereas the multiplicity of intuition is qualitative in nature and can only be rendered quantitative or objective through an effort of symbolization, extraction, and simplification. This notion of qualitative multiplicity refers back to the two types of time, which are not normally perceived as such since they are inextricably combined within this composite.

Bergson makes frequent metaphorical references to music in his writing that illustrate multiplicity in two ways: through the fact that melody only exists due to the memory of preceding notes combining with the note actually being played and also in polyphonic or multi-timbral music through the ever-changing and qualitative encounters between different streams or strands of sound. I will show how a comparable process of dynamic unfolding has become a central concept in the compositional process of *RoadMusic*.

1.2.2. Daniel C. Dennett

If Bergson reflects on the fundamental nature of time and from there the multiplicity through which we experience it, Daniel Dennett is more concerned with the nature of the narrative of conscious thought and how it is constructed. In the context of this research, I draw a parallel between these two fluxes and respectively, those of data capture by *RoadMusic's* sensors (immediacy) and the resulting 'orchestrated' music (narrative). I am above all interested in Dennett's theory as a possible example of a system that constructs intuitively comprehensible narrative in real-time.

In *Consciousness Explained* (Dennett, 1991), Dennett proposes a model for the way in which consciousness works by gleaning resources from a diversity of fields ranging from philosophy to neuroscience. Dennett claims that no single theory from any one of these fields provides a satisfactory explanation for the enigma of consciousness and that instead they 'shift the responsibility' at the crucial moment. Several years later in 2003 Dennett wrote *Freedom Evolves* (Dennett, 2003) possibly as a response to criticism that *Consciousness Explained* failed to take into account the question of free will[10]. He uses

[10] See Marc Slors 1996 article Why Dennett Cannot Explain What It Is To Adopt The Intentional Stance (Slors, 1996). Another testimonial to this debate can be found in John Dupré's 2005 paper You Must Have Thought This Book Was About You: Reply to Daniel Dennett (Dupré, 2005).

examples taken from computer science and game theory to provide insight into the possible 'mechanics' of free will and creativity.

Heterophenomenology

Dennett discredits what he considers a widespread belief in Cartesian dualism: the material body and the immaterial mind. According to Dennett, Descartes' hypothesis that there is a central understander, independent from the rest of the body, remains firmly entrenched in our culture (even if we no longer imagine that it is separate from our bodies and accessed through activity of the pineal gland[11]). This virtual projection room or 'mind's eye' for which Dennett coins the term 'Cartesian Theatre' (Dennett, Conciousness Explained 1991, 17) would be the place where our mind connects to our soul. Dennett's argument against this dualism is that there is no one to watch this virtual screen: no internal organ and no external entity that that could possibly account for this eye. The epistemological position that we identify as phenomenology poses a fundamental problem in that it is not verifiable. Each person's phenomenology is only really known to himself or herself and it is impossible to create a scientific method from the first person singular perspective. Dennett's counter proposition then is heterophenomenology which uses a subject's own narration of their consciousness as a basis for investigation.

> ... We have developed a neutral method for investigating and describing phenomenology. It involves extracting and purifying texts from (apparently) speaking subjects, and using those texts to generate a theorist's fiction, the subject's heterophenomenological world. This fictional world is populated with all the images, events, sounds, smells, hunches, presentment and feelings that the subject (apparently) sincerely believes to exist in his or her (or its) stream of consciousness. Maximally extended, it is a neutral portrayal of exactly what it is like to be that subject – in the subject's own terms, given the best interpretation we can muster (Dennett, Conciousness Explained 1991, 98).

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[11] "Experience shows this in the case of language. Words produce gland-movements that nature has ordained to represent to the soul only their sounds (spoken words) or shapes (written words); but because we have acquired the habit of thinking of their meanings when we hear or see them, that is what our thoughts go to the meanings, not the sounds or shapes when we see or hear those words" (Descartes 50).

The truthfulness of the version provided by the subject is not essential to heterophenomenology since it is how this version gets constructed and not its veracity that is under investigation. In fact, since there are good reasons to suppose that the normal functioning of our consciousness is to focus, edit, interpret and fill in the gaps of our perception, the very notion of a 'truthful version' is inappropriate. This can be demonstrated experimentally by creating apparent motion from still images, known as the *phi* phenomenon (Wertheimer 1912). In a simple version of the phi experiment, a red dot flashes briefly on the left side of a screen and then a (completely separate) green dot flashes on the right side of the screen. A subject, asked to recount what they have seen, describes seeing a dot move across the screen from left to right changing colour in the middle. In Chapter Three (3.3. ASA And Gestalt) I will discuss how similar phenomena can be ascribed to audio perception.

Multiple Drafts Model

Dennett explains the *phi* phenomenon with his 'Multiple Drafts Model' (Dennett, Conciousness Explained 1991, 101 138), according to which all varieties of thought or mental activity are accomplished in the brain by parallel, multi-track processes of interpretation, elaborating data from multiple sensory inputs. Information entering the nervous system is under continuous 'editorial revision' so the red spot turning green can be re-written as needed in the mental process. There is no more a specific time than a specific place when content becomes conscious. There is no 'finish line' where / when different processes converge to create conscious thought. Sensory stimuli evoke brain events which become reinforced, confirmed or transformed by other events, to create increasing specificity, this in turn causes decisions or judgments which lead to further discriminations (such as recognition) used by multiple parts of the brain in different ways at different times. These discriminations are not grouped together in some specific centre of the brain, but are rather used as needed to provoke behavioural patterns, emotional reactions, and semantic readiness. 'They yield over the course of time, something rather like a narrative stream or sequence (Dennett, Conciousness Explained 1991, 113).' This narrative is subject to continual editing (by these distributed processes), and continues indefinitely into the future. Because these discriminations take place at different levels of analysis, perform different functions and can participate in multiple strands of the narrative, the appearance of discrimination within the stream of consciousness does not necessarily take place in the same chronological order as that of the original inputs. Probing of these strands takes place on different timescales with different requirements in

terms of rapidity, accuracy or interpretation, thus fold backs or kinks in conscious time are possible.

Freedom And Evitability

What is the purpose or evolutionary benefit of this editorial purpose? According to Dennett, knowing what has just happened is of relatively small worth for survival and the role of consciousness is more about predicting the immediate future. This requires that our fictional narratives manipulate time to produce future. In *Freedom Evolves* (Dennett, Freedom Evolves 2003), Dennett uses the example of a computer game called *Game of Life* invented in the 1960's by British mathematician, John Horton Conway. The game consists of a grid on which designs made of groups of black cells evolve automatically by following simplistic rules of survival:

1. *Survivals*. Every counter with two or three neighboring counters survives for the next generation.
2. *Deaths*. Each counter with four or more neighbors dies (is removed) from overpopulation. Every counter with one neighbor or none dies from isolation.
3. *Births*. Each empty cell adjacent to exactly three neighbors–no more, no fewer–is a birth cell. A counter is placed on it at the next move. (Gardner 1970)

These rules determine at each 'tick' whether a cell will 'survive' or not. The user creates groups of cells that then evolve, duplicating (reproducing), disappearing (dying), and absorbing (eating) each other.

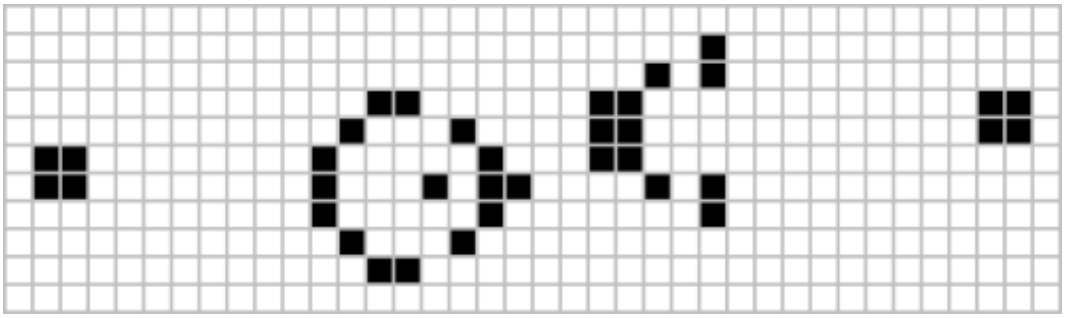

Figure 1-1: Screen shot of Game of Life design.

Their behaviour and their capacity to survive depends on the initial shape of the group, it is possible to design shapes that have a better chance of survival than others. The *Game of Life* designer can learn 'tricks' in terms of good shapes to add to a design, which will probably help it to survive for longer. What interests Dennett is the fact that in this totally determined environment the outcome is not inevitable; that it is possible to design 'evitability'. This proves that determinism and inevitability do not go as a pair, and that 'evitability' can exist in a deterministic system. Avoidance therefore is something that can take place at the 'design level' and with the help of a little 'noise' –random elements in a system– this design can be enabled to evolve automatically.

In humans, the capacity for avoidance has developed through evolution as a good 'trick' for survival. It has made us experts in prediction; we use our capacity to project what *would* happen, to avoid things that might harm us:

> We are virtuoso avoiders, preventers, interferers, and forestallers today. We have managed to get ourselves into the happy situation of having enough free time to sit around systematically looking into the future and asking ourselves what to do next (Dennett, Freedom Evolves 2003, 54).

This gives us the basis of what free will is for, where it comes from and how it works. It also establishes that indeterminacy is not necessary for free will to exist, and that determinism does not necessarily imply inevitability. In fact according to Dennett that the world is deterministic or indeterministic makes no difference (to our lives). As I will show in Chapter Three, our auditory sense and musical emotion in particular is directly dependant on principles of anticipation. By extension, it is important pertaining to *RoadMusic* that what Dennett here calls 'free will' can be generated in real-time from a mechanistic system responding to a minimal variable input.

Memes And The Joycean Machine

Going back to the multiple drafts model, there is an element participating in the construction of our narratives that cannot be ignored, which is that of cultural influence. Dennett caters for this with 'meme theory'. Originally developed by Richard Dawkins in "*The Selfish Gene*" (Dawkins 1976). I will sum this up through a simple metaphor. Consider the human brain as a computer interfaced with the world and with a basic DOS (disk operating system) which runs low level functions. Memes then would be the high level programs which are installed on the machine and which work in the foreground,

they would participate in the user accessible part of the computer and exploit its lower level functionality. Memes (ideas, beliefs or inventions) permeate human society through different vectors such as media, evolve and mutate independently from human will and human evolution. This is Dawkins' original definition of memes:

> Examples of memes are tunes, ideas, catch phrases, cloths, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation… (Dawkins 1976, 206).

The computer analogy described above might make it sound as if the brain is a neatly organized, permanently structured machine on which fixed meme programs run, this is (obviously) not the case. Our brains are plastic and they adapt to and interact with the memes they encounter.

Dennett uses the term Joycean[12] machine when describing how the complex levels of the multiple drafts theory come to appear to us as a single narrative or *stream of consciousness*. Dennett evokes *pandemonium selection*[13] to account for the way in which strands of consciousness battle it out, make them selves heard or indeed disappear without trace. According to Dennett the resulting stream of consciousness is literally talking to ourselves: it is a way of using our powers of language and reasoning to memorize, to evoke and / or reinforce certain mental patterns that negotiate with and participate in the pandemonium. Our stream of consciousness then is far from being our

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[12] derived from Joyce James (1882-1941).

[13] 'Pandemonium Selection : For Pattern-recognition problems (such as identifying faces, printed characters, land terrains, fingerprints, blood cells, etc.), we need to break down higher-level decisions (e.g., what letter this is) into lower level ones. If we design "demons" (algorithms) to answer the low-level questions, we can use their answers to make a final decision. One approach is to invite the demons to a "meeting." We then ask, Is this letter an A? and determine how loud the demons shout. We go through all of the possibilities in the "identification set" (B,C, etc.) and pick the one that causes the demons to voice the strongest approval. Some of the low-level questions are more important than others, and thus some of the demons are more influential (that is able to shout louder) than other demons. The demons also control how loud they shout by how sure they are in answering their lower-level question (Kurtzweil 142).'

complete mental process and neither is it a canonical directive system telling the rest of us what to do. Rather, it is one among many mechanisms that participates in our cognition and behaviour. Dennett's philosophy is partly derived from AI (Artificial Intelligence) and computationalism and inversely it is possible to transpose at least some of the basic principles of multiple *draft theory* as computer programs. The specific ways in which *RoadMusic* uses such principles will become clearer as this thesis progresses but firstly I wish to consider the ways in which Bergson's and Dennett's fluxes converge and diverge.

1.2.3. From Élan Vital To Computationalism

What Flux? What Consciousness?

The mobility of flux is essential to the practice that I am developing - without it *RoadMusic* does not exist, before the car is switched on and starts to move there is no sound in the system, only an empty program. The study of these two philosophers reveals two very different notions of flux: *Duration* and the *Joycean Narrative*. How do these two flux relate to each other and how do they relate to my practice?

At first glance, it might seem that comparing Dennett with Bergson might be somewhat futile – they certainly come from very different schools of thought. In fact I'm not sure that a comparison is exactly in order since the two philosophers' starting points and aims are so different. One might say that one starts where the other leaves off and that where one works from the bottom up the other works from the top down. The heterophenomenology which Dennett studies corresponds to that part of consciousness which Bergson tends to dismiss as the fruit of convention, and at no point does Dennett, for his part, propose his theory as ontology. I should reiterate that my aim in this chapter is twofold. To gain a better understanding of the fundamental nature of time and immediacy and to construct the conceptual basis of a system that can transform this immediacy into art. Bergson's ontology provides some answers to the first part of this quest and the ways in which the human mind constructs its flow of consciousness offer a possible starting point for the second.

If Bergson and Dennett start from opposite poles, there are some notable overlaps occurring precisely in the area that is of most interest to me in this work. That is to say, the articulation or what Bergson calls the expansion, where immediate becoming is transformed into experience or where the raw data of lower levels of perception is transformed into 'understood' information. Surprisingly perhaps, as I shall try to show, where these overlaps do occur, the two theories tend to agree and, although I rather doubt whether either party would concur, I find some complementarity in these two positions.

Bergson	**Dennett**
Virtual	
Intuition	
Perception/Affection (mobility)	Parallel Pandemonium
Multiplicity/Memory	Multiple drafts theory/ behaviour
	Joycean machine
Ready-made concepts	Memes

Figure 1-2: A summary of parallel levels of consciousness covered by Bergson and Dennett.

Ontology

Bergson's development of intuition is a step towards an ontology in which his identification of a dimension of time is central. In his book *Bergsonism*, which has largely participated in a re-awakening of interest in Bergson's writing, Gilles Deleuze demonstrates how the whole of Bergson's writing converges in this idea of intuition as a scientific method (Deleuze 1988). As mentioned above, Bergson's theories have been criticised by some as being unscientific. Deleuze demonstrates that what first appear as contradictions or ambiguities in the writing actually articulate coherently within the (highly complex) scheme of multiplicities and differences in kind:

> Intuition is the method of Bergsonism. Intuition is neither a feeling, an inspiration, nor a disorderly sympathy, but a fully developed method, one of the most fully developed methods in philosophy. It has strict rules, constituting that which Bergson calls "precision in philosophy". (Deleuze 1988, 13)

As Jonathan Crary points out in *Suspensions of Perception*, (Crary 1999, 319) Bergson's flux is hypothetical in nature. He is aware that is not possible to attain the pure perception that he describes as intuition and concedes that our consciousness is necessarily a limited, filtered and constructed version of. Intuition then is an ideal towards which he suggests we should strive. Crary suggests that Bergson's writing was a response to the general standardization of experience and automation of perceptual response at the turn of the century. If so, in *An Introduction to Metaphysics*, Bergson is not attempting to give an explanation of consciousness; rather he is advocating a doctrine of introspection. He is inciting us to delve *beneath* the surface of our consciousness and to go beyond the formatting of modern society (viewed from Dennett's perspective this might be considered as an attempt to counter the dominance of memes). That having been said, if there is spirituality, it takes the form of a monism:[14] *élan vital*, which is within the person and extends from the person. According to Bergson's theory of intuition, all things open to and thus 'virtually'[15] possess all the complexity of the cosmos. It is our consciousness, our free will –which comes about through our mobility– that modifies and limits how we perceive (mobility refers her to any intervention, cerebral or other in between the object and the way in which we perceive it).

> As my body moves in space, all the other images vary, while that image, my body, remains invariable. I must therefore make it a centre, to which I refer all other images. (Bergson, Matter&Memory 1912, 43)

> My body, then, acts like an image, which reflects others, and which, in so doing, analyses them along lines corresponding to the different actions, which it can exercise upon them. And, consequently, each of the qualities perceived in the same object by my different senses symbolizes a particular direction of my

[14] Monism as opposed to dualism, which would incorporate the existence of an external vital force separate from the body: God or soul.

[15] Bergson uses the term virtual to designate the presence of all things from all points of view in the cosmos. This virtuality is reduced to actuality by our perception.

> activity, a particular need. Now, will all these perceptions of a body by my different senses give me, when united, the complete image of that body? Certainly not, because they have been gathered from a larger whole. To perceive all the influences from all the points of all bodies would be to descend to the condition of a material object. Conscious perception signifies choice, and consciousness mainly consists in this practical discernment (Bergson, Matter&Memory 1912, 46).

We can conclude that Bergson's ontology accommodates metaphysics in a method by taking a new dimension –that of instantaneous *duration* as opposed to limitless space and time– as the only absolute and by situating self as the epicentre of this becoming. He does not exclude science (which uses only symbolised time and therefore the spatial dimension) from this ontology rather he considers that it has to be completed by intuition:

> science is part of ontology, it is one of ontology's two halves (Deleuze 1988, 35).

Élan Vital

Daniel Dennett's arguments are largely constructed on a computationalism that finds its origins in positivism, naturalism and AI. An atheist and virulently anti-religious, his recent publication, *Breaking the Spell, Religion as a Natural Phenomena* uses the meme theory to explain the evolution of religion. He makes occasional references to *Vitalism* that are far from complimentary:

> …the recursive intricacies of the reproductive machinery of DNA make élan vital about as interesting as Superman's dread kryptonite. (Dennett, Conciousness Explained 1991, 25)

I cannot help wondering if Dennett studied Bergson's concept of élan vital in sufficient detail before forming this opinion. The term has taken on a quasi-religious overtone, possibly because Bergson himself towards the end of his life incorporated religion into his theory, suggesting that mystics and artists were expert representatives of élan vital (Deleuze 1988, 112). This is how Deleuze (re) defines Bergson's élan vital:

> But, as we have seen, it is the whole of memory that descends into this (cerebral) interval, and that becomes actual. It is the whole of freedom that is actualized. On man's line of differentiation, the élan vital was able to use matter to create an

> instrument of freedom, "to make a machine which should triumph over mechanism," "to use the determinism of nature to pass through the meshes of the net which this very determinism has spread." Freedom has precisely this physical sense: "to detonate" an explosive, to use it for more and more powerful movements. (Deleuze 1988, 107)

This is how Dennett explains the way in which freedom is present on the different levels of the *multiple drafts*. I am not convinced that they are so very different:

> Then we can see that our free will, like all our other mental powers, has to be smeared out over time, not measured at instants. Once you distribute the work done by the homunculus (in this case, decision-making, clock-watching and decision simultaneity judging) in both space and time in the brain, you have to distribute the loop. You are that large. You are not an extensionless point. What you do and what you are *incorporates* all these things that happen and is not something separate from them. Once you can see yourself from that perspective, you can dismiss the heretofore compelling concept of mental activity that is *un*consciously *begun* and then only later "enters consciousness". (Dennett, Freedom Evolves 2003, 242)

Consciousness

Bergson, at least in his earlier writings, tends to use the term consciousness to designate different things. In *Time and Free Will* he refers to 'pure' consciousness as he refers to 'pure' perception or 'pure' duration – to designate 'lower levels' of being (I use the term as it exists in computer terminology where lower and higher refer to degrees of elaboration or abstraction). It is later that he adopts the term 'intuition' (specifically in *An Introduction to Metaphysics*) and adapts the word to his needs. From that point tending to use the term consciousness only to designate what we are aware of. If, as proposed above, Bergson was essentially striving towards ontology this does not preclude the fact that he was extremely well versed in the workings of the mind from the point of view of hard science. In *Matter and Memory*, for example, he makes ample reference to research of the period into the functioning of the brain and nervous system.

Dennett introduces consciousness with an example of his own musings. He is sitting in a rocking chair listening to music and gazing out of the window at swaying branches. He finds himself fascinated by an apparent synchronicity, which has become established

between the music, the swaying of the branches, and a visual distortion created by a combination of variations in thickness of the glass of the pane and his own rocking.

> However, these musings were interrupted in turn by an abrupt realization. What I was doing –the interplay of experiencing and thinking I have just described from my privileged, first person point of view– was much harder to "make a model of" than the unconscious, backstage processes that were no doubt going on in me and somehow the causal conditions for what I was doing. Backstage machinery was relatively easy to make sense of; it was the front and centre, in the limelight goings on that were downright baffling. (Dennett, Conciousness Explained 1991, 26)

Dennett is above all interested in an epistemological explanation of the end result of consciousness, the ultimate internal monologue and how we arrive at it. Bergson and Dennett have (literally) opposite approaches in the sense that they start from opposite ends of the scale of perception. In *Matter and Memory,* Bergson develops his theory of mind from a hypothetical "pure" perception –perception without the intervention of memory. He starts by affirming that this perception is of reality. The object that creates a pattern on our retina is really present in front of us; our perception of that object is the reality of the object, plus our retina, plus our nervous system (so we participate in the reality of this perception).

It is through the 'cerebral interval' (Deleuze 1988, 24) that we abstract from the virtually complete 'image' only that which is of interest to us. To this Bergson adds the idea that extension of perception, within our bodies and beyond, takes place through affect. In *Time and Free Will,* Bergson proposes that varying magnitude of sensation has evolved to provide us with the capacity to resist automatic reaction (the naissance of free will). Thus, rather than the affective state being hardwired to an external stimulus (as it would be the case of pure perception) it is rather a projection of what our subsequent reaction to that stimulus will or could be:

> …the sketching, and, as it were, the prefiguring of the future automatic movements in the very midst of the sensation which is being experienced. (Bergson, Time&Free Will 1913, 34)

This is an extract from Dennett's *Consciousness Explained*:

> The brain's task is to guide the body it controls through a world of shifting conditions and sudden surprises, so it must gather information from that world and use it swiftly to "produce future" – to extract anticipations in order to stay one step ahead of disaster. (Dennett, Conciousness Explained 1991, 144)

So on this point the two philosophers would seem to agree.

For Bergson the stimulus itself is constructed from the inside outwards –our perception of pain for example, would be the gradual calling into action of an expanding area of the body that in turn creates physical sensation. Unlike automata or lower life forms where a stimulus generates a direct reaction, we have an intermediate level where sensation is constructed and therefore free will can intervene. Imagine, for example, the transition from the perception of the touch of a pin on the palm of the hand to the incorporation of affect, of pain that spreads through a large and still larger part of the body as the pin is pushed deeper into the flesh. Bergson argues that if perception works this way for pain, why would it work fundamentally differently for more subtle perceptions?

Things are complicated considerably with the introduction of memory into this equation. It is important not to lose track of the idea that we are referring to something that Bergson considers as being of a different nature to that of 'pure' perception (intuition) where there can only be movement and materiality. Perception is complicated by memory in two different ways: firstly, there is the transformation of the passing moment into memory; and, secondly, there is the weight of the whole of memory which exists as states of contraction and expansion, contracting to the point of real time and expanding to become matter. Our overall perception however is not given to us as these separate kinds; it combines in the moment of becoming as a multiplicity where pure duration and memory are mingled and interdependent. Furthermore, this final result, this consciousness is constructed according to its usefulness.

> …Actual consciousness accepts at each moment the useful, and rejects in the same breath the superfluous. Ever bent upon action, it can only materialize those of our former perceptions which can ally themselves with the present perception to take a share in the final decision (Bergson, Matter&Memory 1912, 188).

Now this sounds rather similar to Dennett's multiple drafts theory. Therefore, when Bergson tackles more concretely how consciousness (as opposed to intuition) works, his theory heralds that put forward by Dennett. It invokes the idea of a mental construction

within which we make interpolations thus generating past present and future and in regards to this research it is a starting point from which to think about creating artistic form in real time.

It is also noteworthy that Dennett's multiple draft theory, which is the substratum to the *flow of consciousness* or what he calls the *Joycean Narrative*, is somewhat reminiscent of Bergson's multiplicity of intuition:

> when I replace myself in duration by an effort of intuition, I immediately perceive how it is unity, multiplicity, and many other things besides. (Bergson, Metaphysics 1912, 31)

So maybe the two philosophies are not as opposed as they at first seem when we look more closely at what they actually mean by consciousness and possibly those differences that exist are more to do with ideology than with scientific construction.

Bergson's intuition is in opposition to Dennett's heterophenomenology in that Bergson maintains that the only absolute being we can experience is the intuition of our own flux. For Dennett the only objective research material we have concerning consciousness is the account, the narration of that consciousness that an agent is willing to give us. Further as far as Dennett is concerned, it makes no fundamental difference whether this account is given by a human or by a talking machine. These two different fluxes might also be considered as the outer limits of our consciousness, at least if one considers consciousness as stopping at self.

Beyond self on Bergson's end of the spectrum there is the virtual that is to say: non-interpreted, non-filtered, non-captured everything. Virtual is the unlimited dimensions, and infinite points of view contained in the cosmos –in everything, since everything is interconnected. What we experience through consciousness is filtered and constructed of the virtual. On the other end, at Dennett's end of the spectrum, we find memes, the programs formatting the human mind, the parasites for which we are the hosts. Memes evolve independently of our individual selves, surfing on our society and our technologies: the 'memosphere'. In regards to my artistic practice and the second aim in pursuing this research, that of formulating a conceptual model for an art of real time flux, things are starting to fall into place. If I take the articulation from Bergson's expansion of the virtual, through perception, through multiplicity or multiple drafts (formatted by memes) to create a flow of consciousness. I might then extrapolate this in computer

technology as follows: exterior, capture of data through sensors, multi-track real-time interpretation of that data (through programs or routines) to create a continuous multiplicity of musical narrative.

Dennett's multiple drafts theory proposes a way in which otherwise senseless data can be 'composed'; take on form while never being fixed. His hypothesis provides an alternative to the supremacy of the final version (the finished work), which is part of what I am looking for. I can develop from it a method for 'being' in duration while incorporating the higher levels of symbolization of an artwork. There are still some missing elements, which I will now underline and which I will develop in the next section of this chapter.

Is Self The Limit?

By centralizing flux within the person, both Bergson and Dennett fail to include the exterior. Bergson's 'élan vital' does take into account the rest of the cosmos, through the all-embracing 'virtual' that I described above, but considers that we can only be aware of a tiny fraction of it; the part that we 'ping'[16] so to speak. He also provides for a connection with others and the outside world through sympathy (Bergson, Time&Free Will 1913, 12). But Bergson's sympathy is a purely human thing: it does not include the human individual in the rest; it works from the inside towards the outside. It provides a way of incorporating the outside world into self through affect but it fails to provide the continuum between self and the environment, which I would tend to include in my idea of sympathy and all importantly, in our relationship to our audio environment. Dennett's theory also has this shortcoming. His adoption of Dawkins' theory of memes does, in a certain manner, include self in an exterior and provides a certain concept of environment but memes belong only to human communication.

Both Bergson and Dennett are human-centric. If Dennett in *Freedom Evolves* discusses dimensions of the universe and determinacy, it is ultimately to point out that it makes no difference to our perception of our (materialistic) world. In order to make art which is based on real time, as is the case with *RoadMusic,* it is necessary to prolong Bergson's intuition of real time beyond purely human perception otherwise it will not be possible to admit that this artwork can participate (actively) in that perception.

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[16] Computing query (another computer on a network) to determine whether there is a connection to it. (Oxford)

If, as Crary suggests, Bergson's theory was essentially a criticism of media systems at the advent of their industrialization at the turn of the 19th century, perhaps he failed to see that it was the appearance of these media systems –the very existence of alternatives to human perception capable of capturing sound and image– which provided him and other contemporary thinkers with the possibility to theorize flux of time and of space. Bergson's theory fails to take into account the diversity of flux: if the measurements taken of the trajectory of the arrow cannot create or effectively represent the flux of that arrow, they can create a new temporality and thus a new flux. However most importantly in regards to this thesis, if Bergson's metaphors of flux are both beautiful and inspirational, Dennett's 'Joycean Machine' provides a possible method for composing with flux; a seamless articulation between human consciousness, media and the machine. Surprisingly his multiple drafts theory is relatively close to the way in which I have been intuitively designing my programs. In the next section, I will consider two theories that propose an extension of flux from self to environment that will provide me with the opportunity to include an artistic device as part of this flux.

1.3. Flux And Environments

The aim of this section is to go beyond the human perspective, to investigate theories of flux that operate on a scale larger than that of the individual or his / her consciousness: if my artistic project is to function other than as an external object, it is conceptually necessary that it incorporates and is incorporated into flux. I will consider two approaches: Gregory Bateson's approach to Cybernetics, which evolves towards a 'global mind' and Henri Lefebvre's 'rhythmanalysis' which proposes rhythm as a scientific method. If cybernetic theory and rhythmanalysis owe a debt to Bergson's theory, they both propose an evolution from his essentially linear time to include periodicity. Whether it is called 'feedback', 'recurrence' (Bateson) or 'rhythm' (Lefebvre) this generates difference, and thus meaning, through the very fact of its repetition or looping.

1.3.1. Norbert Weiner, Gregory Bateson – Cybernetics And Environment

Norbert Wiener first gave the modern definition of the term cybernetics[17], in the title of his book published in 1943: *Cybernetics or control and communication in the Animal and the Machine* (Weiner 1948/1961). Self-governing systems have existed since antiquity when Ktesibios invented the first water clock, and in his 1858 correspondence with Charles Darwin, biologist Alfred Russell Wallace identified a resemblance between the principle of natural selection and that of the governor (the fuel regulator system) of a steam engine (thus breaching the divide between the living and the mechanical). However, it is Weiner and group of scientists including mathematicians, physiologists, psychologists and sociologists who established Cybernetics as a fully-fledged multidisciplinary theory.

The focus of cybernetics is information carried by objects and events. Cybernetics studies systems, in particular systems where a feedback loop can be identified. From the cybernetic point of view certain regions of the interconnected universe can be considered as closed systems (thermostats, ecosystems, societies): it is possible to start anywhere in the circuit and end up at the same point. An input anywhere in the circuit will have an effect on all other points of the circuit later. By extension, previous events will continue to influence the circuit indefinitely (like Bergson's multiplicity). If a random variable is introduced into an otherwise closed circuit, once the seed has been round the circuit it will have been modified by it, therefore its influence on the point of entry is no longer random. From randomness, the circuit produces non-randomness or information; this is the cybernetic notion of feedback.

In the first chapter of *Cybernetics: Newtonian and Bergsonian Time,* Weiner invokes the problem that reversible Newtonian time poses when applied to such modern sciences as meteorology and modern evolutionary biology (Weiner 1948/1961, 30-34) and indeed information and communication. 'Within any world with which we can communicate, the direction of time is uniform' (Weiner 1948/1961, 35). He traces the evolution of this question back to Bergson:

[17] from Greek kubernétés 'steersman'

> Bergson emphasized the difference between the reversible time of physics, in which nothing new ever happens, and the irreversible time of evolution and biology, in which there is always something new. The realization that the Newtonian physics was not the proper frame for biology was perhaps the central point in the old controversy between Vitalism and mechanism; although this was complicated by the desire to conserve in some form or another at least the shadows of the soul and of God against the inroads of materialism. (Weiner 1948/1961, 38)

Weiner takes Bergsonian duration –and, in a certain sense, multiplicity– and applies them to systems in general extracting them from the context of purely human existence:

> Thus the modern automaton exists in the same sort of Bergsonian time as the living organism; and hence there is no reason in Bergson's considerations why the essential mode of functioning of the living organism should not be the same as that of the automaton of this type. Vitalism has won to the extent that even mechanisms correspond to the time-structure of Vitalism; but as we have said this victory is a complete defeat from the point of view which has the slightest relation to morality or religion: the new mechanics is fully as mechanistic as the old. (Weiner 1948/1961, 44)

The first concerted development of cybernetic theory occurred in the context of the war effort, in response to the problem of aiming at the moving target of a warplane. In such a situation it is necessary to aim at point where the plane will be by the time the projectile arrives; this problem being complicated by the fact that fighter planes do not always fly in straight lines. This involves curvilinear prediction and as Weiner puts it ‘To predict the future of a curve is to carry out a certain operation on its past’ (Weiner 1948/1961, 6). It is noteworthy that one of the most important first steps towards AI was the recognition of the possibility of predicting the future from past information.

The relationship between context and content is central to cybernetic theory for example; a phoneme only exists to make a word in relation to other phonemes, which word only exists in a sentence, which only exists in a relationship. An example more germane to this research is provided by Roy Ascott’s analysis of the interactive artwork:

> The relationship between the physical space of an exhibition, the technology used to execute the work and the human movement and behaviour patterns that form

> the basis of individual engagement is critical in the development of responsive environments. These elements form a causal loop, that is, a loop in which the only influences are the elements it contains. (Ascott 2006, 141)

RoadMusic is equally in a causal loop which includes the driver, the car, and the experience of the drive.

Bateson's Cybernetics (Steps To An Ecology Of Mind)

To study or design a cybernetic system it is necessary to know the limits of that system. On the other hand, these limits are (ultimately) arbitrary –at least such is the position adopted by Gregory Bateson. Thus if it is possible to consider the human body from the point of view of informational and feedback systems, it is also possible to consider a human within a system and indeed to consider social, economic and ecological systems from a cybernetic point of view.

> If we now correct the Darwinian unit of survival to include the environment and the interaction between organism and environment, a very strange and surprising identity emerges: *the unit of evolutionary survival turns out to be identical with the unit of mind.*
>
> Formerly we thought of a hierarchy of taxa –individual family line, subspecies, species, etc.– as units of survival. We now see a different hierarchy of units – gene-in-organism, organism-in-environment, ecosystem, etc. Ecology, in the widest sense, turns out to be the study of the interaction and survival of ideas and programs (i.e., differences, complexes of differences, etc.) in circuits. (Bateson 1972, 491)

If we take the feedback loop described in the second paragraph of this section, we might consider that such circuits are never really closed. They communicate outside of their system: they gain and lose energy and they are influenced by events from the outside. If the random event were an external influence, the system considered as closed would inevitably be integrated into a larger one. Specifically, with *RoadMusic*, which unlike Ascott's example is not installed in an exhibition space, the responsive environment incorporates the indeterminate nature of the route and conditions of the journey.

Bateson's cybernetic point of view is that there is no by-default separation between mind, body and environment, since separations are simply the limits of the system we wish to investigate. He illustrates this with the example of a blind person finding their way with the aid of a cane: should the system be considered to stop at the person's brain, at their hand, or at the tip of the cane? If we are interested in the blind person's trajectory then we need to consider the system created by the path, the cane and the blind man and this as a continuously updating feedback loop. I will show in Chapter Five that it is possible to break *RoadMusic's* program down into a multitude of small units, which can be considered as independent cybernetic entities; feedback loops with input provided by the route. It is equally possible to consider that road, car, driver, and *RoadMusic* are all within the limits of the system to be taken into consideration, and all participate in the artwork.

Bateson's theory extends the limits of the system under investigation to include humans in the environment as a single cybernetic system or a "global mind". This has been an important contribution to the development of 'ecological' thinking. Bateson considers that we have created disequilibrium within the natural balance of ecology through of our 'sense of purpose' or the drive that makes us find, learn and transmit to others good ideas that empower us and help our survival. In keeping with Dennett's evitability or Bergson's freewill, sense of purpose is one of the major reasons why our consciousness exists. However for Bateson, it is by its very design blind to the systemic nature of our existence, and, empowered by modern technology, it is leading us to a situation where we are rendering our environment unliveable.

Personally, I do not believe that the use of technologies will necessarily lead us to disaster. However, using them in a more systemic way is an idea that I consider is worthy of investigation, indeed if one follows Bateson's logic one might consider that the influence of *RoadMusic* extends beyond the car to other road users since, arguably, it modifies the driver's perception and thus his or her driving. I will discuss this in more detail at the end of Chapter Five. Beyond my own production, many sonification artworks are extended by integrating external data; examples of such works where the system of the artwork is incorporated into a cybernetic larger whole will be discussed in Chapter Four.

1.3.2. Henri Lefebvre - Rhythmanalysis

Lefebvre posits that rhythm is a fundamental aspect of time and space that no philosophy tackles in detail[18]. For Lefebvre rhythmanalysis can be applied to all things and (importantly, in relation to this research), rhythm transcends thought and things, to accommodate the sensible in a continuum from the human body, through the everyday to underlying social and political structure. The idea that rhythmical measure can be applied universally and thus short circuit dualisms such as mind and body, body and environment, sensible and intellectual is a valuable contribution to these ideas about flux that are central to my thesis.

Although Lefebvre mentions Bergson only in passing, his theory certainly seems to use Bergson's multiplicity of numbers albeit with the important addition of repetition. Lefebvre insists on the co-existence of repetition and difference in a series of integers and develops this to demonstrate that even a simple form of repetition such as counting, will give rise to an event. Unlike Bergson and in common with Bateson, Lefebvre considers that if rhythm applies to human self –his explication of consciousness is similar to the Bergsonian structure of intuition and memory– it can equally be applied to all things. His explication of measure and rhythm is similar in essence to the cybernetic principle of redundancy and feedback:

> No rhythm without repetition in time and in space, without reprises, without returns, in short without measure. But there is no identical absolute repetition, indefinitely. Whence the relation between repetition and difference. (Lefebvre, Rythmanalysis 2004, 6)

> Differences appear immediately in this sequence: odd and even (2, 3, 4, 5, etc.) divisible (4, etc.), indivisible or prime (5, 7, 11, etc.). Not only does repetition not exclude differences, it also gives birth to them; it produces them. Sooner or later it encounters the event that arrives or rather arises in relation to the sequence or series produced repetitively. In other words: difference.

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[18] he does however, credit Lucio Alberto Pinheiro dos Santos (Santos 1931) for the invention of the word rhythmanalysis and Gaston Bachelard with re-using it (Bachelard 1949)

> Does it not permit the following, highly significant formulation (affirmation): 'Differences induced or produced by repetitions constitute the thread of time'? (Lefebvre, Rythmanalysis 2004, 7)

If rhythm occurs spontaneously and thus undefined by human rules, the very existence of rhythm implies measure, a rule or scale by which the rhythm is assessed. He proposes that through this *measure,* rhythm unites qualitative and quantitative aspects and elements. It is similar to Bergson's cerebral interval where the virtual (everything) is filtered by our consciousness at different levels, however measure is not a purely mental or human question and importantly I can consider it as a way of creating form from immediacy or of 'mediating the situation as it unfolds'.

The Rhythmanalyst

In *The Rhythmanalyst A Provisionary Portrait* (Chapter Two), Lefebvre introduces a hypothetical character the 'rhythmanalyst' whose role it is to listen to the world and discern its rhythms. The rhythmanalyst starts by listening to the rhythms of his body, and through this becomes able to distinguish the 'eu-rhythmia' of all different body functions and discern 'arrhythmia' within them (disequilibrium which would tend towards pathologies). If Lefebvre compares rhythmanalysis to psychoanalysis, it seems to be more closely related to yoga, meditation or other 'holistic' practices, requiring awareness of the internal flow of the body. He does make a fleeting reference to such practices:

> All sorts of already known practices, more or less mixed up with ideology, are similar to it and can be of use: the control of breathing and the heart, the uses of muscles and limbs, etc. (Lefebvre, Rythmanalysis 2004, 20)

The rhythmanalyst he explains extends this 'listening' to the external environment:

> The rhythmanalyst will not be obliged to jump from the inside to the outside of observed bodies; he should come to listen to them as a whole and unify them by taking his own rhythms as reference: by integrating the outside with the inside and visa versa.
>
> For him nothing is immobile. He hears the wind, the rain, storms; but if he considers a stone, a wall, a trunk, he understands their slowness, their

> interminable rhythm. This object is not inert; time is not set aside for the subject. It is only slow in relation to our time, to our body, the measure of rhythms.
>
> ...The rhythmanalyst calls on all his senses. He draws on his breathing, the circulation of his blood, the beatings of his heart and the delivery of his speech as landmarks. Without privileging any one of these sensations, raised by him in the perception of rhythms, to the detriment of any other. He thinks with his body, not in the abstract, but lived temporality. (Lefebvre, Rythmanalysis 2004, 20 21)

It is perhaps such a 'lived temporality' that I am striving to achieve in my practice. In Chapter Five, I will describe how I and other people who have experienced *RoadMusic* get a 'subliminal' sense of the journey through the generated music.

Media

Lefebvre opposes the concept of the present and that of presence. The present he argues is the domain of objects, and he includes images in this category. Presence, on the other hand, is rhythm into which presents are incorporated. This dichotomy is similar to Bergson's 'time' and 'duration', however Lefebvre adopts an overtly socially and political position, the 'everyday' replacing self as the point of reference[19]. 'He will come to 'listen' to a house, a street, a town as an audience listens to a symphony (Lefebvre, Rythmanalysis 2004, 20 21)'. As implied by the opening statement to this thesis, incorporating the everyday is an important part of this research and I will show in Chapters Two and Four that a similar transfer can be identified in contemporary music and continues through the practice of artistic sonification.

Lefebvre guards against false presence, notably in the form of media, which he describes as 'present simulating presence'. Media (in the sense of mass media) are simulacra of presence and producers of media are experts in the construction and manipulation of rhythms (leading to the passivity of the audience). Not only do media destroy dialogue they also replace immediacy and its unfolding. As I understand it, Lefebvre's vision of

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[19] It is important to place Lefebvre's work in its historical context. Although *Rhythmanalysis* was published in 1991, the main corpus of his ideas was developed in the 1950's and 60's – Derek Shilling discusses this appearance of the notion of 'the everyday' in his 2003 essay *Everyday Life And The challenge to History in Postwar France – Braudel, Lebfevre, Certeau* (Shilling, 2003).

media is that is of a consumerist flux (such as the permanent watching of television). It is a cheap simulation of presence that fills in for or masks the 'quality' rhythms of existence, a kind of rhythm ‘candy’ so to speak. It is important to place this in the context of the ‘one to many’ media environment of the time at which Lefebvre was writing, however, if his position might be considered dogmatic, part of my concern in creating *RoadMusic* is to provide a media (or at least mediated) experience which does not operate in disjunction with the everyday.

Lefebvre develops in some depth the way in which he considers rhythm can be related to social and political ideas. This is beyond the scope of this thesis but it is worth underlining that his ideas concerning a sensible and corporeal experience through rhythm extend to include ideologies.

> If there is difference and distinction, there is neither separation nor an abyss between so-called material bodies, living bodies social bodies and representations, ideologies, traditions, projects and Europa. They are all composed of and (reciprocally influential) rhythms in interaction. (Lefebvre, Rythmanalysis 2004, 43)

Lefebvre does not refer to musical rhythm (other than in passing) until the final chapter of *Rhythmanalysis*. Possibly the contrary would have eclipsed the concept of rhythm as a fundamental measure of all things. Since the musicological ideas he develops are of little relevance to this thesis I will not dwell on them here.

Lefebvre and Bateson were both politically engaged, and though in very different ways, offered their theories as alternatives to capitalism, greed and consumerism. Lefebvre persists in the Marxist belief that there is a fundamental dysfunction between capitalist society and the needs of the population, it is an ‘arrhythmia’ in need of treatment. Bateson considers that the auto-equilibrating, homeostatic nature of cybernetic systems has been corrupted by empowering human technology that serves ‘purpose’ (self-interest). It is significant that while both have created global theories which include human intelligence as a small part of larger systems, they are developed from a conviction that this intelligence is different from the rest in that it creates disequilibrium. It is not my intention to develop these political aspects, but I should mention that while sharing some of their concerns I do not agree that there is a necessarily dichotomy between art and media, nor between technology and ecology.

1.4. Towards An Art Of Flux

In the following section, I will adopt more personal point of view by explaining what I retain of these different theories of flux and I will discuss what position I consider it is possible to adopt as an artist in the light of these ideas.

On Flux

The implications of Bergson's definition of time, or rather his separation of *pure* time and perceived or symbolized time are fundamental to the works that follow it chronologically. Irreversible time provides the basis on which cybernetics is constructed; in consequence, it is also related to Daniel Dennett's theory of consciousness. I also find useful when thinking about flux to consider that there is a real if imperceptible dimension specific to time, which needs to be considered apart from measured, represented, or conscious time. Probing intuition might be considered as part of my quest in seeking a method of creating art in real-time. However, if Vitalism provides a method that rids us of dualism, at the same time it places self as the unique position from which our universe is perceived. In so doing it fails to take into account the extent to which we modify and are modified by our environment and the feedback loop that this creates: we are not alone and we are in a symbiosis with our environment. That our naturally occurring phenomenological centre moves with our body and that we glean only a meagre representation of the totality of our universe from this position, is undeniable. However, common sense allows that our influence, our place in that world, is not confined to what we perceive.

Cybernetics incorporates Bergsonian time into principles that are non-human, although they do depend on memory. We see how a random event takes on the significance of the circuit into which it is introduced and thus from non-significance, takes on meaning: it tells us something about that circuit. This can be considered as being the same basic operation as élan vital, it produces significance from raw information. It is here that the notion of circularity; of feedback or rhythm takes on all its importance. It is an important extension to Bergson's essentially linear notion of time that developed both in cybernetics and in Lefebvre's rhythmanalysis. On the simplest level, if you read a continuously flowing circuit at a given point, the information that you get will be the accumulation of the successive repetitive tours of the circuit: feedback and rhythm create multiplicity through dynamic memory.

Information, the lifeblood of cybernetic theory, is independent of energy, thus from cybernetics we can bridge the gap between living and artificial, between self and environment. Bateson includes humans as a system, in a system. Our perception becomes a small part of this scheme, which extends simultaneously in all directions. With cybernetics, there is no reason per-se to confine self to the limits of the human body, since there is no reason to detach self from the extended system in which that body is functioning.

Dennett demonstrates that consciousness rather than being 'central control' is our self's 'press agency', so ultimately there is no absolute reason for considering this as the centre of the system under consideration. But even if we retain Bergson's statement that our body is the centre of our perception –all other images being modified by our mobility– when we use mobile technologies, which are to all intents and purpose attached to our bodies, they participate in and modify our perceptual centre. The mobility of which Bergson speaks cannot therefore be considered as constituent of a solely human condition. This is how Bateson suggests we should consider our relationship to the computer:

> Now let us consider for a moment the question of whether a computer thinks. I would state that it does not. What "thinks" and engages in "trial and error" is the man plus the computer plus the environment. And the lines between man, computer and environment are purely artificial, fictitious lines. They are lines across the pathways along which information or difference is transmitted. They are not boundaries of the thinking system. What thinks is the total system which engages in trial and error, which is man plus environment. (Bateson 1972, 491)

In this age of pocket sized, connected computers that provide us with ubiquitous extensions to our communicational capability, this statement would seem more pertinent than ever. It might also reveal an important difference in approach between Bateson and Dennett. Dennett's theory of consciousness is about the way in which we perceive, ultimately his model is based on that of a parallel processing computer with attitude[20].

[20] Dennett in a talk he gave at Edinburgh University on February 10th 2009 compared memes to viruses. He defines a virus as "a string of nucleic acid with attitude" and goes on to explain that a successful virus induces the cell it invades to reproduce it. (Dennett, Breaking the Spell – Religion as a Natural Phenomenon 2009)

The only real interaction that this computer has with the rest of the environment is through programs that are copied from machine to machine (memes), whereas a Batesonian model would tend to include the user plus smartphone plus personal computer plus the Internet plus the social network, in one system. I will discuss ideas concerning mobile technologies and media further in Chapters Four and Five.

As a visual and sound artist, I perceive another limit in Dennett's theory, which is its dependence on language; the idea that consciousness has to be 'written in memory'[21] This, I consider fails to incorporate non-verbal forms of communication and consciousness. Ask a musician how s/he puts expression into a note and s/he will probably be incapable of explaining; similarly an artisan will probably find it much more efficient to show you how to do something rather than to try to explain it. That Dennett (and other philosophers) are above all experts in language possibly biases their perception: in effect, it is difficult to imagine the intelligence of the sculptor if you do not possess that intelligence and if the sculptor cannot describe it to you. In this, I appreciate Lefebvre's inclusion of the *sensible* in rhythmanalysis and his refusal to accept the primacy of 'thinking'. Even if this sensibility does not partake in the heterophenomenological world, in my opinion it does participate in consciousness (although it might be argued that part of perception, this sensibility, is subliminal or pre-conscious in nature). I will develop these ideas further in relation to the particular case of audio and musical perception in Chapter Four.

Nonetheless, what Dennett advances 'makes sense' and above all his theory provides me with a useful model on which to construct an art of real-time data flux. If one extrapolates Dennett's 'multiple draft theory' to include it in a Batesonian environment (and this is not so difficult to do since ultimately both theories have a common root in cybernetics and systems theory) it is surely possible to develop an art form which is included in and includes user and environment, in what Dennett calls a 'Joycean narrative'. A means to create a meandering 'flow of consciousness' that is simultaneously instantaneous, continuous and structured; that includes different scales of time and which adjusts strands of the story even as they unfold. This might seem a little ambitious when stated in literary

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[21] David M. Rosenthal, proposes an alternative to this with his higher order thought hypothesis : When a mental state is conscious, one is conscious of being in that state. On the higher-order-thought hypothesis, one is conscious of a conscious state by virtue of having a roughly contemporaneous thought to the effect that one is in that state. (D.M. Rosenthal 1993)

terms (as is Dennett's tendency), however if applied to the more abstract art of sound composition, it immediately becomes more credible. I will return to this in more detail Chapter Five.

The Role Of The Artist

Bergson, Bateson and Lefebvre all consider that it is the artist who is capable of perceiving and rendering the underlying dimensions of self or environment that their theories identify. If these visions of the artist's role vary along with each theory, all three seem to view the artist as the alter ego of the philosopher –a person of exception possessing special powers that could be directed towards the revelation of their theories.

Bergson considers that the artist has the gift to see what other people fail to see, an augmented 'intuition' of things so to speak. S/he is a specialist and is gifted in one domain only; his/her interpretation allows other non-gifted people to perceive what would otherwise be unperceivable:

> Thus, whether painting, sculpture, poetry or music, art has no purpose other than to remove the practically useful symbols, the conventionally and socially accepted generalities, in short, everything that masks reality, to put us face to face with reality itself. (Bergson, Le Rire, Essai sur la signification du comique 2012)[22]

I have to disagree with Bergson's proposal that traditional artworks –paintings or sculpture[23]– unveil intuition or pure time. On the contrary I would tend to say that they participate in a particularly high level of symbolization, although one might temper this statement, considering that at the time when Bergson was writing there was a renewed interest in the mechanics of sensation and perception, not only in science and philosophy but also in painting, with such artists as Seurat, Cezanne or the futurists (Jonathan Crary develops this articulation in some detail in his 1999 book *Suspensions Of Perception*

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[22] My translation from the original French: Ainsi, qu'il soit peinture, sculpture, poésie ou musique, l'art n'a d'autre objet que d'écarter les symboles pratiquement utiles, les généralités conventionnellement et socialement acceptées, enfin tout ce qui nous masque la réalité, pour nous mettre face à face avec la réalité meme.

[23] It is important to place this in context Bergson is talking about art at the turn of the 20th century.

(Crary 1999)). It appears to me that if the artistic activity itself might be a flux –a continuous quest for the imperceptible– the result is not, rather it is a remnant of such a quest. If there is flux or becoming it is more likely to be found in the artist's activity, in the act of creation itself, rather than in the result. It is not my intention here to belittle the artistic value of an artefact because it is fixed in time; on the contrary, it is quite extraordinary that this sublimation is possible. However, one of the central questions posed in this thesis is: 'Are there not ways in which the art could be more faithful to the creative process in its form and functional mode?'

Bergson maintains the following:

> But it is even less possible to represent it (the inner life) by concepts, that is by abstract, general, or simple ideas. It is true that no image can reproduce exactly the original feeling I have of the flow of my own conscious life. But it is not even necessary that I should attempt to render it. If a man is incapable of getting for himself the intuition of the constitutive duration of his own being, nothing will ever give it to him, concepts no more than images. Here the single aim of the philosopher should be to promote a certain effort, which in most men is usually fettered by habits of mind more useful to life. (Bergson, Metaphysics 1912, 27)

Bergson announces throughout his writing that *pure* time is below consciousness and that it is impossible to capture or represent intuition. I sense a dichotomy between the traditional art object and intuition, and a paradox between the above statement and the special case of the artist who renders 'pure' perception accessible to all.

Bateson considers that the artist's role is to reveal the relation between the levels of mental process (mental process including the external global mind).

> Artistic skill is the combining of many levels of mind – unconscious, conscious, and external – to make a statement of their combination. It is not a matter of expressing a single level (Bateson 1972, 470).

For Lefebvre artist is synonymous with rhythmanalyst, who engages, or re-engages art in the everyday:

> …works (oeuvres) might return to and intervene in the everyday. Without claiming to change life, but by fully reinstating the sensible in consciousness and

> in thought, he would accomplish a tiny part of the revolutionary transformation of this world and this society in decline. Without any declared political position (Lefebvre, Rythmanalysis 2004, 26).

Lefebvre's conception of the artwork is perhaps closer to my own, however, it remains very vague in terms of how this might take place and one might suspect that the production of image or object continues and the traditional role of the artist remains intact.

Towards An Art Of Flux

I propose that we might consider things differently, that rather than it being the artist who, like a recording head, sublimates flux into a fixed and tangible form, it is the artwork itself, which operates with, through and on this becoming. The role of a particular kind of artist might be to define the way in which it does this. It is possible to consider the system and the user as a cybernetic whole. This principle is applicable to most forms of "interactive" art and the idea has been around for some time as this extract from a 1967 text by Roy Ascott shows:

> Art is then determined not by the creativity of the artist alone, but by the creative behaviour his work induces in the spectator, and in society at large. Where art of the old order constituted a deterministic vision, so the art of our times tends towards the development of a cybernetic vision in which feedback, dialogue and involvement in some creative interplay at deep levels of experience are paramount. (Ascott 2006)

However, I believe there is an important difference between interactivity where the user generates data (deliberately or not) and interactivity that incorporates real–time data from the environment, with the user, in a system. In the first instance, user and artwork are included in a closed loop; in the second, an input from outside extends the system into environment and visa versa. If we accept this principle then we need some kind of structure that captures and acts upon real-time in its own way. A way which, without being a fixed form, has the capacity to elevate the immediate data to a state, that 'makes sense' in some way to the person experiencing this art. This is where I return to the Multiple Drafts Theory and the Joycean Narrative as an inspiration for a system that might be an art form of flux.

An Art Which Works Like Consciousness

There is no consciousness without memory, only immediacy, if immediacy 'virtually' contains everything it cannot it be art, it is just raw data. The person experiencing immediacy, pure sensation, may interpret it by raising it to a level of symbolization him or herself but, arguably, this in itself does not constitute art. If there is to be an art made out of immediacy, this art is reliant on memory.

The notions of real-time and real time have shifted from those developed in the introduction to this thesis. An analogy might be made between Bergson's duration and the simple oscillation of the central processing unit of the computer: this oscillation undergoes a primary operation that transforms it from continuous movement to zeros and ones. These traverse increasingly complex levels, defined by computer routines and external connections, in order to create something that makes sense to a human user (the actual oscillation measured in Giga-hertz are imperceptible to human senses). The notion of computer real-time, rather than being immediacy is relative to function. It is something, which updates on a timescale that participates in the usefulness of the final construction presented to the human user. For example, the responsiveness of a mouse is in the order of hundredths of seconds and for the user it is to all intents and purposes immediate. If the mouse input was updated at the speed of the CPU, this would occupy all the computing power and the computer would do nothing else. The activity of the processor is unperceivable (in human terms) without the addition of programs extracted from memory and continuous communication, back and fourth between memory, processor and incoming information.

It is possible, with a computer, to create multiple 'meanings' from a single data-flux. By this I mean that different patterns can be distinguished from the same set of data – for instance in *RoadMusic* a single sensor can inform of the surface of the road (vibrations), of larger movements (bends) in the road, of significant events (changes in direction) and more information can be 'derived' in the form of statistics for example. These all involve different levels of memorisation –of expansion in time from the present moment. It is equally possible to invert this principle: to include several streams of data as a unique final flux. We might perceive this as unity, whereas it is in reality Bergsonian multiplicity. In *RoadMusic*, multiple input data streams may influence a single audio stream.

We create future. We like to do it. It is a mechanism of survival and exercising this capacity, like working our bodies, makes us feel good; it is what Dennett considers as the basis for our free will. We look for patterns in things around us, indeed if we are to believe Bateson our world can be 'reduced' to patterns. We create future from the past. Beyond intuition, the instant only exists as updated past and emerging future, constructed from nascent pattern. We might consider the same capacity in a system, in an artwork, as an extension of our way of experiencing the world. In *RoadMusic*, this is applied to the construction of audio form.

To arrive at a degree of sophistication acceptable as art it is necessary to include elements that create aesthetic sense and sensation, failing this, the artwork will not be recognizable as such, there are different ways of doing this, which I will explore in the following chapters. Since we cannot expect the system to evolve automatically to this degree of sophistication, these cultural objects will have to be imported into the system as programs, or open-ended compositions. In Chapter Two, I will study the work of three key composers who, in different ways, participated in the opening of composition to real-time, making such a program hypothetically possible.

2. Chapter Two - Precursors To Sonification: Iannis Xenakis, John Cage, Murray Schafer

2.1. Introduction to Chapter

Digital technology has greatly modified the time(s) and space(s) within which audio works of art can be projected and apprehended. If recording abstracted sound from its temporal context, and radio or telephone abstracted it from its spatial context, digital computerised audio has further expanded these possibilities. Today's sound artists and composers have access to tools that can achieve a number of things that would have been unimaginable a few years ago. Recorded sound can be repeated endlessly without it wearing out (making it installable), it can be mobilised and transported to or from an individual or a group of individuals. Sound can be organised, modified or synthesised in real-time and key to this research, these processes can be driven by immediately captured data. The artistic possibilities offered by these and other innovations are far from being exhausted. On the contrary, it sometimes seems as if technology evolves faster than our capacity to assimilate it aesthetically; however, it is possible with hindsight to trace the emergence of some important principles.

The middle of the 20th century was a period of radical questioning of the status of musical composition and performance. The thinking of the three artist/composers presented in this chapter essentially precedes the use of digital technology for sound production, however, between them –in what they did, said or wrote– we can find many of the landmark ideas that lead today to the possibility of an art of real-time sonification of environments. Three of these ideas are of particular importance for this thesis: the first is the separation of

musical time from fixed musical notation. The second is the inclusion of the 'everyday' in music, which leads to the third, which is a shift in focus away from the person of the composer and / or performer towards the exterior, the environment or the situation as it unfolds.

It would be possible to start the narrative earlier in the 20th century: the appearance of the everyday in art with Marcel Duchamp and the Futurists or precursors to algorithmic composition with the tone row and serial methods of Schoenberg, Berg and Webern, Messiaen or Boulez. However, Cage and Xenakis also incarnate a period when a questioning of the clear divisions between artistic genres was taking place and with it the naissance of what is known today as sound art (happily the term still lacks a clear definition), and the opening up of new spaces to 'organised sound'[24]. R. Murray Schafer, for his part, alerted the world to 'sound ecology' a trans-disciplinary practice that attempts to incorporate different approaches to sound perception and to create an overall awareness of sound environments beyond that of musical listening. After presenting the work of each composer, I will discuss their respective positions on topics that are of particular importance in relation to my practice in *RoadMusic*.

2.2. Iannis Xenakis

As well as being a composer, Xenakis was an architect, engineer and mathematician. Xenakis restores and renews a direct relationship between mathematics and music introducing Boolean logical functions, notably set theory, as means for composing music. His methods open the way to a number of computer music techniques that I use in *RoadMusic*. Most importantly, he abstracts musical qualities (including values of time) from the fixed score making them available as variable parameters.

Stochastic Composition

Chance operations were being used in music prior to Xenakis. In addition to the aleatoric composition of the serialists, Mozart is reputed to have invented a musical dice game;

[24] Karlheinz Stockhausen's definition of music (Stochausen, 1989 p. 88-89).

early 20th century American composers Charles Ives and Henry Cowell made use of aleatory techniques; and subsequently, as I will develop in the next section, there is John Cage's use of indeterminacy. However, Xenakis redefines the basis of chance operations by using relatively complex mathematical models founded on the law of large numbers[25]. He adopted the term 'stochastic composition' to differentiate his from other methods employing chance of which he was highly critical.

To resume the idea of large numbers: if we toss a coin, at the first toss the chance that the coin will be heads is indeterminate. If however, we toss the coin one hundred times we would expect to find a score close to fifty for both heads and for tails. The greater the number of tosses the more precise this average will become, thus indeterminacy disappears. If we weight the coin slightly on one side, although this might not affect an immediate 'indeterminate' result, it will over a number of throws push the average in one direction. Thus chance can be graduated. When music is chaotic, we no longer distinguish the horizontal melody and the vertical harmony but rather the global effect, which is perceived as a mean quality (an average or rather a central value) thus stochastic control of large numbers, defines macroscopic effect. This observation becomes the crux of Xenakis' subsequent stochastic compositional technique, based on the manipulation of mean values and degrees of variation around them.

Xenakis points out that the world of sound is not perceivable as a succession of distinct notes and proposes instead to consider masses of sounds –in Bergsonian terms qualitative multiplicities.

> …the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mould of time, which itself follows aleatory and stochastic laws (Xenakis, FM 1963, 9).

To illustrate these stochastic laws Xenakis describes degrees of order and disorder in human group-behaviour; the way a chant evolves in a crowd. One chant takes over from another in waves but it can also be disrupted by an aleatory event (such as a gun shot) and

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[25] Universal law introduced by Jaques Bernoulli in his 1713 publication *Ars Conjectandi*.

descend into chaos[26]. The point being that the global degree of order or disorder is not dependent on that the behaviour of individuals but on that of the mean value of the crowd.

Clouds Of Sounds

This leads Xenakis to explore the use of weighted or Poisson probabilities: continuous probabilities, which calculate a curve of values over time, exploited in the scientific domain for modelling natural phenomena such as motion in gases. Returning to the example of the weighted coin, it is as if we were considering a coin with variable weighting, or in the case of the multiple events, a variable degree of weighting randomly applied to one side of a collection of coins. Deviation from the expected 50:50 result would increase stochastically as weighting value increases without actually defining the isolated results. Xenakis applies these curves of probabilities to sound parameters (for example, pitch, intensity, duration, and timbre) to create 'clouds of sound'. Any or all parameters of the cloud can be changed in this manner enabling the slow shift of sound qualities over time (like the chant in the crowd), or indeed a sudden violent perturbation (like the gun shot). If one projects a stochastic cloud visually, it would be an 'organic' form with evolving dimensions, density or colour. One of Xenakis' principal inventions was the systematic use of glissando where not only the starting pitch but also the duration and thus the "steepness" of the glissando are determined stochastically.

In the context of the compositional process these transformations of form are accumulated, confronted, combined or disrupted. For Xenakis they offer a representational system, better adapted to modern music than the strings of notes of classical composition. We might also consider this as Xenakis' response to the inclusion of the everyday in composition. Xenakis' calculations ultimately resulted in a score to be played by an orchestra, however, he pioneered an approach to music as continuously evolving forms, which albeit to obtain a very different result, I largely rely on in *RoadMusic*.

[26] Xenakis frequently refers in his writing to the scenes of social unrest which presumably marked his formative years, using them as behavioural examples of more general mechanisms.

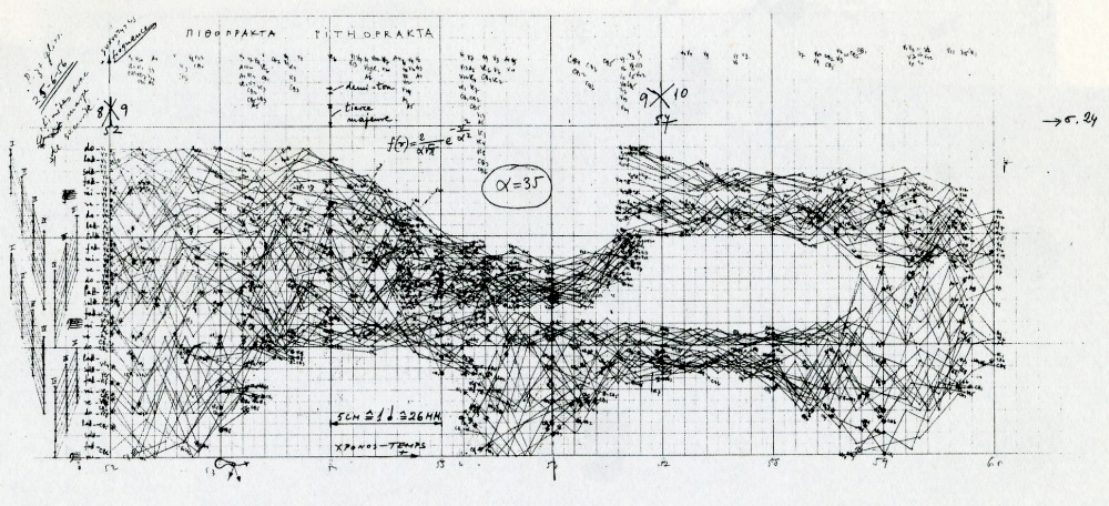

Figure 2-1: Graph of Bars 52-57 of *Pithoprakta*.

Granular Sound

If Xenakis' first stochastic compositions transposed the results of mathematical calculations to standard musical notation, he pursued this principle of multiple sonic events further, developing it as a model potentially capable of generating all nature of sounds. He proposes that sonic particles or grains defined by duration, frequency and intensity can be manipulated stochastically to create all nature of sounds: continuous pure simple sounds which can be made up of short repeating modules through complex random sounds to white noise.

> All sound, even continuous sonic variation, is conceived as an assemblage of a large number of elementary grains adequately disposed in time. So every sonic complex can be analysed as a series of pure sinusoidal sounds even if the variations of these sinusoidal sounds are infinitely close, short, and complex. In the attack, body and decline of a complex sound, thousands of pure sounds appear in a more or less short interval of time. (Xenakis, FM 1963, 43)

Later Xenakis proposes this 'microsound' structure as an alternative in computer music to Fourier synthesis[27]. Xenakis was mistaken in supposing that computers would never have the capacity to adequately synthesize complex sounds using Fourier techniques since today they are the basis of most of our systems of audio compression such as MP3. Nonetheless, he was correct in the sense that the method, which we now commonly call granular synthesis has proven to be one of the richest and most versatile techniques available to the composer of computer music[28]. In *RoadMusic* I use granular synthesis to sonify movement detected in the visual field (see Chapter Five 5.3.5 *Grain*). Xenakis was the first composer to exploit this approach towards musical ends, however it should be noted that the technique was originally invented by British physicist Dennis Gabor who actually went as far as building a sound granulator from the optical/audio system of a cinema projector (Roads 1996, 169).

Symbolic Music (In-time, Outside-time)

Symbolic music marks a shift away from preoccupations with granular sound. Xenakis embarks on a new line of research, undertaking to incorporate all music in a global method based on logic. In keeping with Bergson's notion of the symbolic, symbolic music extracts musical form from the reality of its rendition in time. Before *Herma*, the first composition made with his 'symbolic' system, Xenakis made use of non-commutative time, that is to say that the musical construction followed a unidirectional and linear mode.

If a sound event is taken independently of time it has no temporality —it simply appears and disappears. If we take two sonic events and remove the temporal aspect —they both sound simultaneously— then the two sounds are commutable. If there are two sonic events, in traditional music theory or notation they are in temporal succession, one comes before the next and they are not commutable (a before b =/= b before a). If however we take three sound events (three notes) and consider the temporal interval between the events as a relation rather than a fixed value, the ratio of the time interval between a and b to that between b and c for example, we can then extract the temporal relations

[27] Fourier Analysis : the analysis of a complex waveform expressed as a series of sinusoidal functions , the frequencies of which form a harmonic series (Oxford 2010).

[28] The first computer implementation of granular synthesis was developed by Curtis Roads in 1974.

'independent of the procession of time' and apply algebra 'outside-time'. Musical time is thus vectorised.

> In order to do this I propose to make a distinction in musical architectures or categories between outside-time, in-time, and temporal. A given pitch scale, for example, is an outside-time architecture, for no horizontal or vertical combination of its elements can alter it. The event in itself, that is, its actual occurrence, belongs to the temporal category. Finally, a melody or a chord on a given scale is produced by relating the outside-time category to the temporal category. Both are realizations in-time of outside-time constructions (Xenakis, FM 1963, 183).

It is important to stress the significance and the consequences of the symbolization of music, which is reminiscent of the distinction between communication and causality that occurs in cybernetics. If prior to this, the transposition or inversion of musical notes were part of compositional syntax, they were inscribed within a framework of fixed time values. By separating what he calls outside-time from music and treating time intervals as relative proportions rather than fixed values, Xenakis makes a final step which allows all musical operations to be abstracted which in turn means that these operations (what ever the final form of notation) can be calculated entirely using logical operations. He re-defines musical notes as vectors composed of pitch (frequency), amplitude and duration (outside-time). He purposely eliminates questions of sound quality (variations within a note, timbre, density) to concentrate on the symbolic values of 'sonic events' (or entities). We might consider this as the precursor to MIDI[29]: the language of electronic and digital instruments established as an industry standard in 1982.

Vectors can be one note or a temporal sequence of notes. Xenakis uses Boolean logic (sets and classes, intersection, disjunction, included in, union, negation) as a basis not only for composition but also to re-encode and thus better understand the structure of existing music —he demonstrates this by transforming a fragment of Piano Sonata No. 23, Op. 57 by Beethoven into symbolic form. Beyond this, his symbolic system can incorporate musical arrangements other than those based on the twelve notes of the modern twelve-tone system (notably ancient Greek music). He hypothesizes that modes and scales are a relatively modern evolution of musical theory:

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[29] Musical Instrument Digital Interface.

> I believe we can go further and affirm that ancient music, at least up to the first centuries of Christianity, was not based at all on scales and modes related to the octave, but on tetrachords and systems (Xenakis, FM 1963, 183).

Xenakis considers that there is a degradation of temporal thinking (outside-time structures) in music due to the predominance of thinking in-time which itself is derived from the predominance of polyphony.

To situate this in the discussion in relation to the real-time manipulation of notes or other sound parameters, of particular importance to this thesis, Xenakis was not concerned with the 'here and now', rather he was developing an alternative to the fixed temporality of a traditional score; a method that considers time values as a variable parameter among others. However, in doing so he opens the door to the possibility of influencing the temporal structure of a composition (which might have other predetermined qualities such as melody for example) in real-time.

Game Theory And Heteronomous Music

In autonomous music content is entirely contained within the score, the only variation being a good or bad performance, (excluding possible elements of improvisation but which Xenakis considers as being locked to the linearity of the score) 'the unfolding of the sonic discourse follows an open line without loops. (Xenakis, FM 1963, 110)' Any conflict or discourse is internal to the music itself. Heteronomous music on the other hand, includes the notion of conflict external to the music, in short music based on competition. This 'contradictory virtuosity' can be found in some non-western musical traditions, where while following established rules, instrumentalists attempt to pull the music in a direction where the other participant finds it hard to follow. Xenakis gives the example of Indian tabla and sarod players (another example might be the duelling banjo scene in the 1970 film *Deliverance* by John Boorman).

Game theory[30], which can be considered as one of the consequent branches of cybernetics, deals with reaction and interaction, equilibrium and competition between

[30] The branch of mathematics concerned with the analysis of strategies for dealing with competitive situations where the outcome of a participants choice of action depends critically on

parties. Game theory entered the realms of philosophy and politics in the early 1950s and interest in it was peaking at the time when it was used by Xenakis to introduce a stochastic element exterior to the written score: a system other than improvisation or aesthetic judgement providing the music with an opening to the outside. *Duel* (1958-59) was the first of two works (along with *Stratégie* (1962)) to be composed using this principle. Xenakis proposes a game involving two orchestras where the conductors play against each other. The game consists of a given number of 'sonic constructions', 'tactics' that can be combined by the conductor in a given, limited number of ways that are predefined rules of the game. A matrix has been calculated in such a way that while the game is not symmetrical –Conductor A doesn't gain the same points as Conductor B with a same combination of sonic tactics– it is fair: they each have the same overall probability of winning. Each combination of tactics awards points to the composer. There is a minimum time during which a tactic must be played, beyond this it can be changed or otherwise looped until it is changed. Listening to a recording of *Stratégie*, I would say that the music produced clearly reflects the method employed: one hears the tension of the combat —although I must admit that the spatial organisation (separated orchestras) reinforces this impression.

Taken more largely this notion of heteronomous music might be applied to sonification, it is a relatively small step to place an external force at the position of one of the 'protagonists', and indeed Xenakis does, in a sense, project this eventuality.

> We could equally well imagine setting up conflicts between two or more instrumentalists, between one player and what we agree to call natural environment, or between an Orchestra or several orchestras and the public. (Xenakis, FM 1963, 112)

Xenakis had set up the ideas that could have led to a sonified composition, perhaps something akin to John Eacott's flood tide where the composition is generated in real time from the flow of the tide but interpreted by live musicians (see Chapter Four 4.3.2). However, if at that period Xenakis was gaining access to computers for the first time, they were far from being capable of the real-time calculations that we now take for granted.

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the actions of other participants. Game theory has been applied to contexts in war, business, and biology (Oxford 2010).

Composing With Computers

Paradoxically perhaps, since Xenakis paved the way for so much in computer-music technology, his early work[31] using computers essentially transposed his existing algorithms to computer language. Even his later use of computers might be considered as the relocation of his earlier techniques. This is not to reduce the importance of his contribution to the domain but it is interesting that he developed these ideas just before the technology (to which they are so well suited) became available and that today they still represent among the more radical approaches employed in computer music.

> This approach seems to the author to be of a higher value for the foundation of a "true" computer art than the widespread ambition to emulate human creativity by computers and to build up an artificial brave new world of music (Hoffmann 1998).

The most notable research conducted by Xenakis in computer music was the development of UPIC (1977), a sophisticated graphical interface which permits a versatile manipulation of predefined musical events, including independent scaling of different parameters. The development of this ambitious, government-funded project continues today and is now available as open source software that will run on a home computer[32]. Figure 2-2 shows a screen shot of a test that I made with using the free *HighC* software.

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[31] Xenakis' first access to a computer was in 1962, an IBM-7090. This gave rise to a composition entitled *ST/10-1*, 080262 performed at IBM-France's headquarters in May 24th by the Ensemble de Musique contemporaine de Paris conducted by C. Simonovic.

[32] IanniX (Iannix 2011) HighC (HighC 2011)

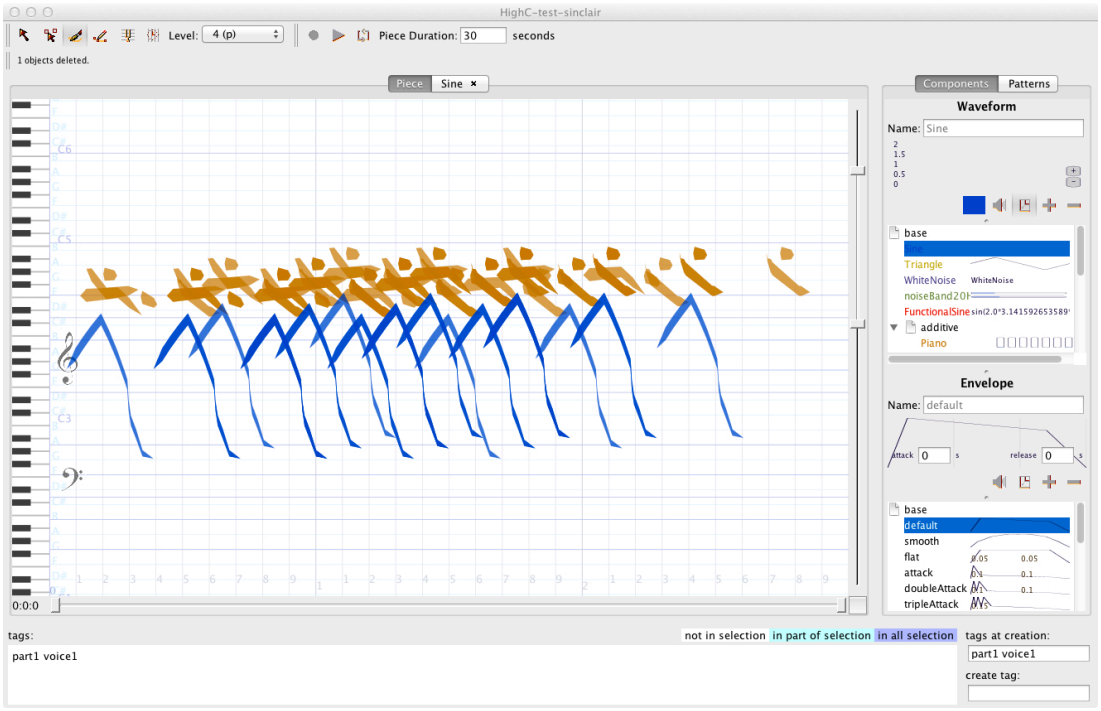

Figure 2-2 : HighC graphical interface

Xenakis' formalised music develops two main ideas that I can use for *RoadMusic*. Firstly, he allows thinking of musical sound in terms of form as opposed to voice (line of melody) and provides ways of manipulating such forms stochastically, that I can adapt to real-time sound generation. Secondly his invention of symbolic music offers the possibility to extract any parameter(s) of notes or the relationships between them, to manipulate them algorithmically and / or 'heteronomously' and again, in the case of computer music, opens the possibility of varying these parameters in real-time.

2.3. John Cage

Although John Cage was a contemporary of Iannis Xenakis and like him included chance operations in his compositional method, his reasons for doing so were in many ways opposite. Cage's ideas concerning chance will serve a quite different purpose in this thesis to Xenakis *Formalized Music*. Much has been written about John Cage and my approach will focus above all on those aspects of his work that I consider have a bearing on *RoadMusic*. These are above all the different conceptual and technical methods he invented to include flux of the situation or, to put it in other terms, 'the everyday' in his composition.

Art And Music

> 'One way to write music: study Duchamp' (Goldberg 1988, 124)

It has struck me that John Cage is the composer most liked by artists and disliked by musicians. If this is a purely personal impression, Cage can certainly be included among the conceptual artists[33] and can also be placed among the pioneers of art/music 'hybridisation' known today as sound arts. His approach to and use of audio material, has as much to do with a visual art lineage as a musical one. Indeed Cage himself cites visual artists among his most important influences: for example, credit for the use of chance in composing goes to his idol Marcel Duchamp and his *Erratum Musical* (written in 1913 and published in 1934).

> … drawing jumbled notes at random from a hat. Duchamp composed Erratum Musical with his sisters Yvonne and Magdeleine, seventy-five notes picked by chance to accompany as many syllables of the randomly chosen dictionary entry for "imprimer". "How is it that you used chance operations when I was just being born?" Cage asked Duchamp.
>
> …He would occasionally use chance the way Duchamp did (pulling slips of paper out of a hat) whenever he happened to be some place without his own I-Ching simulation program (Lotringer 2000).

Although Cage ambiguously offered various explanations as to what inspired him to realise *4'33"* (the silent piece) over the years, one of these was his encounter with Robert Rauschenberg's white paintings:

> Actually what pushed me was not guts but the example of Robert Rauschenberg. His white paintings. … When I saw those, I said, 'Oh yes, I must; otherwise I'm lagging, otherwise music is lagging'. (Kahn 1999, 168)

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[33] A form of art where the idea is predominant over the end result. First used by Henry Flynt as the title for a 1963 article *Concept Art* published in a fluxus journal *An Anthology of Chance Operations*.

It might be considered that the questioning of highly codified practice in art, the freeing of art from its academic shackles and the introduction of individual methods of working, happened earlier and more easily in the sphere of the visual arts than in music. Experimentation in music was limited, at least in the domain of orchestral music, by the resources needed to pass from the idea to the musical result. Since these were considerable, approval from official bodies with entrenched ideas was all but essential whereas if visual artists were never oblivious to the academy, they had a better chance of creating their project independently.

This situation changed with the advent of electronic audio technology, which provided multi-timbral, controllable sound sources, without, or with far less, human resources, which were both costly and complicated to obtain. Although John Cage did write music for instrumentalists, he was among the first to appreciate the liberating potential of electronic sound sources, notably recorded sound, which he recognised as musical material, beyond its use as a system of storage and reproduction (a function for which he had little consideration). In the text published as 'THE FUTURE OF MUSIC: CREDO' originally delivered as 'a talk at a meeting of a Seattle's arts society organized by Bonnie Bird in 1937', Cage makes the following statement:

> I BELIEVE THAT THE USE OF NOISE… TO MAKE MUSIC… WILL CONTINUE AND INCREASE UNTIL WE REACH A MUSIC PRODUCED THROUGH THE AID OF ELECTRICAL INSTRUMENTS… WHICH WILL MAKE AVAILABLE FOR MUSICAL PURPOSES ANY AND ALL SOUNDS THAT CAN BE HEARD. PHOTOELECTRIC, FILM, AND MECHANICAL MEDIUMS FOR THE SYTHETIC PRODUCTION OF MUSIC… WILL BE EXPLORED. WHEREAS, IN THE PAST, THE POINT OF DISAGREEMENT HAS BEEN BETWEEN DISSONANCE AND CONSONANCE, IT WILL BE, IN THE IMMEDIATE FUTURE BETWEEN NOISE AND SO CALLED MUSICAL SOUNDS. (Cage, Silence 1971 3-4)[34]

[34] The original text is the merging of two texts. I have replaced the second text with (…). I have respected the capitals of the original typography.

This statement was made before Pierre Schaeffer's first concerts and the appearance of 'Musique concrète'[35]. Shortly afterwards Cage wrote *Imaginary Landscape No.1*: For 2 variable-speed phono turntables, frequency recordings, muted piano and cymbal. To be performed as a recording or broadcast by 4 performers (Chaudron 2012)'. It was premiered on March twenty fourth, 1939 at the *Hilarious Dance Concert* at the Cornish School in Seattle, performed by John and Xenia Cage, Doris Dennison and Margaret Jansen.

Paradoxically, it was perhaps recorded sound that opened Cage's ears to the possibility that a score might include variability. He found a positive value in the indeterminate nature of these first concerts of electro-acoustic music: since it was not possible to start a multitude of tape recorders used for the concert simultaneously, the way in which the sources mixed together in the acoustic space was always slightly different. If the problem of multi-track playback synchronicity had already been resolved at the time of Cage's relating this, the serendipitous lesson had already been learnt: the different recorded elements had became independent parts (as opposed to a fixed score), which inevitably combine in different ways at each playing back.

Experimental Music And Indeterminacy

John Cage re-defines the notion of experimental music to include the notion of listening. The composer becomes a listener and discovers the music along with the audience. In a 1987 talk at the San Francisco Exploratorium, *Speaking of Music*, Cage defines his motivation in composing in the following terms:

> I think many composers hear music before they compose it, but I write music in order to hear it and I try to find ways of doing that which will succeed. (Cage, Speaking of Music 2012)

The practice of experimental music involves placing (at least part of) the decision-making processes normally considered as synonymous with act of composition outside of the composer's control. By doing so it inevitably creates a unique unrepeatable situation, a performance based on the here and now.

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[35] Music constructed by mixing recorded sounds: see Chapter Three.

> This is a lecture on composition which is indeterminate with respect to its performance. That composition is necessarily experimental. An experimental action is one the outcome of which is not foreseen. Being unforeseen, this action is not concerned with its excuse. Like the land, like the air, it needs none. A performance of a composition which is indeterminate of its performance is necessarily unique. It cannot be repeated. When performed for a second time, the outcome is other than it was. Nothing is therefore accomplished by such a performance, since that performance cannot be grasped as an object in time. A recording of such a work has no more value than a postcard; it provides a knowledge of something that happened, whereas the action was a non-knowledge of something that had not yet happened. (Cage, Silence 1971, 39)

I retain Cage's definition of experimental music which provides a category into which *RoadMusic* would seem to enter (although the term performance does not apply the rendition of *RoadMusic*) and offers an element of response to the question posed at the beginning of this thesis as to whether sound produced from indeterminate data can be considered as artistic.

The degree of this indetermination and the methods used to obtain it vary from work to work, it is applied to composing, to performance or both. In 1951 Cage adopted the Chinese oracle system *I-Ching*[36] using it to introduce chance operations into the compositional process[37]. He used it to create charts or matrices (similar to those first used by Milton Babbitt[38]) that determine occurrences or parameter values of sounds or silences. In the first works involving *I-Ching*, results were translated to traditional notation. Later they were used to create graphical notation, which allowed for increased freedom of interpretation (Cage's graphical notation being interpretable in different

[36] Normally used to interpret aleatory 'heads or tails' tosses accumulated as hexagrams by referring to the written *I-Ching* texts.

[37] First used to compose 'Music of Changes' (1951).

[38] American 'New Music' composer (1916-2011).

directions). Cage also used other sources of chance such as the imperfections in paper[39] or star charts[40] to compose sounds.

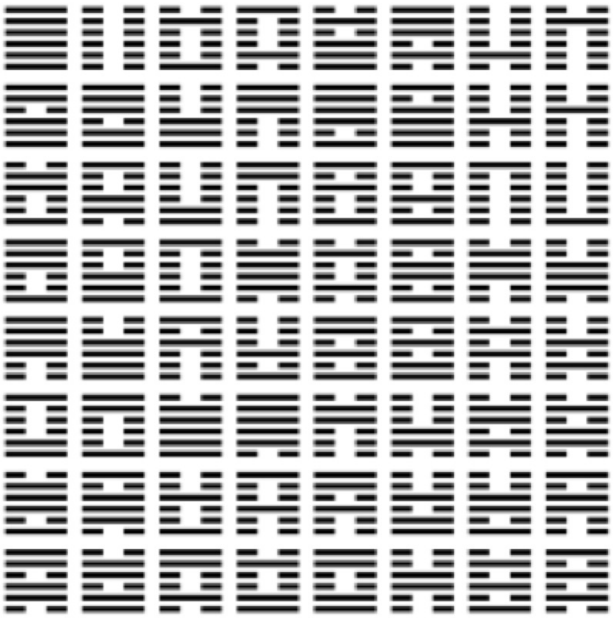

Figure 2-3 : I-Ching Hexagram

In terms of performance, he often allowed for a large part of decision making to be made by the musician. However, this differs from improvisation (if one relates improvisation to a musician's self expression) since the score defines 'global' parameters and the musician is expected to make random choices within those limits, which depend as little as possible on personnel preference.

Cage accommodated the incorporation or penetration of environmental sounds into his music. He makes an analogy with the way in which certain modern or contemporary sculptures visually incorporate their surroundings through transparency[41] and are thus never viewed in the same way. Why should the incidental sounds that are not deliberately included in the music be excluded from our listening? This thought process leads in turn

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[39] 'Music For Piano 1' (1952 – 56)

[40] 'Atlas Eclipticalis' (1961–62)

[41] Cage possibly refers to Duchamp's 'Grand Verre', and according to Peter Gena 'he also very much admired Richard Lippold's wire sculptures' (private correspondence).

to Cage's refutation of the existence of silence itself, which he demonstrates through, an often repeated anecdote, describing his experience in an anechoic (soundproofed) chamber:

> I entered one at Harvard University several years ago and heard two sounds, one high and one low. When I described them to the engineer in charge, he informed me the high one was my nervous system in operation, the low one my blood in circulation. Until I die there will be sounds. And they will continue following my death. One need not fear about the future of music. (Cage, Silence 1971, 8)

Cages' most famous composition *4'33"* is a logical extension to this argument: performed by any musician or combination of musicians, no deliberate sounds are made throughout the duration of the piece (*4'33*" divided into three movements). Thus, the audience are incited to concentrate on the silence, or lack of silence; the music consists of the incidental sounds that might be heard during the piece.

4'33" And 4'33" n°2

4'33" is dependent on convention to exist –in other words without the score, the venue and the musician, the silence is inaudible so musical establishment in fact remains intact, possibly reinforced. However, if we take a step back from *'4'33"'* and consider Cage's use of notation in general, we might consider that by making compositions 'indeterminate with respect to their performance', Cage transformed notation into 'routine' to be executed in real-time. I use the word routine in the sense of a computer program, in other words a set of instructions applied to a variable input and that result in a modified output. If the routine can conceivably be considered as an artwork, the art itself takes place in real-time within or through that modifying process and is not 'hard coded' in the score or the recording. One might argue that this is the case of any interpretation of written music before the advent of recording, however this (at least in the nineteenth century) was not the deliberate intention, on the contrary the idea was to render what was written in the score as precisely as possible, music was conceived of as an object not as a process (in the given context). This notion of process as opposed to score is central to *RoadMusic* and I will return to it in more detail in Chapter Five.

Cage's notation evolved from the generation of notes using chance operations, to be played by musicians; through indeterminate scores that obliged the performer to make aleatory decisions; to notation, which was created a posteriori to the performance itself

(*Variations V – VII*). In this last case, we might well consider that the notation becomes more a description of what happened than of what is intended and that it is more a documentary archive than a score. Of more interest in the context of this thesis is the fact that in these cases the transformative routine (as I call it) continues to exist but is shifted from the score (written instruction) to technical devices which are used to capture or reveal the everyday that Cage wanted included in his music. John Cage talked about dissolving the difference between art and life. If he had done so completely, perhaps we would not be aware of the fact. What he did rather was to mediate the real world in 'real time' through the use of devices. An example of this, which provides an interesting counterpoint to *4'33"* is *0'00"* (otherwise known as *4'33" n°2*), written and premiered in 1962 and which consists of a single instruction:

> In a situation provided with maximum amplification (no feedback), perform a disciplined action. (Chaudron 2012)

Here Cage abandons temporality, and with it the last element of conventional notation, replacing it with a mediating device[42]. One of Cage's favourite inventions was the use of record players to amplify microscopic sounds (the cartridge is placed on a surface and functions as a contact microphone). Other examples are the use of unusually large theramines[43] to turn body movement into sound (*Variations V*), of microphones that capture audio outside the performance space and pipe it inside, and the audification of invisible waveforms (*Variations VII*).

John Cage And Sonification

> It was done in New York, sponsored by the EAT (Experiments in Art and Technology). That was several years ago, in 1967, I think. The air, you see, is filled with sounds which are inaudible, but which become audible if we have receiving sets. So the idea of *Variations VII* is simply to go fishing, so to speak,

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[42] A performance of 0'00" can be seen on You Tube that features Equineviolinist cleaning a violin in front of open microphone. (EquineViolinist 2012)

[43] An early electronic instrument, where pitch and amplitude of a tone are determined by the proximity of the musicians hand to the instrument's antenna. It was invented by Léon Theremin in 1928.

> in a situation that you are in, and pick up as many things as you can, that are already in the air.
>
> Well, there were ordinary radios, there were Geiger counters to collect cosmic things, there were radios to pick up what the police were saying, there were telephone lines open to different parts of the city. There were as many different ways of receiving vibrations and making them audible as we could grab with the techniques at hand. (Cage, You must take a global point of view 1970)

From this description, I conclude that John Cage did actually use real-time audification and sonification to tap into the environment during *Variations VII*. For another piece entitled *Reunion,* John Cage and Marcel Duchamp, followed by John Cage and Teeny Duchamp, played chess on a board designed by Lowell Cross at Cage's request. Each cell of the Chessboard was equipped with a gating sensor (photo resistors), covered or uncovered by the pieces as the game evolved, routing sounds accordingly. The sounds consisted of tape music by Lowell Cross and electronic sounds 'composed live' by David Behrman, Gordan Mumma and David Tudor. These were directed depending on the moves of the game to one or several of eight loudspeakers situated around the audience. In his 1999 article Lowell Cross describes the evolution of the project and the subsequent performances in detail (Cross 1999).

If we are indebted to John Cage for having placed flux at the centre of artistic preoccupations, and for these examples of artistic sonification (which must be among the first), I remain perplexed in the face of what I see as a paradox between this concern with the everyday and the creation of exceptional, often spectacular events. The premier performance of *Reunion* is a case in point: to reflect Cage's ideas of incorporating the everyday in art it was staged theatricalised as a 'homey' scene. By inviting Duchamp –at that point in time probably the best known artist in the USA– as well as renowned musician/composers to mix their sounds before they were influenced by the chess-board, the whole performance moves, in my opinion, firmly away from everyday and the aleatory; and I would venture, away from listening and towards the spectacular. In keeping with the idea of a possible art of real-time that I sketched out in the conclusions to Chapter One, I would perhaps be more interested in a permanently playing version of Cage's chessboard than in its presentation as a performance.

In his article describing *Reunion*, Cross criticizes the fact that the performance did not produce an elegant result (Cross 1999). It is not this, however, which I would question:

elegance can be considered as a matter of taste and Cage had dealt with taste long before. What bothers me is that the exceptional and consecrated nature of artwork is here replaced by the consecration of the exceptional presence of *the artist.* But there is, I think, an unresolvable paradox: if all things (sounds) are different but they are all of equal value why would we need a composer to single them out? In addition, doesn't amplifying certain sounds make them unequally loud?

However, rather than end here I will describe the Cage 'piece' which I like the most and which, although it does not use technology, exemplifies the way that I envisage human computer interaction. The quotation is a transcription from a documentary film by Peter Greenaway. After talking about how the sound produced during a performance (scraping a music stand across the floor) was out of his control, John Cage comments on an excerpt where we see several performers (including him) manipulating conch shells with water in them:

> The result was that whatever I did, I got something that wasn't in my mind to get. That leads to a kind of improvisation that results in discoveries. The same is true of conch shells filled with water, particularly with respect to…to the time of the gurgle. You have no way of controlling it.
>
> You can think that you have the shell under control or the gurgle under control and you do just exactly what you're supposed to do to get the sound and (laugh) nothing occurs, and then before you know it, even when you don't intend to do anything… it gurgles (Cage, 4 American Composers 1983).

We might consider this is similar to playing an instrument but it differs in the degree of 'equality' between the system being manipulated and the manipulator. The cybernetic feedback between the performer and the system becomes apparent, because it is sufficiently complex to reveal itself as something other than a simple extension to the human body. As a veteran builder of machines that never quite do as one expects (an idea which has become central in *RoadMusic*) I am particularly interested in this aspect of what Xenakis would call heteronomy.

2.4.Murray Schafer

Soundscape

Murray Schafer is internationally recognised both as a theorist –inventor of the concepts of 'soundscape'[44] and 'acoustic ecology'– and as composer. If his music seeks inspiration in the natural environment and indeed some compositions are written to take place outside, in specific natural environments (Becker 2000), his compositions remain relatively classical in their conception. I will therefore be concerned with his written contribution to the world of sound, primarily his book *The Soundscape, Our Sonic Environment and the tuning of the world* (R. M. Schafer 1977). This book has had an important influence on the evolution of sound art, sound design –or acoustic design as Schafer calls it– and the general appreciation of our audio environment. For reasons that I will discuss in Chapter Four, sound design has a significant role in sonification –the case of *RoadMusic* being no exception– and Schafer has become an inevitable reference for many artists sonifying environmental data.

Acoustic Ecology Acoustic Design

> Acoustic ecology is thus the study of the effects of the acoustic environment or soundscape on the physical responses or behavioural characteristics of creatures living within it. (R. M. Schafer 1977, 271)

Writing in the 1970's, Murray Schafer had clearly benefitted from John Cage's teaching when he introduced the notion of soundscape as a global composition:

> The best way to comprehend what I mean by acoustic design is to regard the soundscape as a huge musical composition, unfolding around us ceaselessly. We are simultaneously its audience, its performers and its composers. (R. M. Schafer 1977, 205)

[44] The sonic environment.

However, if, in continuation with Cage's thinking, Schaefer's perception of soundscape pushes us towards heightened awareness of all sounds, contrary to Cage, he counsels the application of aesthetic judgement, through careful analysis of those sounds within their context; further he advocates a proactive response. Acoustic design is a multidisciplinary method, which attempts to assemble the different disciplines dealing with sound perception and sound creation, including: acoustics, psychoacoustics and aesthetics; but also composition and audio engineering. It is a global approach to audio environment that takes into account both the physical and signifying qualities of sound which makes it an approach particularly relevant to sonifcation. Through its use of data and arguably in opposition to 'pure' music, sonification almost automatically implies that context be taken into account, furthermore at least one approach to sonification involves correlating virtual gesture or form with plausible acoustic properties. I will enlarge on this in Chapter Four.

Acoustic design aims to improve the audio environment primarily by creating a heightened awareness of that environment through careful listening, analysis and composition (the reconstruction of sounds being according to Schafer the best way to learn to discern sounds). It can also imply acoustic control or noise abatement, although Schafer is sceptical about the efficiency of these and puts more faith in the idea that heightened consciousness of our audio environment will lead to the conservation of ecologically important sounds or 'Soundmarks'[45] and improved organisation or planning of our future soundscape.

One of the consequences of Schafer's teaching is the appearance of 'Soundwalking'[46] which, I would venture, can now be considered as a nascent discipline in itself and which plays an important role in the evolution of mobile audio art forms and the possibility of considering listening as a compositional process. I will show in the following chapters how soundwalking is an important predecessor to sonification and indeed to my practice.

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[45] The term is derived from landmark to refer to a community sound which is unique or possesses qualities which make it specially regarded or noticed by people in that community.

[46] The soundwalk is an exploration of the soundscape of a given area using a score as a guide. The score consists of a map, drawing the listener's attention to unusual sounds and ambiances to be heard along the way. A soundwalk might also contain ear training exercises… When the soundwalker is instructed to listen to the soundscape, he is audience; when he is asked to participate with it, he becomes composer-performer (R. M. Schafer 1977).

History And Politics

Schafer points out that the only records that we possess of the sound environment prior to audio recording are written descriptions and a large part of *The Tuning of the World* is dedicated to a study of the evolution of the world's sound environments, through historical literature and other written records such as legal acts concerning noise abatement. His approach centres on a study of social-acoustic context, (unlike Xenakis or Cage, his musical production is largely separate from his theory). Schafer associates the license to make loud noise (Sacred Noise[47]) with the possession of power. From the church to the battlefield, from bells to cannons and later to industry, the sounds of power have escaped sound abatement legislation.

Sound Objects Versus Sound Events

Schafer's approach to 'real world' sound is very different to Cage's, in that his analytical listening is critical or even judgemental in nature. It is also very different to that employed previously in 'Music Concrète', where if the 'objet sonore' of French composer and acoustician Pierre Schaeffer[48] was the object of analysis it was also, as Schafer points out, deliberately extracted from its context and considered apart from its signification.

> But Schaeffer deliberately excludes all considerations of the sound object in any but physical and psychophysical terms. He does not want to confuse the study of

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[47] Schafer identifies the symbolic origins of Sacred Noise in awe inspiring, naturally occurring phenomena, such as thunder or earthquakes which would have been the only sources of unusually loud noise prior to human artefacts:

> 'I call this Sacred Noise to distinguish it from the other sort of noise (with a small letter), implying nuisance and requiring noise abatement legislation… During the Industrial Revolution, Sacred Noise sprang across to the profane world. Now the industrialists held power and they were granted dispensation to make Noise by means of the steam engine and the blast furnace, just as previously the monks had been free to make Noise on the church bell or J.S. Bach to open out his preludes on the full organ.' (R. M. Schafer 1977, 76)

[48] See Chapter Three: 3.1. Autonomous versus Heteronomous Music

> sounds by considering their semantic or referential aspects. That a bell sound comes from a bell does not interest him. (R. M. Schafer 1977, 231)

Schafer is primarily concerned with signification and context of sounds in the field and deliberately chooses an alternative to the term 'sound object' which he calls 'sound event':

> The sound event, like the 'sound object' is defined by the human ear as the smallest self-contained particle of a soundscape. It differs from the sound object in that the latter is an abstract acoustical object for study, while the sound event is a symbolic, semantic or structural object for study, and is a nonabstractable point of reference, related to a whole of a greater magnitude than itself. (R. M. Schafer 1977, 274)

For Schafer the descriptions of sound events, not only their acoustic qualities but also the density of their occurrence, the way they are perceived against background, and their social significance, enable an interpretation of the evolution of our sound environment. Terminology such as 'Self-contained particle' and 'densities' might remind us of Xenakis' 'sonic events', Schafer's purpose however is quite different: where Xenakis essentially defines a musical unit and its characteristics (so that it can be manipulated in ways, which classical notation does not allow for), Schafer's sound event is a way of studying sounds in relation to their context. In 'The Tuning of the World', this analysis leads to a consideration of technical-social development; the progressive shift from rural to urban and from human to industrial scaled activities. The corresponding shift in the soundscape, is principally presented as loss, destruction and/or blanketing of the natural sound environment.

The LoFi Environment

Schafer borrows the term HiFi[49], which he uses to qualify an environment where 'sounds may be heard clearly without crowding or masking (R. M. Schafer 1977, 272)' and creates its counterpart the 'Lo-Fi' environment where on the contrary sounds become

[49] high fidelity : the reproduction of sound with little distortion, giving a result similar to the original. (Oxford 2010)

indistinguishable from one another –ultimately one where the signal to noise ratio[50] can become 1:1 (all becomes background noise). According to Schafer, this is the case in certain industrialised audio environments.

Schafer believes that musical style evolves in symbiosis with acoustic environments, participating in, reacting to or imitating ambient sound. He identifies what he calls keynote sounds: sounds which are so evident that they are possibly no longer noticed by inhabitants, they form a background which is often only identified when it disappears. Keynote sounds like the fundamental of a harmonic scale are the inevitable reference to which all other sounds return. In pre-industrial communities this might be the sound of the sea, in today's electrified environment, it is more often the drone of mains alternating current – 60Hz in North America or 50Hz in Europe– that, according to Schafer has become the referent sound to which our ears are adapted.

Aggregate textures are unfocussed masses of sound that 'massage the listener with continual presence (R. M. Schafer 1977, 158)'. For Schafer they are another manifestation of the LoFi environment, (this might be also be considered as an example of Lefebvre's arrhythmia). Schafer cites Xenakis' composition as an example of music influenced by this noise: 'More to the point, Xenakis has drawn his inspiration directly from the observation of the contemporary soundscape (R. M. Schafer 1977, 158)'. John Cage, I might add, goes beyond this since in his later life he announced a predilection for sounds such as that of the traffic on Sixth Avenue in New York in which he hears 'all sorts of things (Cage, John Cage on Music, Representation, and Kant 1991).'

Schizophonia And The Media Environment.

Schizophonia is Schafer's term to describe the condition of mediated sound that is distanced from its original source in time and/or in space.

> Since the invention of electro-acoustical equipment for the transmission and storage of sound, any sound, no matter how tiny, can be blown up and shot around the world, or packaged on a tape or record for the generations of the future. We have split the sound from the maker of the sound. Sounds have been

[50] The ratio of the strength of an electrical or other signal carrying information to that of unwanted interference. (Oxford 2010)

> torn from their natural sockets and given an amplified and independent existence. Vocal sound, for instance, is no longer tied to a hole in the head but is free to issue from anywhere in the landscape. In the same instance it may issue from millions of holes in millions of public and private spaces around the world, or it may be stored to be reproduced at a later date, perhaps eventually hundreds of years after it was originally uttered. (R. M. Schafer 1977, 90)

If Schafer does not make an out-right condemnation of the use of audio technologies, he does draw attention to the fact that they are acoustic 'aberrations'. His concern is with the modifications being wrought on natural cycles and rhythms of soundscape. The telephone is a prime example of a schizophonic media, according to him, having our thoughts continually interrupted by its ringing 'has undoubtedly contributed a good share to the abbreviation of written prose and the choppy speech of modern times (R. M. Schafer 1977, 89)'. He criticizes the construction of radio programs –the acceleration of the number of words pronounced compared to normal conversation and the imposing of isometric rhythms through commercial breaks. This relates to Henri Lefebvre's distinction between present and presence his warning against 'faux' presence in media 'The present simulates presence and introduces simulation (the simulacrum) into social practice (Lefebvre, Rythmanalysis 2004).' To situate this discussion in relation to my work as an artist, I actually find the idea of schizophonia (of distance listening and sound transmission) stimulating in the possibilities that it offers for experimenting with space and different types of 'presence'. On the other hand, *RoadMusic* falls on the side of acoustic ecology since it is offering a carefully designed sound environment that adopts and adapts to the rhythms of the situation.

The musical wallpaper of Muzak [51] is targeted as a deliberately manipulative reconfiguration of human rhythm and a concession to LoFism.

> The same programs are played to both people and cows, but despite the happy claim that production has in both cases been increased; neither animal seems yet to have been elevated into the Elysian Fields. (R. M. Schafer 1977, 97)

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[51] Originally a company which delivered music to commercial companies over electrical power lines, with the democratisation of radio in the 1930s and 40s Muzak became specialised in the marketing of background music specially engineered to increase productivity.

If his real problem is with the playing of radio or Muzak in public spaces, (apparently permanently present in in train stations and in railway carriages of North America at that time), his criticism extends to private listening where the radio is used not for its content but as a 'wall of sound (R. M. Schafer 1977, 93)'.

The audio environment has evolved since Schafer's time of writing, it may or may not (due to the recognition of noise as pollution) have got quieter, however, the undesirability of Muzak is generally recognised and it is probably safe to say that it is in decline, (the company declared bankruptcy 2010, although it has now been resuscitated and reorganised). One of the reasons for this is the activity of private iPod listening (I will enlarge on these ideas in Chapter Five 5.2. *Muzak*). Murray Schafer's position on the subject of headphone listening is unusually ambiguous since while emphasizing separation of the user from the (natural) sound the environment, he seems to find a spiritual elevation in this 'head space':

> When the yogi recites his mantra he *feels* the sound surge through his body. His nose rattles. He vibrates with its dark narcotic powers. Similarly when sound is conducted directly through the skull of the headphone listener, he is no longer regarding events on the acoustic horizon; no longer is he surrounded by a sphere of moving elements. He is the sphere. He is universe. While most twentieth-century developments in sound production tend to fragment the listening experience and break up concentration, headphone listening directs the listener towards a new integrity with himself. (R. M. Schafer 2004, 35)

If this was written before the invention of the ubiquitous Sony Walkman –where the walled garden is mobilised with undeniably heightened schizophonic consequences– M. Schafer in a sense predicts the empowerment through headphones documented by Michael Bull (Bull, Sound Moves 2007) that I will discuss in Chapter Four.

Sonification

> Indeed, the overkill of hi-fi gadgetry not only contributes to the lo-fi problem, but it creates a synthetic soundscape in which natural sounds are becoming increasingly un-natural while machine-made substitutes are providing the operative signals directing modern life. (R. M. Schafer 1977, 91)

Given Schafer's position on the electrical soundscape one might imagine that there is not much to be gleaned from his acoustic ecology of use to someone interested in sonification of environments. However, although he takes a critical attitude to towards the modern soundscape, it is not the attitude of the luddite, it is in fact more a appeal directed at those who are interested in sound to take care of the audio environment, be it artificial or natural. Thus, one of the projected roles of the acoustic designer –a projection that is increasingly becoming reality– is to carefully consider the field: the aural, social and historical context into which sounds are to be introduced and how they will interact with it. The following description of Schafer's hypothetical 'Soniferous Garden' might be considered as his advice on sonification of environments.

> A garden may also be a place of human artefacts such as a bench, a trellis or a swing, but they must harmonize with their natural surroundings, indeed appear to have grown out of them. Thus, if synthetic sounds are introduced into the soniferous garden, they should be sympathetic vibrations of the garden's original notes. (R. M. Schafer 1977, 247)

To conclude, I might say that Schafer provides me with useful tools for analysis, which extend sound environment beyond the sphere of purely musical thinking. His ecology is however at times sectarian as is his differentiation between HiFi and LoFi, electrical and natural. His notion of sound events and sound marks can lead to a regionalism, or folklore which while laudable in some aspects can also be a dangerous path when change is seen as intrusion. Here too there is a paradox: that of listening to the world as a composition but wanting it to sound a certain way.

2.5. Review Of Different Positions

Philosophy And Aesthetics

All three composers were also scholars with an interest in philosophy and the social sciences. Although they did not necessarily share the same references, they were all concerned with extending the world of audio perception beyond that implied by musical convention of the period and sought philosophical and scientific foundations to underpin this quest. This was in the air of the times: an epoch when artists and composers sought renewal through scientific thought. Simon Emmerson associates this with the post-war discrediting of romanticism:

> With the discrediting of both the German romantic and French neo-classical traditions, the past literally lay in ruins. Perhaps personal expression itself had become associated with such a heritage. At least initially, impersonality was the order of the day. A claim to 'objectivity', a negation of history and hence part of the self, was the aim. The idea that 'systems other than the composer' might generate aspects of the music came to the foreground of avant-garde ideas after 1945 (Emmerson 2007, 37).

Cage says that when he listens to music he has the impression that someone is talking to him and that he does not want music to talk to him, on the other hand when he listens to traffic he just hears a multitude of variations present within the sound. He cites Kant for his recognition of the independent or subliminal nature of music[52] 'He said there are two things that don't have to mean anything one is music and the other is laughter (Cage, John Cage on Music, Representation, and Kant 1991).'

It is well known that Cage was interested in oriental philosophy and Zen (although he self -confessedly reinvents his own version of it) and he frequently refers to the teachings of D.T. Suzuki:

> HE THEN SPOKE (Suzuki) OF TWO QUALITIES: UNIMPEDEDNESS AND INTERPENETRATION. NOW THIS UNIMPEDEDNESS IS SEEING THAT IN ALL OF SPACE EACH THING AND EACH HUMAN IS AT THE CENTER AND FURTHERMORE THAT EACH ONE BEING AT THE CENTER IS THE MOST HONORED ONE OF ALL. INTERPENETRATION MEANS THAT EACH ONE OF THESE MOST HONORED ONES OF ALL IS MOVING OUT IN ALL DIRECTIONS PENETRATING AND BEING PENETRATED BY EVERY OTHER ONE NO MATTER WHAT THE TIME OR WHAT THE SPACE. (Cage, Silence 1971, 46)[53]

I will return to the way in which this perception of Space / Time is interpreted in Cage's composing but I retain that this (what I will describe later as sympathetic) interconnectedness is fundamental to his art. As Douglas Kahn puts it:

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[52] Kant's influence on musicology will be discussed in Chapter Three (3.1 Formalism).

[53] Capital letters were used in the original typography.

> Overall, Cage was less interested in getting the ego out of the way to enable the unconsciousness to come out into the world than in removing the ego so more of the world could get *in* unobstructed. (Kahn 1999).

Xenakis for his part was well versed in classical philosophy and devotes a chapter of *Formalized Music* to the discussion of how his compositional techniques reconnect with reason, the Ionians and consequently cosmology:

> Above all, we must note that the opening taken by the Ionians has finally surpassed all mystiques and all religions, including Christianity. Never has the spirit of this philosophy been as universal as today: The U.S., China, U.S.S.R, and Europe, the present principal protagonists, restate it with a homogeneity and a uniformity that I would even dare to qualify as disturbing (Xenakis, FM 1963, 201).

For Xenakis 'We are all Pythagoreans'. It is worth recalling here that Pythagoras' 'Music of the Spheres' –which according to myth, sprang from the observation of the resonance of different sized hammers beating on an anvil– postulated that music and the whole universe alike, was defined by harmonic vibrations and subsequent rules of proportion. It is only later with Plato and Aristotle that music is internalized as human emotion. There exists, then, what we might consider as a common cosmological foundation to Xenakis' and Cage's thinking. Murray Schafer, writing after and undoubtedly influenced by these two composers, is unconditional in his distinction between voice / emotion and cosmos. The title of 'The Tuning of the World' says much in itself[54] and he commences the text with this statement:

> There are two basic ideas of what music is or ought to be. These may be seen clearly in two Greek myths dealing with the origin of music. Pinder's a twelfth Pythian Ode tells how the art of aulos playing was invented by Athena on hearing the heart-rending cries of Medusa's sisters after Perseus had killed the Gorgon. In a Homeric hymn to Hermes an alternative origin is proposed. The lyre is said to have been invented by Hermes when he surmised that the shell of the turtle, if

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[54] 'In Robert Fludd's *Ultruisique Cosmi Historia* there is an illustration entitled *The Tuning Of The World* in which the earth forms the body of an instrument across which strings are stretched and are tuned by a divine hand (R.M. Schafer 1977).'

> used as a body of resonance, could produce sound. In the first of these myths music arises as a subjective emotion; in the second it arises with the discovery of sonic properties in the materials of the universe. These are the cornerstones on which all subsequent theories of music are founded. In the former myth, music is conceived as subjective emotion breaking fourth from the human breast; in the latter it is external sound possessing secret unitary properties. (R. M. Schafer 1977)

My choice to include these composers in this thesis is related to these quests and their respective contributions to the opening of sound arts to environment and (real-time) situation. I consider that through their inclusion of the everyday, rather than or as well as the artist's imagination, they lead rationally to sonification of environments. I should add however, that if Schafer's separation between the internal and the external is appealing in its simplicity, it is to my mind too categorical and I have preferred when designing the compositional programs for *RoadMusic* to adopt an approach which like *Rhythmanalysis* can incorporate both internal (melodic) and external (soundscape) approaches. I consider that this is particularly important in the context of mobility where sounds emitted by a mobilised body (including voice) can set the 'shell of the turtle' into resonance. I will expand on these ideas in Chapters Four and Five.

Listening, Composing, Performing - Notation, Recording

> Composing's one thing, performing's another, listening's a third. (Cage, Silence 1971)

As mentioned above, Cage's approach to composition was in some respects conceptual; the eventuality that a composition might be unplayable, for instance, was not in itself a problem. If there is one lesson above all that I retain from his teaching (the choice of the term is deliberate), it is the value attached to listening. Cage's listening is participative, it includes us in the world and it lets the world into music. We might surmise that for Cage the success of a 'composition' might depend above all on the extent to which it convokes this engagement (through whatever means proves the most effective including provocation). This is possibly why he was so hostile to the use of recorded music since it implies a commodification, which renders participative listening unnecessary.

Murray Schafer also learns this lesson from Cage but his engagement with careful listening becomes a political one. This shift from the musical to the social means that we

no longer require the pretext of composition in order to listen to the environment. Sound-ecology provides the context for listening, without the use of the concert hall or the performance (in the same way that ecology *tout-court*, provides the context to enjoy nature without a garden). However, this mind-set does (at least in Schafer's original version) imply reference values –so in the same way as green is good for an ecologist, so the HiFi environment is good for the sound ecologist and Schafer, unlike Cage, cannot take pleasure in listening to traffic. But, if 'deep listening' is still sometimes connected to Schafer's somewhat extreme position, it should also be considered in the light of work by artists such as Pauline Oliveros[55] or Barry Truax[56] who have contributed to a concept which has evolved to become a multi-faceted discipline.

Xenakis has a different position. As an engineer and architect, he believed in making things. If it was his awareness of the disconnect between musical conventions of the time and the 'real world' sonic environment that pushed him to invent his stochastic method, the actual musical result is for the most part firmly battened down, to the extent that it would sometimes seem that Xenakis' only consideration for musicians interpreting his work is that his compositions remain just within the limits of the physically playable. They are reflections based on the social and physical world, but are presented as models of, rather than as participating in or as porous with, those worlds. Xenakis refuses Cage's indeterminacy in performance, which he considers as the improvisation of our forefathers revisited and an excuse for not doing the job of composing. For Xenakis, chance and his stochastic methods are tools to be used by the composer who must work away, adjusting their parameters until the result sounds 'right' (although there is an exception to this: the concept of heteronomous music and the application of game theory to the conducting of works in the form of a duel).

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[55] Musician and composer Pauline Oliveros coined the term deep listening in 1991: 'Deep Listening® is a philosophy and practice developed by Pauline Oliveros that distinguishes the difference between the involuntary nature of hearing and the voluntary selective nature of listening. The result of the practice cultivates appreciation of sounds on a heightened level, expanding the potential for connection and interaction with one's environment, technology and performance with others in music and related arts. (Oliveros 2012)'

[56] Barry Truax is a Canadian composer and computer music expert. Successor to Murray Schafer as professor of soundscape composition at Simon Fraser University in Vancouver Barry Truax has, among other things, reconciled granular synthesis with soundscape recording.

Indeterminacy In Composition And Performance

Before discussing the respective positions of these composers concerning this question it is perhaps useful to make the distinction between indeterminacy as a philosophical position, a doctrine that considers that not all events are determined by antecedent causes (the opposite of determinism) and its usage in musicology. This is the definition given by musicologist Bryan Simms:

> Any part of a musical work is indeterminate if it is chosen by chance, or if its performance is not precisely specified. The former case is called "indeterminacy of composition"; the latter is called "indeterminacy of performance" (Simms 1986).

It is possible then to be a determinist and author of indeterminate music. Although indeterminism in philosophy is a complicated question with many ramifications, I would venture that John Cage's own beliefs tend towards determinism, which would reinforce the validity of the indeterminate nature of his compositions (what will be, will be or possibly already is).

Xenakis' mathematically sophisticated use of indeterminacy is very different to that of Cage. If his stochastic composing techniques make use of the random, they do so by dosing it as a measurable quantity: almost like adding water to paint, this dosed randomness changes the overall characteristics of sound. In fact, Xenakis doesn't really believe in chance; it is a question of degree and of context. Within a given context, whether it be a social situation or a composition, we can consider randomness of events on a slider which moves between order and chaos, these limits being determined by the scale of what we are dealing with –or to put in terms of cybernetics, the informational system under consideration. Xenakis' stochastic construction becomes a tool, to be wielded by the composer, an adequate method to create musical sound based on principles similar to those occurring in the environment, while for Cage it is the presence of that environment itself.

In my practice of sonification, I employ both these principles simultaneously by using real-time, real-world data to vary symbolised parameters of composition. Today indetermination has entered into artistic methodology and we might consider that the question becomes: in what way and to what degree it is applied? Do we stay on the level

of raw data; as close as possible to Bergson's 'durée' (or Cage's silence) or do we parse it so that we make something from it and if so, according to what criteria?

The question of degrees of determination is one that I face in the programming of *RoadMusic*. The music is generated in real time, entirely from data, which is gathered while travelling. When I describe *RoadMusic* people sometimes retort 'so it's random'. In fact, there is little which is random in *RoadMusic* whether we take random to mean mathematically aleatoric 'governed by or involving equal chances for each item' or if we take the more common usage of being 'made, done, or happening without method or conscious decision (Oxford 2010).' There are no coin tosses making decisions about what is going to happen next, it is the route, which in a sense becomes the method. It is also dependent on the action of the driver but similarly to John Cage's conch shell playing, it is not controlled rather it responds or reacts. If the drivers' actions are in part responsible for the sounds produced, so is the road and the landscape, his / her actions are sensed within this multiplicity but seldom in a direct causal, comprehensible relationship (a counter example might be striking a note on a keyboard). If we accept my interpretation of John Cage's compositions as 'routines', we can consider the program of *RoadMusic* as an indeterminate composition and the drive as indeterminate performance or to use Xenakis' terminology that there is a heteronomous relationship between the program, the driver and the route.

Time, Real-time and Rhythm

As might be expected from composers defying musical convention, time is of particular importance to all three. Cage's attention to indeterminacy, which goes with his predilection for an art of immediacy, finds an echo in Bergson's philosophy and his élan vital. However, time structure (the aspect of time which Bergson considers as belonging to space), was the aspect of composition which Cage considered as the most valid to maintain: if he saw no reason to decide why particular notes should follow each other in an order of pitch; time exists also for silence:

> To repeat: a sound has four characteristics: frequency, amplitude, timbre and duration. Silence (ambient noise) has only duration[57]. A zero musical structure must be just an empty time. (Cage, Silence 1971, 80)

Moreover, *4'33"* explicitly maintains a temporal frame, the last thing left to make the sound music:

> A time that is just time will let sounds be just sounds and if they are folk tunes, unresolved ninth chords, or knives and forks, just folk tunes, unresolved ninth chords, or knives and forks. (Cage, Silence 1971, 81)

Alternatively, to put it another way sounds become music only through the temporal framework of composition. However, Cage does find a way to include indeterminate time in composition. It resides in graphical notation, where the temporal dimension is no longer defined as linear –being read necessarily from left to right– rather the musician interpreting the piece, navigates following his own inclination in the same way as ones gaze might meander over a painted canvas. In these cases the total duration of the piece might be left up to the musician or the organisers of the event[58].

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[57] Cage's use of the word refers to a period of time should not to be confused with Bergsonian duration or 'durée'.

[58] Cage's *Variations* series (I – VIII) are examples.

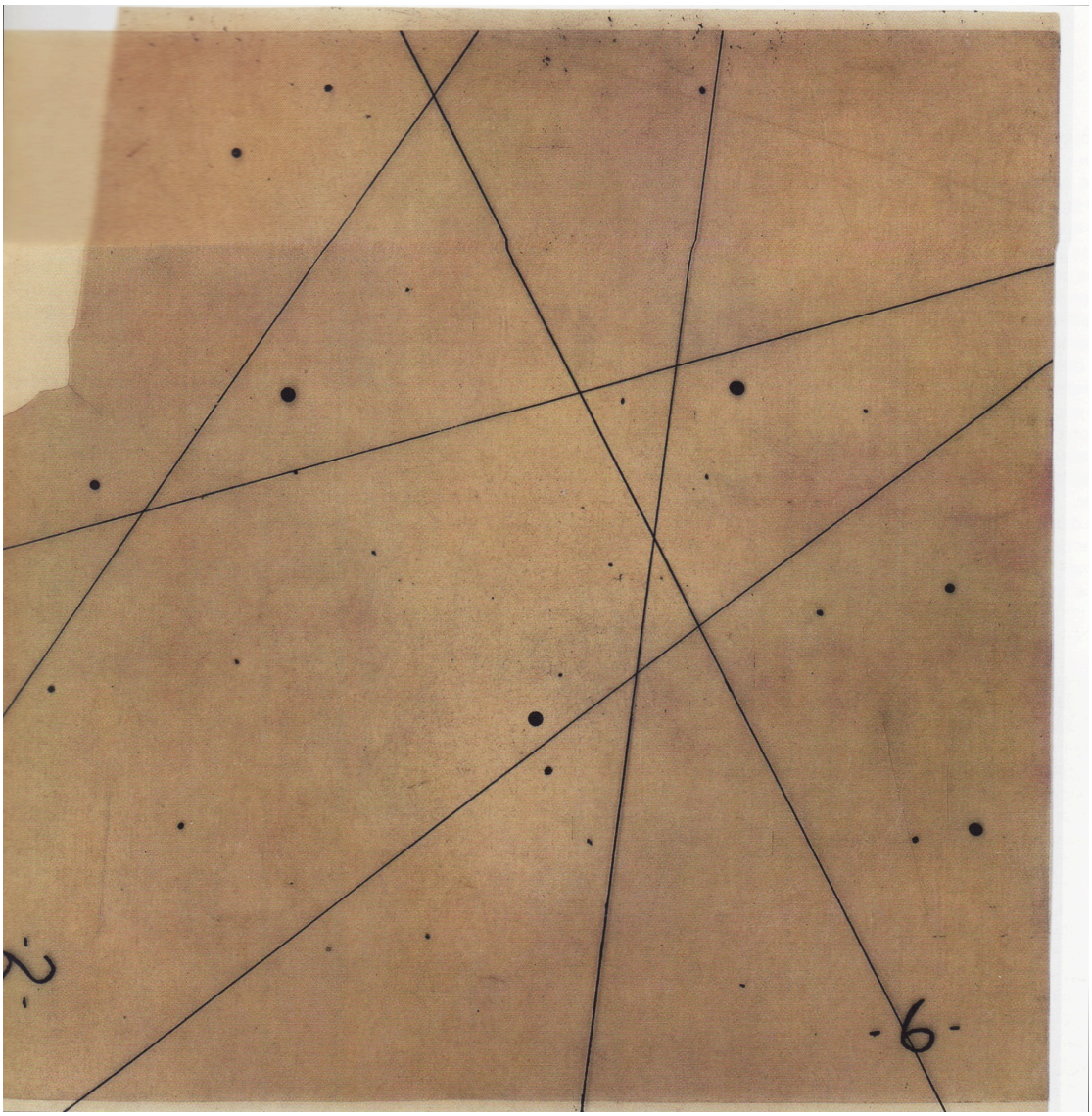

Figure 2-4 : John Cage Variations I 1958-1960 (Source : The New York Public Library for the Performing Arts)

Figure 2-4 shows the score for John Cages Variations I. The score consists of eight sheets, six of which are transparent and can be superimposed to combine in different ways. The score also includes instructions concerning how to interpret the lines and points.

Xenakis' turned time intervals between notes into vectors (scalable values) rendering time-directionality and time-scale (hitherto largely taken as fixed values) independent within the compositional process –his computer program UPIC is designed in such a way that time values can be expanded or reduced, either all together or discretely at any point

during the compositional process. Current computer techniques make it possible to do this on (acoustic) microstructure as well as (symbolic) macrostructure. To give an example, I recently witnessed an event proposing a version of Ludwig van Beethoven's ninth Symphony 'stretched' to last 24-hours[59] (without pitch distortion), created using the 'granular synthesis' techniques that Xenakis participated in developing. With a modern computer, temporal values can be manipulated in real-time –in other words it would be possible to navigate a recording of Beethoven's 9th, changing the timescale and direction at will.

Real-time calculation of computer-generated sound (that is the generation of the sound at a rate which is as fast or faster than the rate at which it is rendered audible) was originally an important goal for computer engineers, since it allows the composer to hear the sound s/he is working on as s/he is working on it. However, it also offers the possibility for the human composer to avoid rendering the symbolisation process altogether, in other words composing and playing multiple channels of sound can be achieved through the same gesture. The intermediate score does not have to appear, although this symbolisation process does of course take place on the machine level (the program) and the way in which it will structure or interpret input has to be decided by someone at some point in time. As concerns the sonification processes I am interested in, this implies that these 'gestures' can be delegated to an outside source, the computer program being un-determined in the temporal dimension; rather than being *unrolled* (so to speak) it is *activated*.

R. Murray Schafer's contribution to the question of time is rather different since his concern has less to do with the notion of musical time and more to do with the perception of biological, ecological, historical and social time through sound. One might question the aesthetic aspects of Schafer's analysis. His rejection of temporally continuous sounds on the grounds of their being 'Lo-fi' is problematic and indeed debated by the other composers cited here, since John Cage later in his life revelled in the continuous variation of drone sounds and Xenakis was concerned (precisely) by the limit between the separable and the continuous. His insistence on categorisation, the distinction between events and non-events and the nature of their significance can also appear dogmatic. On the other hand, Schafer's approach does provide certain tools to study sound perception, and subsequently sound creation on different time-scales to those habitually imposed by a

[59] Leif Inge's *9 Beet Stretch: AV Festival Newcastle March 1st 2012.*

musical context. His documentary methods analysing variation in the number and type of sound occurrences over days, seasons and historical periods, lead me to reflect on how these scales of rhythm might be explored within mediated sound environments.

I would venture, for example, that a sonification that is permanently 'on', might rapidly become unbearable if continuously generating audible levels of sound, whereas one that periodically generates sound events might be better perceived and might –if carefully tailored– lead to an augmented perception of an existing environment. Thus, rhythm on 'environmental' scales appears as an interesting line of investigation to be included in a reflection on artistic use of sonification. At the time of writing, the temporal scale of *RoadMusic* is related to that of the journey in that it expands from the instant, to the moment when the car was started in the past and to when it will stop in the future. This places it perhaps more in the realm of an indeterminate score than in environmental time since consideration of the variable scale of the journey is essential to the work, and it is its mobility rather than its permanence which defines its functionality. However, I am interested to include in a future version larger scale parameters such as, time of day, day of week or season, that might be obtained either via the computers' clock or through sensors of a different type than those currently used (for example, outside temperature[60]).

Similarly, Schafer's thinking concerning media-rhythms solicits reflection rather than approbation: it seems futile to consider the rhythms of the media environment from a purely negative point of view. However, taking these rhythms into consideration, investigating their nature and experimenting with them can be artistically rewarding, particularly in regards to developing technology that offers the capability of responding in real-time. This is similar to the criticism I made of Lefebvre's attitude to media and it should be pointed out that both were referring to a media sphere very different to that of today.

Sound art/composing: Navigating music, Listening to art.

It is fundamental to *RoadMusic* that the process of composition itself is mobilised with the user. The way in which this is accomplished is dependant on recent technology; however, important ideas that incorporate mobility in composition and listening predate

[60] It might be argued that larger scale temporal parameters are reflected in data already present such as dominant colour

computers and perhaps participate in the very notion of sound art. Although, as I suggest at the beginning of this chapter, sound art resists definition, it is probably safe to say that its appearance is related to a challenging of the categorization of the temporal (music) versus spatial (visual arts); the liberation of music from the constraints imposed by human interpretation on one hand, the permanence of recorded or electronically generated sound potentially conferring the status of the artwork, on the other. This combines with a more general questioning of the validity of rigidly defined artistic categories in the first half of the 20th century, giving rise to the appearance of numerous multidisciplinary approaches. Galia Hanoch-Roe proposes that the appearance of the neo-serialist 'open score' creates a breach in categorical thinking:

> The unravelling of an open-composition lends a choice of movement to the performer and allows him to move freely or randomly about the musical work. In such constructions, the function of the musical score changed from an object to be read by the performer into a process to be built. … In this, the process of performance becomes similar to that of a movement within a structural space, where the observer chooses his way about it. In a comparable manner, both performer in the open-composition and observer in the structural space gather several of the infinite existing possibilities inherent in the art-work to an artistic entity which is but one of its many "realizations." (Roe 2003)

John Cage (and others such as Christian Wolff, Earle Brown, Haubenstock-Ramati and Paul Ignace) extended the notion of open scores by using graphical notation. Often presented today, hung on gallery walls as visual art, the original purpose of graphical notation was to enable the performer to navigate a composition. Rather than defining what is to be played they act as a guide, in a similar way that a map might aid a hiker to plan and execute his / her walk.

Cage was also concerned with sound spatialisation, placing loudspeakers and/or performers in or around the audience. He considered this as another way of eroding the frontier between art and life, in the sense that it reinforced the fact that each auditor inevitably and unquestionably lived their unique version of the performance. Xenakis also engaged in experimentation with sound spatialisation, which started with his work for architect Le Corbusier, leading him to design the Philips Pavilion in 1958. Xenakis continued this research into multiple sources of sound in his Polytope installations, (different versions of which were created in different locations from 1967 onwards):

> The dispersal of multiple sound-sources throughout the space does not just make it possible for a tone to wander through the room. By projecting different sounds in different places there is an overlapping of many sound spaces. Each listener perceives the music in a different way according to his or her location at the time. The acoustical space is no longer homogeneous, but divides itself into different spatial areas (Oswalt 1991).

If one considers that the perceived sound is the result of the superposition of the progression of the sound in space (over time) with that of the progression of the listener then following Roe's logic, the interpretation of the music, is performed at least in part by the audience. This brings us progressively to a situation that resembles listening through normal mobility in a non-musical sound environment.[61]

Soundwalking, as developed by Schafer and his collaborators of the 'The World Soundscape Project' notably Hildegard Westerkamp (Westercamp 2007), completes this transition towards mobile listening as sound art. Although the activity was first considered as primarily educational, it evolved to become a set of instructions in the form of questions to the walker / listener, close in form to a Fluxus score (McCartney 2012). Soundwalks can also actively engage the listener in 'sounding' actions; they can involve the use of recorded sound and headphones, or indeed sonification, as I will develop in the next chapter.

A Critical Approach To Technology And Media.

> It is better to make a piece of music than to perform one, better to perform one than to listen to one better to listen to one than to use it as a means of distraction, entertainment, or acquisition of culture. (Cage, Silence 1971, 64)

All three artists considered here adopted a critical attitude towards mass-media culture. Schafer was almost fanatical in his opposition to the rhythms imposed by modern media and in his glorification of the pastoral. However, we might consider that schizophonia

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[61] It should be mentioned here that at this time other sound artist/composers were experimenting with navigable sound spaces notable examples being: La Monte Young's 'Dream House' (conceived in 1962, it exists today as a permanent installation in New York) and David Tudor's 'Rain Forest' (1968).

generated consciousness of soundscape, in the same way that industrialization produced the romanticism of the 19th century. Schafer engages in a new form of romanticism (sound ecology) made possible through the appearance of the very media he criticises. Xenakis was also critical of the industrialization of music:

> It floods our ears in many public places, shops, radio, TV, and airlines, the world over. It permits a consumption of music on a fantastic scale, never before approached. But this music is of the lowest kind, made from a collection of out dated clichés from the dregs of the musical mind (Xenakis, FM 1963, 200).

However, Xenakis wasn't against this industry rather he hoped that it might be improved qualitatively by introducing the basics of logic into musical education.

Cage's voiced opinions of recorded music ranged from saying that he had nothing against records but did not use them personally (Cage, Speaking of Music 2012), to denouncing them as a negative influence on listening (Cage, 4 American Composers 1983). In any case, his interest was in revealing the uniqueness of sounds and if he used recorded sounds or even radio (randomly tuning between stations) to this end, this was evidently in contradiction with the goals of the audio industry. But Cage was far from being an opponent of technology. His father was an inventor and Cage himself had a fascination with and an easy understanding of emerging technologies which he continued to investigate until the end of his life (as an example, in a 1987 talk he uses time stretching and compression techniques to modify his discourse in real-time (Cage, Speaking of Music 2012)). He regaled in the *detournement*[62] of these technologies, playing with them: tapes were of interest for their infidelity while magnetic cartridges (record players) were used to amplify microscopic sounds. Radio or other receivers were used to give voice to otherwise inaudible sound sources and for their aleatoric content (because not chosen by the performer), rather than for communication. Humour was always an important part of Cage's vocabulary; he was virtuoso in revealing new perspectives. His use of devices simultaneously disclosed sound, environment and even the device itself in unexpected ways. Above all, he used transformation through technology as a permeable membrane through which the real in real-time, by the simple fact of being mediated, became art. If

[62] Hijacking, or diverting something from its original function : term originally coined in an artistic context by the Letterist International movement.

Cage did this mostly in consecrated (art) time and (art) space, it paves the way for the possibility of extricating art from the art context by using mediation.

If Xenakis had a sense of humour it does not transpire in his work, his use of technology was wholly serious. He was a staunch believer in art science (his doctoral thesis was published under that name), his theories drew on a solid background as an engineer and mathematician and he employed cutting edge technology as a means to his end. Paradoxically perhaps, Xenakis was also strongly attached to the 'artistry' of the composer, the aesthetic beauty of sound, and the uniqueness of human intelligence. He had what appears today as a conservative view of the capabilities of computers and scoffed at the idea that they might have a creative role in the making of music.

2.6. Conclusions To Chapter Two

The second half of the 20th century saw a breakdown in the traditional divisions between artistic genres and with it the appearance of a number of new questions. As I have shown, if the reasons for this are in part political, social and aesthetic they cannot be separated from evolutions in technology; in fact, a strong dialogue was set up between technology and aesthetics. Today this situation is reinforced with the appearance of mobile networked and 'intelligent' media and an artistic interrogation of these emerging forms appears ever more valuable.

We have witnessed a shift in the role of the composer, a questioning of his relationship to the exterior and to an audience and with it a questioning of the notion of authorship. We have seen that mediation can become the very 'place' where the everyday becomes art and that this in turn questions the primordial nature of dedicated artistic space. Artistic ecology –the notion that our senses can be cultivated not only via the appreciation of an artists interpretation but also through an attitude of listening to the real world– has evolved as an art practice in its own right that considers mobility within the environment as composition.

If these paradigms were initiated by the three artist/composers cited here (among others), they raise questions that find their continuation in the practice of sonification of environments, which I will consider in Chapter Four. Before doing so I will return to the specifics of audio and musical perception.

3. Chapter Three - Music and Audio Perception

3.1. Introduction To Chapter Three

In this chapter, I pick up from where I left off on my reflections on the perception of time and focus on the particularities of audio and musical perception. My hypothesis is that an understanding of how we 'make sense' out of the audio environment around us and the relationship of this to musical listening, should be a good starting point for composing in real-time from data about the immediate situation. After all, our hearing takes place in real time and does not necessarily have a score to follow.

This thesis is not just about musical sound and it will have been understood from the choice of artists in the preceding chapter that I am above all concerned by modes of composition that extend beyond or deviate from what might traditionally be considered as music. However, *RoadMusic* sonifies both by creating sounds which are ambient in nature and through more 'traditional' musical forms based on rhythm, melody and harmony. Also, as I will discuss in Chapter Four, there is some debate concerning the potentially different status of sonification and music, thus it seems appropriate to broach, albeit briefly, the difficult subject of meaning and information in music from the point of view of musicology. I will investigate certain aspects of musical perception and the 'humanness' of the emotions that are related to it. I will consider Leonard B. Meyer's theory of 'kinetic syntactic' musical perception and finally I shall concentrate in more detail on Albert Bregman's theory of audio perception 'Auditory Scene Analysis', which incorporates both musical listening and unintentional hearing.

Autonomous Versus Heteronomous Music

In a 1966 publication, *Traité des Objets Musicaux* (Treatise on Musical Objects) composer, engineer and acoustician, Pierre Schaeffer undertook the task of classifying musical sounds (Schaeffer 1966). Considered as the inventor of *musique concrète,*

Schaeffer integrated new forms of acoustic production, such as recorded and synthesised sound, into musical theory –up until then based essentially upon notes. Like Xenakis' stochastic composition but more directly related to electronic technology, the invention of *l'objet musicale* (the musical object) made it possible to include continuous sounds, sounds of varying pitch and recorded sounds of everyday objects, in a classification based on acoustic form and texture rather than on pitch and harmony. To accommodate everyday sounds as music, Schaeffer distinguished two types of listening attitudes: 'causal listening' and 'reduced listening'. A third category, 'semantic listening' is added by Schaeffer's one time student and close collaborator Michel Chion, in his 1983 book *Guide to Sound Objects* that clarified and completed Schaeffer's earlier work. (Chion, Guide Des Objets Sonores - Pierre Schaeffer et la recherche musicale 1983)

Causal Listening is the mode of listening where we glean information about the source of the sound, often, as Chion points out in his writings on cinema (Chion, L'Audio Vision 1990) as an 'added value' to visual information. Causal listening has several different levels: idiosyncratic (the sound of the well known but unique object: my dog, my car); categorical (a dog barking or a car passing); and class (an unidentified animal noise or mechanical noise). Reduced Listening is listening to a sound exclusively for its acoustic qualities; this requires that the sound be mentally detached from its source. Schaeffer's hypothesis is that by repeatedly listening to a recorded sound it is possible to operate this shift in perception –musical listening is essentially reduced listening.

Semantic listening implies sound that is encoded to carry a message; for Michel Chion, this is essentially limited to spoken language or other codes such as Morse. However, it might be argued that much music contains a semantic element in the sense that it follows conventions that the listener is expected to understand. Nevertheless, arguably, this does not include the same type of precision as language but rather a more general feeling. Indeed according to the absolutist school of thought promoted by 19th century philosopher and music critic Eduard Hanslick (following Kant's theory of the sublime cited by John Cage (Chapter Two 2.5)) music is completely autonomous.

> Now a musical idea reproduced in its entirety is not only the object of intrinsic beauty but also an end in itself, and not a means for representing feelings and thoughts. The essence of music is sound and motion. (Hanslick 1854)

If Hanslick's position might appear extreme, it does explain that music can be enjoyed through essentially reduced listening –as is the case for instance when listening to a

recording of music from an unknown culture– and this idea has paved the way for the formalism of much contemporary music. The opposite, or heteronomous position, considers that music functions by conveying specific ideas, thoughts and emotions and is therefore a language. The truth probably lies somewhere in between these positions since music incorporates different modes of listening, for different people, at different times. The question here is whether sonification modifies this listening and if so in what way?

Musical Emotions

Music has always been difficult to pin down. What it is and where it happens, whether it provokes or invokes human emotions has been discussed throughout the history of western philosophy, and music remains perhaps the most enigmatic of the arts. In fact, possibly due to its ineffable nature, for a long time music was not considered as an art in its own right at all. In his book *Introduction To A Philosophy Of Music* (Kivy 2002), Peter Kivy discusses the long-running debate as to whether the emotions, which are undeniably caused by musical listening, are contained in the music itself –whether music is formal, or if it is a metaphorical language with which we communicate about the world. To put it another way is there beauty in the relationship between sounds themselves or is it through cultural significance that musical relationships evoke this beauty?

This in turn begs the question as to whether musical appreciation is innate or learnt. These questions open a vast domain beyond the scope of this thesis. However, in brief, experimental evidence tends to prove that both alternatives are in fact true and co-exist. Babies, even those born of mute parents, prefer (simple) harmony to dissonance (Trehub 2011) and yet it is possible to recognise music of different nationalities through traces of measure and melody that find their origins in a composer's native language. We all have favourite songs which have developed a signification other than purely musical for us (Ball 2010) yet conversely, we can also enjoy 'world music' when experiencing it for the first time and without prior knowledge of the cultural context to which it is normally associated.

Recent research using brain-scanning techniques shows that when we listen to a familiar piece to which we are emotionally attached, almost all the different functional parts of our brain 'light up'. From the primitive cerebellum responsible for the timing and coordination of movement (rhythm) to the hypothalamus that rewards us by producing dopamine, all participate in listening or appreciation to some degree (Levitin 2006, 189 -

192). In accordance with Dennett's theory of consciousness that was discussed in Chapter One, there is no one place where musical emotion emerges or crystallises. Music is experienced in many different ways and on different levels of cognition –reflexive, pre-conscious and conscious– and music is undoubtedly part of the memosphere. Therefore, we might consider that these different hypotheses can co-exist without being contradictory. I will now consider some of these different aspects of musical cognition, before dwelling on those that are most useful in regards to my practice of generating music in real-time.

Hardwired Reactions

Much of what we call our hearing takes place in or beyond the auditory cortex however neurobiologists have shown that there is a short cut, a direct routing between our inner ear and the cerebellum (or reptilian brain) so there is a 'primitive' reaction to sound before it is analysed or interpreted. This connection is to do with startle responses:

> A sudden noise causes us to jump out of our seats, to turn our heads, to duck, or to cover our ears.
>
> The auditory startle is the fastest and arguably the most important of our startle responses. This makes sense: In the world we live in, surrounded by a blanket of atmosphere, the sudden movement of an object —particularly a large one— causes an air disturbance. We perceive this movement of air molecules as sound. (Levitin 2006, 185)

This type of 'reptilian' response has been exploited to musical effect, an example can be found in the Andante movement of Haydn's 'Surprise' symphony: *Symphony n° 94 in G major* as Philip Ball describes:

> Such aural jolts are like a shriek in the library, activating primitive alarm reflexes hard-wired into the brain stem that serve to alert us to danger –The roar of a predator, the crack of a falling tree. Such surprises can be enjoyed when they are revealed immediately to pose no real threat– but, being instinctive, they are also barely dulled by familiarity, since they kick in before they can be suppressed by slower cognitive reasoning (Ball 2010, 261).

There is also a correspondence with a category of sonification, specifically that of alarm sounds. These tend to be loud and abrupt and, as I discovered when interviewing Dr Bruno Debian, would also appear to short-circuit any kind of aesthetic consideration (Sinclair 2011). In the case of the audio environment of the car and therefore *RoadMusic*, the place of audio alerts of various kinds (in-car feedback or external sounds of other vehicles) is a question which cannot be ignored, even if my goal is essentially artistic. In contrast with the relative safety of most situations in which we used to listen to music, there is potentially a *real* threat from large, fast moving objects. Vehicles are more and more insulated and depend increasingly on assisted perception (cameras or proximity sensors for example); the driver's visual concentration is approaching its limits, thus aural perception is of particular interest for the automobile industry in terms of alarms, alerts and general safety. I will discuss this further in Chapter Five.

Mimesis, Memory and Culture

Plato considered that different harmonic modes imitated the passions of the spoken voice, thus music composed in a certain scale might incite bravery since it mimicked the cries and shouts of brave warriors, another mode might correspond to noble peaceful sentiments (Dorian and the Phrygian harmonies). Modes could equally have a detrimental effect on the listener and Plato suggested that the 'soft and convivial Lydian mode should be banned, since it incited 'drunkenness and softness and indolence (Plato 402a)'. Although this aspect of music has been played down in more recent musicology (Kivy 2002, 111-134) it is difficult to deny the existence of anthropomorphically perceived qualities of music; sad music is often slow and heavy, happy music rapid and lively. However, there are limits to this theory and although research has shown that there seems to be a universal perception of simple general moods, it seems to be an incomplete account of the complexity of all the feelings, emotions and ideas that can be provoked by listening to a piece of music. One such emotional response is what Philip Ball calls the 'Proust effect' (Ball 2010, 272). An example is to be found in the movie *Casablanca* when Rick (Humphrey Bogart) forbids his bar pianist from ever playing *As Time Goes By*, since the memories it evokes are unbearable to him. We are all familiar with this phenomenon where special signification becomes tagged to a particular piece of music due to a personal experience. At the other extreme, baroque music applies strict codes to musical form, creating a degree of syntactic unity. In this case, the composer is not expected to indulge in self-expression of any kind but rather to compose according to rules that are responsible for defining the mood. If these 'codes' were intended to be understandable to everyone listening, they are surely undecipherable for the non-initiated

(although as I will develop, they are possibly founded on perceptually efficient mechanisms of auditory scene analysis).

Formalism

Although music has probably always been a vehicle for diverse and subtle perceptions beyond its referential content singled out by Plato, a way of considering them theoretically was first set in motion by Kant's formalism in the second half of the eighteenth century. Kant described music as 'the beautiful play of sensations' (Kivy 2002, 59) and ascribed to music formal beauty inherent in the music itself; even though he considered that its lack of what we might today call 'message', prevented it from being a fully fledged fine art in its own right.

Building on this nascent formalism, the 19th century philosopher and music critic Eduard Hanslick pushed the autonomy of music further suggesting that music, rather than being tied to spoken language was language in itself, a language constructed with its own form and logic, of a different nature from the spoken voice and thus incapable of the symbolism of words. A critic of Wagner, Hanslick campaigned against specific representation and 'cheap' emotion considering that absolute beauty is to be found in the form of the music itself.

> If, instead of looking for the expression of definite states of mind or certain events in musical works, we seek music only, we shall then, free from other associations, enjoy the perfections it so abundantly affords. (Hanslick 1854, 59)

Hanslick's understanding of musical beauty shifts the notion of formalism from structure considered in its entirety or at least in chunks (phrases or sections) and thus in retrospect –a sort of audio architecture, in which symmetry and proportion are paramount– to what composer and philosopher Leonard B. Meyer calls the kinetic-syntactic position (Meyer 1961). I will show how this is of particular usefulness when considering real-time aspects of musical listening and composition.

3.2. Musical flux And Anticipation

One of the particularities of music is that it unfolds in time. Even if we may hold in our memories the structure of a piece after listening to it –allowing a certain form of comprehension *a posteriori*– surely a large part of musical affect and even profound 'understanding' takes place as it unfolds? As described in Chapter One (1.2.1. Multiplicity), Bergson often used music as a metaphor for duration (that aspect of time, which can only be perceived through intuition and cannot be projected as a spatial concept) and the multiplicities that arise from it.

> Might it not be said that, even if these notes succeed one another, yet we perceive them in one another, and that their totality may be compared to a living being whose parts, although distinct, permeate one another just because they are so closely connected? (Bergson 1913, 60)

Philosopher and musicologist Vladimir Jankélévitch, following in Bergson's footsteps, puts it this way:

> Music is certainly no system of ideas to be developed discursively, no truth that one must advance toward degree by degree, or whose implications must be explained, or whose import extracted, or whose far-reaching consequences must be made explicit. Yet despite everything, just as the richness of implicit and latent meaning slumbers within the words of "deep" text, so a "deep" music accumulates within its notes –in a state of reciprocal implication– an infinite number of "virtualities"; just as the whole is immanent, according to Bergson, in each part, so the whole melody slumbers, unfolded, in each harmony. (Jankélévitch 1961, 68)

This is all very well but Bergson was talking about what is happening in our minds, the human experience of immediate time expanding through different scales of memory. How does this get to be within the music? After all music can affect a group of people simultaneously, so it is not purely individual élan vital.

In his 1956 book *Emotion And Meaning In Music,* Leonard B. Meyer offers a *kinetic-syntactic* explanation to this question[63]:

> Music is a dynamic process. Understanding and enjoyment depend upon the perception of and response to attributes such as tension and repose, instability and stability, and ambiguity and clarity. (Meyer 1961, 257)

Because of a previous musical event, a subsequent musical event becomes more or less likely to take place (we know this, according to Meyer, because of our pre-existing knowledge of musical form), thus the significance of a next musical event is dependent on its degree of expectedness. An event that is totally expected is without significance – it is tautology. Taken further and viewed from the position of information theory 'it is the flux of information created by progression from event to event in a pattern of events that constitutes the reality of experience… (Meyer quoting (Coons et Kraehenbuehl 1958)).' This flux then does not just depend on the musical event which immediately proceeds the present one but on the whole string of events since each has an influence in succession or as Meyer puts it: 'the significance of an event is inseparable from the means employed in reaching it (Meyer 1961, 259).'

But why would degrees of expectedness create an emotional response? Meyer's theory is based on the work of philosopher/psychologist John Dewey who considered that cognitive processes, rather than being governed by stimulus and response are decided by circumstances and are accumulative in nature (John Dewey's functional psychology is prior to cybernetics but shares the idea of a feedback circuit which considers a system beyond that of the human mind). In musical terms if, for instance, we are obliged to wait for the resolution of a musical phrase, we will be held in suspense –our expectations are thwarted, and the longer and more tortuous the path to the expected result (resolution) the greater the relief once we arrive at it.

Musical pleasure is therefore related to the answering of expectations, but above all the skilful manipulation of discrepancy with obvious expectations. We are given clues but we

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[63] It should be specified that Meyer makes it clear that he considers that the kinetic-syntactic explanation works with and completes referential and formalist theories of music, rather than being opposed to them.

are not sure what the result is going to be. Like Bergson's freewill and Dennett's evitability our pleasure in listening to music would then essentially come from our being put into a complicated situation of prediction; of exercising our capacity for informed guessing at what is going to come next. Total predictability is boring, just more of the same; being totally lost is frightening and disagreeable, getting a little lost then finding the path and finally making it home is a pleasurable adventure.

This would appear to be in contradiction with the fact that, at least to a certain point, our appreciation of a musical work tends to increase the more we hear it. Meyer provides several arguments for this. In a musical work involving different levels of apprehension, memory and intellect, there is enough complexity for us not to have fully appreciated all the implications of the series of events on the first listening. Human memory is not absolute and we tend to rework, compile and schematize our memories so while some strongly structured passages might be memorized other less evident passages might not. Then there is the Bergsonian weight of memory on the present moment which means that we are never listening to a same piece from the same position since through our experience, our memory is continually changing.

Confounding musical expectation can take many different forms from delaying of a cadence to syncopated rhythms or saturation through prolonged repetition. Meyer's theory works for music where we have learnt the given cultural codes that go with it. It can also explain why musical aesthetics evolve, since in order to maintain a degree of desirable unexpectedness, doubt or surprise to give the successful degree of titillation without the auditor being completely lost, the composer has to keep up with cultural habituation by providing new tricks, deviating from what has become expected.

Meyer's theory is essentially concerned with a conception of music in which the role of culturally determined codes is predominant. It is possible to create a musical program that automatically generates culturally recognisable but always-different musical forms (using Xenakis' symbolic music processes) and indeed *RoadMusic's* more melodic 'instruments' do just this. The bass (*Swingbass*) for instance superimposes 'improvised' notes over a steady riff composed from a modal scale, thus events in the journey disrupt, complicate or enrich what would otherwise be a monotonous pattern (a detailed description of the functionality of this and the other instruments is given in Chapter Five 5.3.5 Instrument Descriptions). The use of (recognisable) melody and rhythm is solely one aspect of *RoadMusic* and I will now turn to a theory of audition that accommodates

both musical and environmental listening without being in contradiction with Meyer's hypothesis. In fact, I would suggest that it ultimately consolidates it.

3.3. Auditory Scene Analysis (ASA): Albert S. Bregman

Meyer's theory provides me with a possible explanation of the origin of pleasure and other emotions intrinsic to music. It correlates with both Bergson's and Dennett's theories of consciousness (our predilection for predicting the future) and furthermore, technically speaking, it is possible to integrate Meyer's ideas as a computer program (I will develop on the way that this is applied in my practice in Chapter Five). The fact remains, that much of *RoadMusic's* music is ambient type sounds or sound events, many of which do not possess the cultural or even the acoustic qualities to which Meyer refers. The aim of this research is to create music that is anchored in the situation and which mediates the terrain that it is traversing. I consider that using only musical notes is not necessarily the best use of sound to serve this purpose. Being of the post Cage, Xenakis and Schafer generation of composers and sound artists, for me the use of non-instrumental sound is quite usual. It is however, more common when working with such sounds to mix them in a studio or prepare them to be played as an instrument in a context where the overall structure of the piece is (more or less) known. In the context of *RoadMusic* this is not the case and what I am seeking is a theory, which like the kinetic syntactic approach to music considers structure as a flux, and simultaneously provides me with a theoretical means to create or incorporate environmental sounds in real-time in such a way that they *constitute art.*

Canadian psychologist Albert Bregman laid out ASA theory in his 1990 book: *Auditory Scene Analysis – The Perceptual Organization of Sound* (Bregman, ASA 1994). This considers that there is a primitive aspect of audition, a sorting level so to speak, which is prior to and independent of cultural influences on listening. It is not however the simple reflex/startle response that I evoked above, rather it is a relatively complex mechanism or collection of mechanisms, which have evolved in response to our environment and possibly to our neurological system. It is an intermediary located between the capture of sound through the basilar membrane and the construction of significance through schematic memory and culture. Bregman does not deny the existence of higher 'from the top down' mechanisms, he maintains however that they are built with and on top of a

primitive segregation, that he calls 'Auditory Scene Analysis'. I shall devote the rest of this chapter to an account of the mechanisms of ASA, since these offer both an analytical approach to sound environment (something that Schafer's theory fails to deliver) and the basis for a (real-time) compositional method that I will unfold in Chapter Five.

> Primitive segregation employs neither past learning nor voluntary attention. It is present in infants and, therefore, probably innate. It partitions the sensory evidence by being sensitive to relations that indicate that parts of the input have come from different sound generating events. These relations tend to be valid cues over wider classes of acoustic events. By way of contrast, the schemas that are involved in schema-based organization have been developed for particular classes of sounds. They supplement the general knowledge that is packaged in the innate heuristics by using specific learned knowledge. (Bregman, ASA 1994, 667)

ASA tackles the following problem: the auditory system in a first instance needs to build mental objects from the real-time data of an incoming audio wave, which is the immediate convolution of all the different sound events in the environment around us (a one-dimensional cross-section so to speak). In a sense, we might consider that this is the point of contact of Bergson's cone.

How does the ear identify coherent auditory objects from this cross section, this simultaneous mash-up of frequencies? How from the immediate incoming vibrations does our mind distinguish those parts of the frequency spectrum belonging to one source from those belonging to another? If it might seem obvious to us that different sound qualities belong to a same source, from the cognitive point of view it is a complex problem. Each sound we perceive is made up of a multitude of frequency components spread across the spectral range of our hearing, so although we know that the first step in auditory analysis (the cochlea) breaks up the incoming signal into frequency bands, it is unlikely that we are able to identify a sound through this mechanism alone. The task of identification is complicated further when multiple sources of sound are present simultaneously. How is it that in a cocktail party we can distinguish the voice of a friend and follow a conversation, while sounds of possibly hundreds of other voices are creating similar and simultaneous

vibrations in the air all of which ultimately combine as a single movement that excites our basilar membrane?[64]

Before we can create signification or identify a source of sound, we have to know which parts of the audio amalgam go together. According to ASA, this segregation takes place in two main categories; these are respectively sequential and simultaneous grouping. We might also call these horizontal and vertical groupings (or in musical terms melody and harmony). These two types of segregation are dependant on multiple and accumulated qualities.

Streams

Bregman employs the term 'auditory stream' as opposed to 'sound' since the identification and perceptual grouping of a sound 'thing' can be multiple occurrences of that sound in time –footsteps for example– or, on the contrary, groupings of multiple different sources –for instance when several musical instruments play the same melody simultaneously. Also, Bregman points out, when we refer to sound it is unclear whether we are referring to the physical phenomena (vibrations of the air around us) or to what we hear: 'It is useful to reserve the word 'stream' for a perceptual representation, and the phrase 'acoustic event' or the word 'sound' for the physical cause (Bregman, ASA 1994, 10).'

The auditory stream is the grouping together of qualities around an 'it' (in the sense that we can know that an 'it' exists before being able to name it) the equivalent in visual perception being: 'it is red, it is close, it is moving'. Streams are the identification and correlation of qualities that permit the subsequent construction of auditory objects[65].

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[64] 'This cocktail party problem' was first identified by Colin Cherry (Cherry 1953).

[65] Although Bregman's stream principle shares with Pierre Schaefer's/Michel Chion's definition of 'Sound Objects' the integration of multiple (abstract) qualities (unlike musical notes which are principally defined by pitch and duration) here we are dealing not with a categorisation of sounds, considered as collected or observed specimens but rather with the brain mechanisms that allow us to identify events as they unfold. And to situate Murray Schafer's 'Sound Events', Bregman's stream theory is principally concerned by those lower level mechanisms which participate to allow us to construct coherence 'a computational stage on the way to the full description of an auditory

Gestalt

Bregman's ASA is built on Gestalt psychology (with some important differences that I will explain below) and applies many of the principles originally used to explain mechanisms of visual perception to our hearing. Perhaps the most important of these is the principle of 'belongingness', which maintains that we always allocate a property to something. The allocation may shift but it is not (in general) allocated to two objects at the same time. A well-known visual demonstration of this occurs in the illustration of the vase/face.

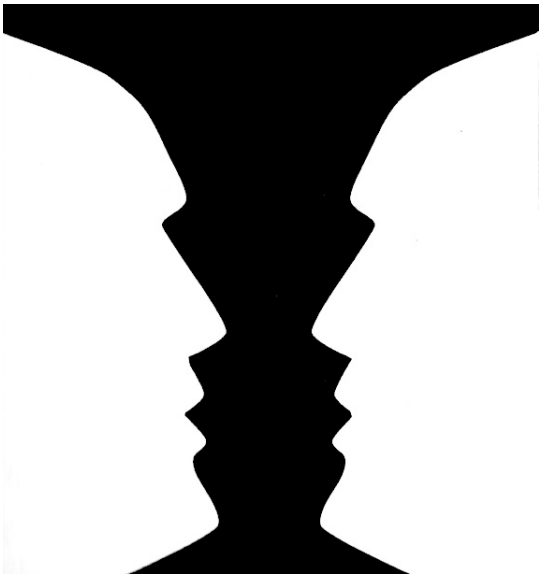

Figure 3-1 : A vase or two faces? (source Bregman, ASA 1994, 13)

In this example when we look at the image, we allocate the outline to the vase shape or to the face shape. This is a useful perceptual tool since it is unlikely in the 'real world' that two shapes will have a same and matching outline; the closer object will normally be cut out against the background object.

Allocation of properties also takes place in audition. Bregman has conducted exhaustive experiments to demonstrate how we segregate sounds into different streams and how we allocate different properties to single streams. I will mention a few here because they

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event.' and not by the signification, contextualisation or categorisation which appear at a higher levels of consciousness.

clarify what might otherwise remain abstract ideas. However I am above all interested in the results and conclusions of this research, what these suggest about our perception of audio environment and the way they can be applied to the creation of an artificial (musical) one. My hypothesis is that composing based on such a theory might conceivably produce a result, acceptably coherent with the 'real-world' and not necessarily built on musical convention.

Bregman uses examples of auditory illusions (where participants mistakenly construct a pattern) to prove that a process of building descriptions is taking place: 'Only by being built could they be built incorrectly (Bregman, ASA 1994, 16).' A subject is played a repeating sequence of pure tones (sine waves) such as that shown in Figure 3-2.

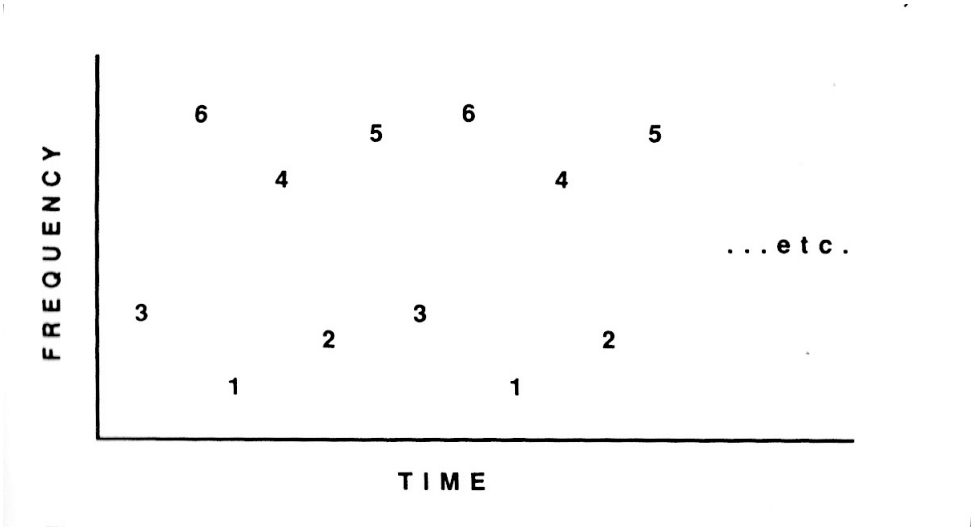

Figure 3-2 : A repeating cycle of six tones, of the type used by Bregman and Campbell (1971) (source Bregman, ASA 1994, 17)

If the sequence is played slowly the listener will hear the single sequence 142536142536… but as the sequence is speeded up a phenomenon occurs where the listener starts to hear two separate and parallel sequences 1-2-3-1-2-3- … and 4-5-6- 4-5-6- 'as if two instruments were playing different but interwoven parts (Bregman, ASA 1994, 17).' This perceptual grouping increases with speed until it becomes impossible for the listener to concentrate on both streams at the same time –rather one is heard and reported in its correct order while the other is heard as 'background'.

Another thing our vision does is to create continuity: if the central part of a form is obscured by another, apparently closer, form we 'fill in' the invisible part. Faced with a 2d line drawing we mentally assume that what actually appears on our retina as three different forms is one form obscured by another. In audition, masking and continuation function similarly: We continue to hear a soft sound when it is masked by a louder one (such as a simple tone and a burst of white noise). An illusion of this continuity also exists: if we remove the part of the signal that is masked we continue to hear the non-existent part of the tone as if it continued covered by the white noise.

Grouping happens according to what goes best together. There is competition to decide to which 'it' a quality is attributed. The example of the vase and the face demonstrates an ambiguous borderline between two possible solutions but a more common scenario is that our perception avoids this ambiguity through an accumulation of weighting across the perceptual field where allocated properties bind to designate the 'it'. For example, if one were to add shading to the vase, the choice of figure would cease to be ambiguous.

ASA And Gestalt

Gestalt considers perception purely from the point of view of mental process and construction –the identification of pattern. Gestalt psychologists considered the mechanisms to be automatic, physiological functions of the brain: perception comes first and then the world is subjected to that perception. ASA on the other hand, considers that these same mental phenomena or mental constructions are related to the environment; that our perception has evolved and adapted to the way in which real world objects produce sounds. From incoming raw data, we group what we group because there is a likelihood that this corresponds to the 'real world' behaviour of an object:

> The internal organs of animals evolve to fit the requirements of certain constant factors in their environments. Why should their auditory systems not do likewise? (Bregman, ASA 1994, 39)

An example of the difference between Scene Analysis and Gestalt can be found in the explanation of the phenomena of apparent movement in lights (the phi phenomena which I described Chapter One 1.2.2. Heterophenomenology), where two flashing lights, or dots on a screen, are perceived in continuity as a single light moving from one position to another. This illusion is dependent on conditions of frequency and distance, the inclusion of lights in a stream only taking place above a certain threshold of flashing speed. The

Gestalt explanation for this is physiological: our visual sensors cannot keep up with the flashing and an artificial interpolation is created between one signal and the next; the intermediate movement is 'filled in' with a best guess because our optical-neural system has a minimum refresh rate. But when the physical distance between the luminous points is increased, the time interval between flashes accepted as being part of a stream also increases, as if the luminous point needed more time to 'jump' a greater distance (Körte 1915). As shown by the experiment described above (Figure 3-2), a similar phenomenon takes place in audio perception: we will have a greater tendency to include notes with a big difference in pitch in the same stream if there is a long temporal interval between them (as if they were continuous variations in pitch being interrupted by something).

The ASA explanation for this phenomena accepts that there is a mental interpolation taking place but proposes that rather than this being a purely physiological process, it is a mental architecture which has evolved to allow accurate 'guessing' about the 'real' source of sound and its behaviour in the environment. Thus, bigger jumps in pitch are acceptable if there is a longer time interval between them, because very rapid changes in pitch are unlikely to be coming from a single physical object. Therefore if what we are hearing is a single sound source masked for a short period of time, the corresponding increase in pitch is likely to be small whereas a longer period of masking would allow for greater change.

Other low level perceptual mechanisms segregate or group other parameters of sound, (amplitude, directionality, timbre etc.) according to criteria of coherence with physical realities. Attribution of properties contributes towards heuristic[66] deductions: two sounds are assimilated into one stream because they are close in fundamental frequency *and* they have similar timbre or because *although* they have different frequencies they start at exactly the same moment. It is as if there was a voting process whereby the (unconscious) decision to include elements in one stream rather than another is decided by the number and the loudness of voices expressing the same opinion albeit for different reasons. It is similar concept to the 'Pandemonium Selection' that Daniel Dennett identifies (see Chapter One 1.2.2 Memes and The Joycean Machine**)** and indeed ASA segregation and inclusion can be considered as a specific mechanism of multiple drafts. Thus, collaboration as well as competition accumulates towards inclusion in a stream. If this

[66] A technique used in computer programming, based on probable rather than absolute solutions.

basic mental architecture is innate; according to ASA, it has evolved to recognise common characteristics, of our environment most likely to provide an accurate representation of our world. This is an important consideration in regards to the design aspects of *RoadMusic*. It means that rather than building on a basis of culturally defined musical aesthetics, we are discussing a fundamental structuring principle, which finds its origins in the reality of the environment itself.

Grouping can be *simultaneous* or *sequential* –simultaneous integration is a decision as to which parts of the spectrum arise from a single sound (for example a voice) while sequential integration concerns decisions about continuity of recurring sounds (for example: a sentence) or changing sounds over time (for example a word)[67].

Sequential Grouping

Globally speaking what links separate sounds together as a sequence is similarity and closeness. However, as in the example shown in Figure 3.2. types of closeness can also compete: temporal proximity is normally a stream reinforcing factor but if there is a big difference in pitch between the sounds of a sequence reduction of the time interval between notes will work against integration. The 'steepness' of the jump between notes becomes the segregating factor. Proximity in pitch is also, in general, a factor favouring stream integration –however if this works with pure tones (single frequencies), two complex sounds with identical fundamental frequencies but a different harmonic structure or timbre[68] will tend to segregate. 'Common fate', on the other hand, the fact that a

[67] Recorded audio demonstrations of these effects can be heard on the McGill University's ASA website (Bregman, Audio demonstrations of auditory scene analysis 2012).

[68] An elusive quality that designates the characteristics of a sound aside from its amplitude and fundamental frequency. In this instance timbre might be considered as the 'weighting' of spectral components —a bright tone will have more energy in its higher harmonic components— and their stability or lack of stability (noisiness,) over time. Timbre might also be considered as the accumulated characteristics of the vibrating body of a sound source and the resonators that the sound traverses (the vocal cords and the vocal tract, or dripping water and a cave or indeed a refrigerator and a kitchen). Finally it has also been suggested timbre cannot be considered correctly without including timbral envelope (the separate evolution of different spectral elements over time) (Smalley 1997) and which are essential in creating the identity of musical instruments. Bregman recognises the importance of this spectral morphology and indeed more recent research,

quality or qualities of different parts of the audio spectrum evolve in a proportionally similar way over time –for instance a group of changing frequencies maintain the same harmonic ratio– has a strong effect on integration as a stream. Micro modulation, or tremolo in musical terms, is a special case of common fate where this commonality of the variation of frequencies (in a voice for example) creates a strong stream identity.

Duration effects segregation, all other considerations being equal, the stream will have a greater tendency to segregate if it continues over time –as if the recent memory accumulated as 'evidence' contributing to this segregation. This factor of stream reinforcement over time might conceivably be considered as being schema based or learnt, since it involves an element of memorisation. However, in more recent research using neurological monitoring techniques, subjects who were played three short repeating sequences simultaneously, while attending to another task (while not paying attention to the sounds) registered a brain reaction to a slight change in pattern of one of the sequences (this automatic recognition of difference only works with a short sequence of notes). Similar experiments have shown brain responses to breaks in pattern in sleeping infants and non-human animals.

Sequences of sounds exist in nature and it is easy to understand the advantage of being able to relate similar, repeating sounds in order to be able to consider them as a perceptual object (footsteps or words for example). However sequential grouping is also particularly important in listening to music –it would seem that rhythm and melody are based on the segregation of sounds into streams this might seem paradoxical but we can only include in a melody (be able to follow it as such) notes which are 'accepted' as part of a stream. Finally, the number of streams that we can segregate and those that we actually pay attention to are two different things. If it is difficult for a musician to pay attention to more than three streams at the same time; we can perceptually distinguish far more (Bregman gives the number as six).

> But the existence of a perceptual grouping does not imply that it is being attended to. It is merely available to attention on a continuing basis. Metaphorically speaking, it holds up its head to be counted but does not do the counting. (Bregman, ASA 1994, 465)

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relating ASA to Sonification investigates the influence of temporal variations in tone on expressivity (Barthet, Kroland-Martinet et Ystad 2007).

Returning to Dennett's *heterophenomenology*, it is noteworthy that in the context of audio and musical perception a large chunk of what we experience does not make it as far as the *Joycean Narrative* but in spite of this partakes our audio awareness and in our musical appreciation. It is also an important point in relation to potentially informative aspect of *RoadMusic* and the possibility that a subliminal aural perception of the driving situation might alleviate perceptual saturation. I will discuss this further in Chapters Four and Five.

Simultaneous Grouping

Probably the most obvious factor that influences simultaneous grouping is synchronized onset. If different spectral elements start at the same time, they are likely to be considered as (and indeed in the 'natural' world probably are) emanating from the same source. This is a strong factor in grouping; for instance, two sounds with different spatial locations will tend to be grouped as one diffused source whereas the same sounds with a slightly different onset will be perceived separately. Resonating bodies tend to produce harmonic structures with a similar ratio of partials (also known as harmonics, overtones or formants); a series of frequency peaks multiples of the fundamental frequency forming a predictable pattern. Our auditory system recognises these patterns and groups partials with their corresponding fundamental as one sound. Thus, the audio spectrum will tend to be segregated into as many fundamentals and their subsequent harmonics as are identifiable. This is one of the mechanisms that allow us to separate different notes (each of which is a harmonic series) playing simultaneously.

In music, simultaneous onset is important in perceptual grouping, particularly in the case of different instruments playing together as one virtual source. Experimentation has been carried out to determine temporal and frequential distances below which fusion is compulsory. However, fusion is largely dependent on relative lengths of silence between events. Sounds following a long silence will have more of a tendency to form a vertical perceptual group:

> The auditory system appears to form clusters by demanding that the within-cluster separations in pitch and time be smaller than between-cluster separations. (Bregman, ASA 1994, 473)

Horizontal and vertical integration functions are influenced by different properties of sound. Although in some cases these properties overlap they can also compete in terms of

grouping, for example a sound which is included in a horizontal stream is unlikely to be included in a separate simultaneous grouping (although it is possible to have a vase and face type of ambiguous situation). In certain cases occurrence of simultaneous grouping can cause cessation of an existing stream: the horizontal grouping 'steals' an element from the previously identified sequence. However, Bregman has also identified an 'old plus new' heuristic whereby if a spectrum becomes more complex, especially if this occurs suddenly, ASA will extract the previously identified elements from the new mixture hearing the new mixture with the old components subtracted from it.

Horizontal and vertical discriminations form the basis of the architecture of *RoadMusic* not only of the musical result but also in the way in which the program analyses and modifies the incoming data. In the data control part of the program these are called *streams* and *events*. Streams are segregated by separating a signal from, what on a given scale, is considered as noise (for example, road surface from relief) and events are notable changes or incidents (for example, a change in colour or a bump). These are mediated through audio synthesis respectively as variation on continuous audio streams (continuous flux or patterns) and as the generation of musical events (such as a percussive sound) or notable changes.

Returning to ASA, sequences of different types of sounds (whistles, buzzes, hisses for example) integrate less. When listening to an unknown sequence of different sounds, it is likely that these sounds will be considered individually or as sub-sequences that are gathered not in chronological order but according to their family. They will tend to group with the sounds most similar to them and not necessarily those that are temporally closest. This suggests that within a stream sequence we might have a more subtle parsing of difference and change between occurrences of sounds within that stream which in turn would offer an explanation for an innate attraction to melody and rhythm –bearing in mind that in order to consider these as such, they first have to be integrated as a stream.

Our naturally occurring audio environment is constituted more of continuous sounds than of sequences but being able to integrate repeating sound events is clearly a highly useful function. Grouping footsteps, birdcalls or a branch creaking with the wind, as issuing from the same source is evidently necessary if we are to subsequently derive information about them over time. If each footstep is taken alone as a separate entity, it will not enable us to build a model of what is going on around us whereas knowing that the latest occurrence of a footstep belonging to the same animal or person is getting closer is

potentially useful to survival. Once a stream is formed, the information resides as difference or transformations of a same 'it'.

Thinking in terms of stream inclusion / exclusion, is particularly useful in the case of *RoadMusic* where different modules or instruments (potentially thirteen) share the same acoustic space. Independently of their purely musical role, these streams sonify different aspects of the unfolding situation. Employing these principles of stream segregation and integration helps me to reinforce their identities and consequently use them to vehicle subtle variations on a larger time scale.

Virtual Sounds

Emergent properties are born of the grouping of individual elements into a higher order of organisation, an analysis on a larger scale (the bigger picture). '…we can compose a sound that is voice-like, despite the fact that not one of the sine waves that composes it is voice-like (Bregman, ASA 1994, 459)'. In the natural environment, our auditory system groups different properties to identify (or second guess) a single sound source. This is called natural assignment. Chimeric assignment can also occur where sound parameters from two or more different sources are 'mistakenly' assigned to the same stream. 'Natural' hearing has evolved to avoid this happening as far as possible; music on the other hand deliberately creates chimera; Xenakis' clouds of sound are a prime example of chimeric assignment.

In the case of computer music, this relationship is modified: all the sound sources are virtual, that is they are not generated acoustically by objects but rather by calculations. When they are transformed into acoustic waves by vibrating membranes, it is, at least with stereo sound, in a virtual sound space –although there are two audio signals coming from two loudspeakers, we hear separate sounds positioned somewhere in between or even beyond the two. The chimera definition becomes less evident, since although there might be an addition of different oscillators, this is not apparent: there is no visual information, *a priori*, to confound the auditory and possibly no cultural reference either. Whether one hears additive synthesis (the accumulation of single frequency waves) as a single audio stream or as several different ones, is not influenced by considerations such as the presence of several individual instruments, or the inevitable variations in their renditions. Technically speaking, when using digital audio techniques, any source can be combined seamlessly with any other, thus what binds to become a stream and what does not can arguably be considered from a purely perceptual point of view. As Bregman

points out, there is a danger when composing electro acoustic music, which is that what the composer considers as a sequence through his own conceptual schematization might not respond to primitive ASA and that in order for a listener to recognize it as form it might therefore require multiple auditions.

In the case of the synthesized sounds which I create in *RoadMusic* the question of real or fictitious is ambiguous –the synthesis is initiated by the 'real life' situation so there is an anchor which is neither virtual or imaginary and which is corroborated by our tactile and visual senses. However, the sounds are virtual in the sense that the way they are constructed and combine is acoustically arbitrary. Bregman's advice is particularly useful pertaining to a method of composition in real time, since repeated listenings are out of the question and the composer disposes only of a general idea of what the captured data will be, therefore each sound has a life of its own. Bearing in mind the rules of ASA allows me to have a better idea of how an individual sound in a mixture of sounds is likely to be perceived, even when that sound is subject to variation[69].

As discussed above timbre is a factor effecting stream integration. If melody is considered as information (difference) in that case, the timbre of the instrument can be considered as the carrier of that information. That having been said it is also possible to inverse this role: detaching timbre from melody is also a compositional 'effect' which can be obtained by playing a single melody with successive different instruments (klangfarbenmelodie), thus essentially revealing difference in timbre. Webern in his orchestration of *The Ricercar* from *The Musical Offering* makes considerable use of this principle (Berliner Philharmoniker 1995). In *RoadMusic,* timbre plays an unusual role. As I explained briefly in the introduction and as I will explain in more detail in Chapter Five, it is permanently modified by variations in the road's surface and other vibrations of the car body or movements of the car. This applies to almost all the 'instruments' and in some cases, it characterises the foremost variation of the audio stream. In such cases, a simple repetitive melody or rhythmical pattern becomes the carrier of this timbral information (the sound of the road).

Consonance-Dissonance

Helmholtz explains acoustic dissonance[70] as the degree of perceived roughness that increases with spectral complexity due to the beats or fluctuations that occur when non-harmonic spectral elements are juxtaposed. Thus one might expect that fusion between notes with a simple harmonic ratio –having a common or related fundamental– would be stronger than between notes with a more complicated one, and indeed this is the case. What is less easy to understand and conceivably paradoxical is that it is it is possible to perceive dissonance. If fusion is dependent, as some musicologists have suggested, on the harmonic ratio being consonant, how is it that our perception does not simply separate out the dissonant elements into as many separate streams rather than hearing them as a dissonant whole. According to Bregman this is due to the weight of other factors which reinforce integration. If the harmonic relation between notes is complex, but qualities such as simultaneous onset, common fate or proximity in pitch are present (as in the case of a dissonant chord) and lending their 'vote' to identify a single sound-object, the different spectral elements will be incorporated as roughness rather than separate sounds. Thus, fusion or integration is necessary for dissonance to exist. This again is useful information when composing (as is the case with *RoadMusic*) with dissonant (noisy) sounds.

3.4. Conclusions

I have considered in this chapter some of the many ways in which music is perceived. I passed rapidly over such mechanisms as startle response and mimesis to concentrate essentially on two theories, which I think, are complementary and which are germane to my project and to sonification in general. L.B. Meyer's kinetic syntactic theory provides me with an approach to musical perception that eliminates the need for a preconceived plan of a musical piece. Like Bergson's multiplicity or cybernetic feedback, the appreciation of the note currently being played depends on the path taken to reach it. This

[70] Psychoacoustic dissonance as opposed to musical dissonance, which is at least in part a question of convention and taste.

is clearly appropriate for *RoadMusic* where musical construction is indeterminate in regards to its duration and literally dependant on the path taken.

ASA possibly helps to explain some of the more mysterious aspects of musical perception in that it identifies some of the mechanisms at work in what might be called a preconscious level of cognition. A level where our mind is working hard to make sense of the world, without bothering that relatively thin upper layer which is the 'desktop' of our awareness. Bregman posits that musical syntax arises from an auditory system, which is essentially an adaptation to our audio environment. This provides me with an opening to rethink this order, when placing music as environment and provides a theoretical basis for composition that can incorporate different types of sound. Thinking of the overall audio mix in terms of qualities that participate in the inclusion or exclusion in streams is an appropriate method when composing for real-time where characteristics can be programmed in advance but the actual result is unknown as is the case with *RoadMusic*. Finally as I will develop in the first section of Chapter four, sonification of environments almost inevitably leads to some design questions relating the source of the data to the generated sound. I consider that the rules of Gestalt and ASA are a valid background to this reflection.

4.Chapter Four- Artistic Sonification and Environments

4.1. Introduction to Chapter Four

Sonification –using data to generate or vary sound– is the term given to the principal technique employed in *RoadMusic*. In this chapter, I will discuss practical, conceptual and artistic concerns arising through the use of sonification, in particular, when it concerns environmental data. I will consider sonification works by fellow artists, paying attention to the case of real-time data sonification and I will extend the chapter to take into account the special case of mobile media systems.

Conveying information through non-verbal sound has a long history. Alerts and alarms ranging from the sounding of the post horn or the chiming of a clock to the warning given by a siren might be considered as precursors to sonification.

> The post horn also employed a precise code of signals to indicate different types of mail (express, normal, local, packages) as calls for arrival, departure and distress and indications for the number of carriages and horses –in order that the changing stations might receive advance warning (Schafer, 1977, p. 47).

We can recognise the traits of auditory perception that make it particularly well adapted to these types of signals: hearing is both omni-directional and always available; we cannot close our ears, even when sleeping. As described in Chapter Three (3.1. Hardwired Reactions), we are 'hardwired' to react to loud sounds, but ASA shows us that there are other primitive mechanisms at work, distinguishing variations in multiple streams, without demanding our conscious attention. There are clear advantages in exploiting these faculties in an environment where our visual attention is increasingly monopolized by electronic screens or other technical tasks such as driving.

A well-known example of sonification is the Geiger counter where the frequency of clicks designates the intensity of radioactivity. The nature of the clicking sound of the Geiger counter is the result of its pre-digital electronic circuits, today however, sonification almost inevitably involves choice: that of what sound or which variable parameters of sounds to map to otherwise silent data.

4.2. The semiotics and Aesthetics of Sonification

Sonifications are pervading our environment and the necessity to distinguish between them is giving rise to complex and sophisticated techniques where analysis of function, and subsequently design, play an increasingly important role. To give another familiar example, a mobile telephone no longer ‘rings’ but notifies the user by playing a specifically chosen sound, which distinguishes his or her telephone from those of others. It probably plays different sounds for different types of alerts (or even to identify different callers) and beyond this, recent 'smart phones' provide carefully tailored feedback sounds for touch screen functions.

Different principles or techniques of sonification can be identified:

Audification (Kramer, 1994, p. 152) is the direct transposition or transduction of a signal into the audio domain. Audio-biofeedback is an example where sensors connected to a subject’s muscles or skull capture electrical impulses that are amplified directly and played through a loud speaker as an audio signal. It is also a technique exploited by several artists (myself included) often because it is perceived as being as close as possible to the physical reality of captured phenomena.

Mapping Based Sonification modifies parameters of a sound such as pitch or amplitude. An example is the pulse-oximeter that monitors a patient’s blood oxygen saturation as pitch and pulse rate as tempo (Sinclair, Living With Alarms, 2011). This is also perhaps the most obvious method for creating musical sonifications since MIDI based, digital music systems (see Chapter Two 2.2 Symbolic Music) are inherently adapted to accept a variable input driven by data.

Auditory Icons have a symbolic relation to an action they represent, examples are to be found providing feedback on personal computers, for example: the sound of crumpled paper falling in a waste paper bin used to indicate that a file has been moved to the trash folder.

Earcons (Sumikawa, 1985) are usually short tones, combinations of tones or simple melodies an example might be the jingle preceding an announcement on the PA of a train station.

Spearcons are time compressed speech samples, which can be played at speeds where they are no longer recognizable as words. They represent the advantage of being non-arbitrary, easy to create and easy to learn.

Simply from these definitions, it is apparent that sonification design is approached in different ways. Indeed, the numerous aspects of audio and musical perception evoked in Chapter Three represent an equal number of possible sonification tactics. In the technical and scientific domains sonification has shown rapid development to a point where units such as: The Sonification Lab at Georgia Institute of Technology (Georgia 2011) Or The Sonic Communications Research Group at Canberra University (SCRG 2011), designate it as the focus of their research. The Laboratory of Mechanics and Acoustics, in Marseille, France have developed a 'intuitive control' synthesizer, which takes as input parameters the projected qualities of an object: materials (plastic, wood, metal) and dimensions (as opposed to notes for example). Their hypothesis is that these can be used to create perceptually relevant audio feedback to sonify interaction with virtual objects (Aramaki, et al. 2009). Scott Gresham Lancaster's research project at IMERA (Mediterranean Institute for Advanced Research) proposed varying elements in an existing musical environment as a way of carrying information.

> Imagine researchers monitoring on-going experiments or researching systems that are made up of extremely large amounts of data, listening to music of their choice that is being discernibly modulated by the real time information as it flows through that given network (Gresham-Lancaster, 2012).

It is interesting to note that these specialised groups show an interest in artistic and musical use of sonification, going as far as to produce artworks. Examples are: 'Listening to the mind listening' organised by SCRG (Barass 2004) or a project involving legendary musician and sound artist Laurie Anderson, sonifying the movement of fish in an

aquarium at GT Sonification Lab. It would seem that from the starting point (discussed in the Introduction) of sonification being considered as quite apart from sound art and music there has been a gradual recognition of the fact that to a certain extent it is all "organised sound" (see footnote [24]).

Paul Vickers is a Reader in Human Computer Interaction at Northumbria University who specialises in Sonification. He develops and defends this position in his 2006 paper *Sonification Absraite/Sonification Concrète: An Aesthetic Perspective Space For Classifying Auditory Displays In the Ars Musica Domain* (Vickers 2006). Vickers argues that music is inherently the realm of audio expertise and suggests that musicians, in particular, have the knowhow to engage in sonification design. He correlates different approaches to composition with different forms and concepts of sonification.

This ties in with my research since in *RoadMusic* there is an important design factor, which involves making the music intuitively consistent with the journey (see Chapter 5.3.6. Evolution Of Compositional Process). In *RoadMusic,* the tailoring of sound to function is inseparable from the musical result.

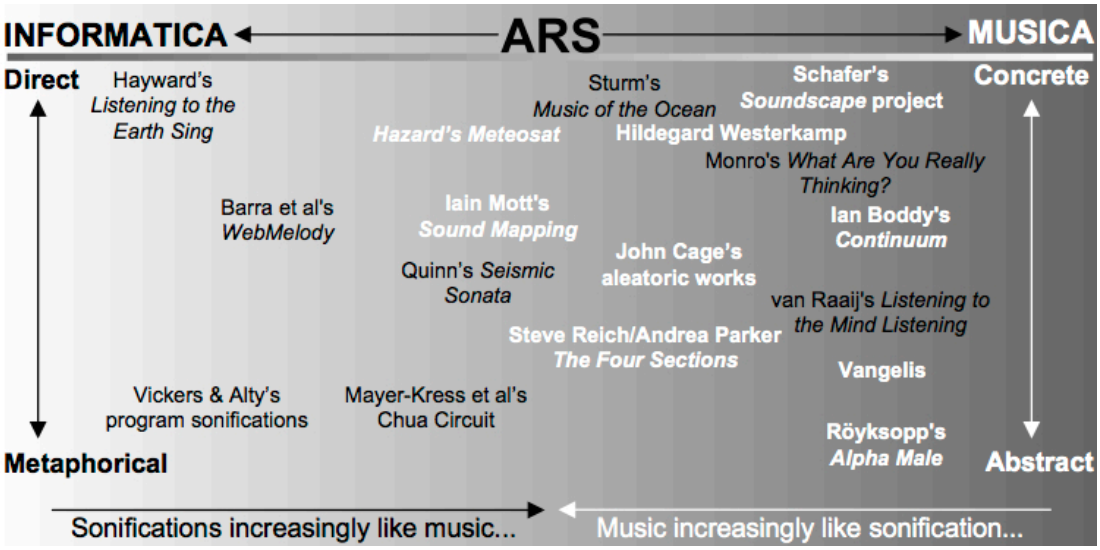

Figure 4-1: Paul Vickers: Source Proceedings of the 12th International Conference On Auditory Display, 2006.

Figure 4-1 shows Vicker's coordinate system with two double-ended axis Ars Informatica-Ars Musica and Concrete-Abstract. The Concrete-Abstract axis he proposes might be considered as a slider between Schaeffer / Chion's "causal listening" and

"reduced listening" discussed in Chapter Three (3.1. Autonomous Versus Heteronomous Music). Their theory and indeed the corpus of electroacoustic and concrete music can teach a lot to the sonification designer. For example, LMA's synthesizer cited above, can create sound objects through the abstraction of acoustic qualities that do not have a physical (object) counterpart in the 'real' world but sound natural. This research might be considered in the lineage of *musique concrète's* classification of sound objects.

Vickers proposes that a Schaferian approach is useful for the designer of sonifications; that a 'soundscape[71]' listening/composing attitude, is likely to produce successful sonifications:

> What then becomes important for sonification designers is not how 'musical' their work sounds, but how easy they have made it for the audience to listen to it, and by listen we mean 'attend carefully'. (Vickers, 2006)

From the ASA point of view, as I have shown in Chapter Three (3.3.), it is possible to consider composers and musicians as experts in the manipulation of the auditory scene and our fundamental principles of audio segregation / integration. Consequently, I find Vickers arguments for the inclusion of musical culture in the design process of sonification convincing. He pursues his reasoning to conclude that there is no distinction between sonification and music per se, but rather that it depends on the listener's position or the creator's intention. While it would be impossible for me to disagree with this, in the light of the radical musical positions documented in Chapter Two (such as Cage's *4'33"*), my approach here is a different one, since my hypothesis is that data sonifcation applied to music might bring about a change in the artistic paradigm. If Vickers' arguments shed some light on formal relationships between sonification and music, they do not answer what I consider as equally important interrogations when considering an art of sonification, which are: what data is sonified and why? A significant part of this chapter will be dedicated to reviewing how different artists respond to these questions.

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[71] "The sonic environment. Technically, any portion of the sonic environment regarded as a field for study. The term may refer to actual environments, or to abstract constructions such as musical compositions and tape montages, particularly when considered as an environment (R. M. Schafer 1977, 275)."

Significantly, perhaps, many of the sonifications that Vickers cites as musical or artistic were produced as part of scientific research programs into sonification (for instance *Listening to the mind Listening* by Stephen Barrass or *Seismic Sonata* by Marty Quinn – see Appendix One). In these cases, the original motivation behind the use of data is the research project itself and is therefore a priori non-artistic. If this takes nothing away from the artistic potential involved in 'crafting' the sound, it is a different situation to that of the artist who has made a spontaneous choice to use sonification for a specific project or in a specific way.

4.3. Sonification - What Where How Why

Taking a different approach to artistic sonification, in March 2010 I organised and chaired an international symposium entitled *Sonification- What Where How Why: Artistic practice relating sonification to environments*[72]. I made the choice of restricting the subject to sonification and environments since my research specifically interrogates the use of data flux as a potential vector to the world outside the artwork. I also felt it was necessary to restrict the field, since artistic sonification can also be considered to include the vast domain of electronic instrument design and human / computer interaction. While being rich in creative terms, this is beyond the scope of this research and already well documented[73].

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[72] The symposium was organised through Locus Sonus – *Audio in Art*, ESAA Ecole Superieure d'Art d'Aix-En-Provence, ENSAB Ecole Nationale Superieure d'Art de Bourges. Co-directors; Jerome Joy, Peter Sinclair. In collaboration with:

CRISAP: Creative Research Into Sound Art Practice, LCC, UAL University for the Arts London. Co-directors; Angus Carlyle, Cathy Lane.

MMSH: la Maison Méditerranéenne des Sciences de l'Homme, LAMES CNRS-Université de Provence. Director Samuel Bordreuil.

IMERA: Institut Mediterranéen de Recherches Avancées. Represented by Roger Malina.

[73] NIME (New Interfaces For Musical Expression) an international symposium dedicated to the subject has been held annually for over a decade (NIME 2012).

Contributions explored a broad range of artistic practices (composition, performance and sound art), scientific research (astrophysics, sociology) and theory related to artistic practice (philosophy, art history) My aim was, not so much to adopt a curatorial or critical stance, but rather to provide a survey of the field. Participants in the symposium were asked to take into consideration the following questions:

- What distinguishes sonification from other forms of data mediation?
- What are the different ways in which sonification is used in art?
- What parallels, similarities, differences & contradictions exist between the use of sonification or audio display for technical & for artistic purposes?
- What differences in the artistic approach does the use of real-time as opposed to recorded data imply?
- What is the importance of the relationship between the source of data and the way in which it is mediated?

As a follow up to the symposium I was invited to guest edit a special issue of *AI&SOCIETY,* published in May 2012 and bearing the same title as the symposium (Sinclair, Sonification - What Where How Why, 2012). In addition video documentation of the presentations and debates is available on the Locus Sonus website (Locus Sonus, 2013) and video interviews of participating artists, responding to a fixed set of questions on my own website (Sinclair, Research 2011).

The following artists and researchers took part in the symposium and/or contributed a paper for the special edition: Lorella Abenavoli (Artist, Quebec); Stephen Barrass (Researcher - Canberra University); Samuel Bordreuil (Sociologist – Director LAMES Mediterranean Laboratory of Sociology, CNRS, France); Jens Brand (Artist - Germany); John Eacott (Composer, Researcher - University of Westminster UK); Angus Carlyle (Researcher - Co-director, CRISAP, LCC, University for the Arts London); Jean Cristofol (Epistemologist - Aix-en-Provence School of Art); Peter Gena (Composer - School of the Arts Institute of Chicago); Scot Gresham-Lancaster (Composer, Researcher - California State University USA); Scott Fitzgerald (Artist, Researcher - Locus Sonus, France - New York University, USA); Florian Grond (Artist, Researcher - Bielefeld University, Germany); Jerome Joy (Composer, Researcher - Locus Sonus, France); Stuart Jones (Composer, Researcher - UK); Roger Malina (Astrophysicist - Director, IMERA, France - NASA, USA); Andrea Polli (Artist, Mesa Del Sol Chair of Digital Media - University of New Mexico, USA); Marty Quinn (Composer - Design Rhythmics Sonification Research Lab, USA); Richard Kroland et al (Researcher - Laboratory of Mechanics and

Acoustics, CNRS, France); Atau Tanaka (Composer, Researcher - Culture Lab, University of Newcastle upon Tyne, UK); Victoria Vesna (Artist, Researcher - UCLA, USA); Valentina Vuksic (Artist, Switzerland).

Brief descriptions of a key art works by participating and other artists are provided in Appendix One: Sonification Works.

4.3.1. What Data

One of the questions posed in this thesis is 'How is it possible to mediate the situation as it unfolds in such a way that it constitutes art?' Beyond (or before) questions of design this leads me to ask: What of the signification of the data itself? Additionally: What of the situation and circumstances in which the sonification takes place? In the following section, I will describe some of the ways that the significance of data appears in sonification works. In many cases, these are in a conceptual continuum with the ideas and techniques developed by the composers cited in the Chapter Two who sought the emancipation of (their) music in regards to (their) expression in the middle of the last century. Digital technology makes this all the more feasible since it can mediate the everyday, render audible the imperceptible or anchor artistic form in real-time and in real-place.

Program Music

If taken from the technical point of view, sonification might seem to fall on the side of heteronomy since according to the definition cited at the beginning of this thesis (Introduction, Sonification), sonification conveys information. As discussed in Chapter Three the extreme heteronomic position in music (Wagner for example) has been abandoned for some time and yet it seems difficult to place a sonification in the category of absolute music –music which is completely self contained and autonomous– since we might assume that the data itself is automatically a source of signification of some sort.

Program music appeared in the nineteenth century and consisted of a symphony accompanied by a text that can vary in complexity from a simple title (for example *Tragic Overture* as opposed to *Symphony n°...*) to a text several pages long, pertaining to the composers' intentions (for example Hector Berlioz's *Symphonie Fantastique*). According to Peter Kivy this evolution can be traced to the influence of German philosopher G.W.F. Hegel '…who decreed, at the time the status of music as a fine art

was being debated, that absolute music could not be a fine art without a content and could not have a content without a text (Kivy, 2002, p. 192).'

I propose this idea can be applied to certain sonifications where the art emerges as an articulation between the symbolic nature of the source of the data driving the sound and the sound itself. I would venture to group these works into the category of conceptual art[74], since it would appear that the idea behind the piece is primary to the result or that the sound or music is incomplete without the signifying value of the source of data. In the case of certain audifications where the data is simply rescaled or transposed and used directly to generate an audio signal, it could be argued that the data itself can be understood or at least sensed, simply through hearing. This idea, as I will describe below, enables artist Andrea Polli to liken audification to soundscape listening. However, in the case of the audification of the earth's movements or of meteorological data that she describes, the transposition in time and or frequency is so vast that it seems improbable that an auditor could intuit the original source. Therefore, to my mind, knowledge of the source remains a prerequisite to a full appreciation of the artwork.

Indeterminacy

Several composers that I have encountered such as Peter Gena, Stuart Jones and Scot Gresham Lancaster cite John Cage as a direct and important influence and we might consider that their use of data incorporates Cageian notions of indeterminacy that I evoked in Chapter Two. Thus when Gena uses the pattern of a rug from a home weaving kit as a source of data for creating a musical work, it is unlikely that the rug itself is considered as having particular significance, it is more the aesthetic position that 'anything can be music' which dominates this process. Other works such as John Eacott's *Floodtide* use the aleatory to drive crafted algorithmic compositional, processes perhaps a closer descendent to Xenakis' *symbolic music* than to Cage's *Variations*.

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[74] 'In conceptual art the idea or concept is the most important aspect of the work. When an artist uses a conceptual form of art, it means that all of the planning and decisions are made beforehand and the execution is a perfunctory affair. The idea becomes a machine that makes the art.' (Lewitt 1967)

Scale: Extended Perception

Sound and music are readily associated with cosmology and holistic thinking. The idea that they are representative of the higher (and lower) order of things is sporadically recurrent throughout the ages: Lefebvre's Rhythmanalysis discussed in Chapter One is at least in part inspired by cosmology. The universality of sound is also largely reflected in non-western philosophical traditions such as Sufism, as this quote from *The Sufi Teaching of Hazrat Inayat Khan* illustrates:

> Since all things are made by the power of sound, of vibration, so every thing is made by a portion thereof, and man can create his world by the same power. Among all aspects of knowledge the knowledge of sound is supreme, for all aspects of knowledge depend upon the knowing of the form, except that of sound, which is beyond all form. (Khan, 1996, p. 27)

That sound and music can inform us of, or can be a vehicle for, information that is otherwise imperceptible because too vast to perceive, is a dominant concept in several examples of artistic sonification. Lorella Abenavoli sonifies the vibrations of the earth, compressing them in time in such a way as to render them audible. With her installation *Le souffle de la Terre* Abenavoli invites us to 'drop in and listen to the earth' (Abenavoli, 2004). Marty Quinn has worked with NASA using data from solar storms as a source (Quinn, 2011), and Richard Kroland-Martinet, Solvi Ystad & Mitsuko Aramaki, sonify cosmic particles —invisible but constantly present in our environment.

On the other end of the spatial scale Victoria Vesna has collaborated with nano scientist James Gimzewski, creating sonifications of the metamorphosis of a butterfly. Originally stemming from an audification technique used by Gimzewski to display scientific data (the evolution of yeast cells), the Californian artist/scientist couple present this perception of the infinitely small as a public installation entitled *Blue Morph*, which reflects their holistic philosophy:

> As many speculative ideas in the West circulate around ideas of energetic approach to matter in general, particularly the body and mind, alternative medicine and other Eastern philosophies are thriving. …We have investigated

these ideas from the sounds of cells to the concept and realization of the Blue Morph installation at the Integratron[75] (Vesna, 2011).

Blue Morph became a ritualized, verging on fantastic, performance, where visitors were immersed in the installation and experienced the metamorphosis through sound.

Nicolas Reeves, son of the famous French/Canadian astrophysicist and ecologist Hubert Reeves, applies his training in architecture and physics to the domain of media arts. His installation *Cloud Harp* sonifies by reflecting laser beams off cloud cover, using a technology similar to that of a cd player. The artist qualifies his work as 'Keplerian' (in reference to the German Astronomer, who incorporated cosmology into universal mathematics and revisited Pythagoras' *Music Of The Spheres* in his 1619 publication *Harmonices Mundi* (Kepler, 1619)). For Reeves, 'Cloud Harp' reflects a social political and ecological position that advocates the integration of human technologies into the greater order of things. The work can be said to 'listen' the environment rather than imposing itself on that environment as such, we can hear an echo of the influence of Murray Schaffer.

Beyond Expression

Another recurring idea in sonification is that by externalising some of the 'expression' in the work; by allocating a responsibility to data, there is a shift of sensibility away from the individual artist or musician, creator of the work, and towards the environment being sonified; the artist adopts a different position in Batesonian 'ecology of mind'. This is a trend, which can be noted in much digital art, where artists see themselves as an element in (as opposed to the author of) a process. There is also a strong ecological presence in sound art, manifested through practices such as field recording and sound walking considered as being less dominant or imposing forms than traditional composing.

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[75] The Integraton is something of a curiosity; originally designed as a rejuvenation machine by an eccentric engineer it was supposed to draw energy from the crystalline structure of the rock of the Californian desert from which it was excavated.

Polli uses sonification to render public significant but normally imperceptible data. Her intentions are overtly political; she compares sonification to soundscape listening and soundwalking, which she considers as essentially socially engaged activities.

> As if engaged in a political demonstration, soundwalkers move through space in a silent protest of both the visual dominance in contemporary culture and the constant industrial and electroacoustic noise assaulting our sonic environment (Polli, Soundscape, Sonification and Sound Activism , 2011).

Polli pinpoints dichotomies between soundscape listening and musical listening (and creation): In the ways that they are most often presented: directional or immersive; stationary or moving; pitch-based or timbre-based; repeatable or non-repeatable. This extends to the ways in which they are received: conscious or unconscious; foreground or background; Western or non-Western; inspiring power or inspiring empathy. Here I identify a continuum with the artistic ideas that prone emancipation from egocentric creativity that I identified in Chapter Two (2.5. Philosophy and Aesthetics). For Polli audification can readily be considered as an extension to soundscape, since it is the simple translation of non-audible vibration into audible vibration. In comparison, mapping-based sonification (more specifically 'geosonification'[76]) potentially poses other problems, since the translation involves higher levels of human intervention and therein a danger of over-simplification; an inevitable subjectivity appears through the choices involved in the mapping process.

Geosonification offers an important advantage over soundscape listening, which lies in the possibility of both temporal and geographical rescaling, an important factor in Polli's work, which often seeks to bring climatic phenomena to public attention. *Sonic Antarctica*, created during a National Science Foundation residency in Antarctica in 2007/2008, is a multimedia installation that awakens the public to the reality of climate change. Polli combines sonification and audification of scientific data with field recordings and informal dialogue between scientists as they evoke 'the politics and the science of climate change (Polli, Atmospherics/Weather Works, 2012).'

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[76] Geosonification: the sonification of data from the natural world inspired by the soundscape.

Another example of sonification that evokes both scale and in a certain sense politics, is Jens Brand's Global Player. Presented as a commercial brand, Global Player has a dedicated website (Brand, 2004) that uses spoof advertising to present a genuine technique that consists of sonifying the relief of the earths' surface, from data supplied by orbiting satellites. His advertising slogan is 'Brand – We Play The world– What Are You Playing?' The website offers two products the GP4 'an exclusive, top-notch Hi-Fi product which plays the earth as a disc' and the G-POD a portable version of the Global Player which looks (suspiciously) like an apple iPod. It is also possible to listen and subscribe to a daily podcast 'a thirty minute excerpt of a carefully selected sonic blend of the world's most exciting satellite tracks which itself is updated daily (Brand, 2004)'. This sounds like an audification, but –from what I have managed to glean by questioning the artist –involves a slightly more sophisticated operation based on Fourier transformation[77] (I am not certain of this since, possibly as part of his artistic position, he refuses to give technical details on the grounds that it is a trade secret). Jens Brand presents his work in contemporary art contexts, as a boutique selling his products or, as was the case in the *Sonification- What Where How Why* symposium, as a faux sales pitch. Behind the pure humour of the advertising campaign (Brand, never actually sells his products) is a comment on the global economy and our desire to humanize the world through unnecessary gadgets. His slogan 'We play the world' reveals with irony his position, where the notion that the human race might dominate and control the world through technology is revealed as absurdly pretentious. When I asked him (in a private correspondence) if he was an ecologist he replied 'no I am part of ecology I think' followed by 'ecology is about economy' –although Brand's vocabulary is artistic, one senses here the impact of Bateson's ideology. The audio result of Brand's system is, in my opinion, quite compelling which adds to the complexity of his artistic concept.

4.3.2. Time and Place

In the example of Polli's 'geosonification' described above, non real-time sonification, informs on a time scale beyond the scope of normal human perception, thus this very non

[77] The Fourier transform is a mathematical operation that decomposes a function into its constituent frequencies, known as its frequency spectrum.

real-time quality can be an intrinsic part of an artistic proposition. Polli describes a difference that she had with a curator on the subject of real-time.

> For example, prior to the sonification process of the author's Atmospherics/Weather Works project, the author's scientist-collaborator Van Knowe spent weeks tying up several high-end computers at his lab modelling the meteorological data for the project. The curators of the project were very interested in the idea of real-time interactivity, and for this reason the author and her scientist collaborator had to explain that the weather models they were using were too large to be generated in real time. The complexity of the model seemed to be less interesting to the curators than the concept of presenting everything in real time, although ultimately the curators were very pleased with the final result. (Polli, Soundscape, Sonification and Sound Activism 2011)

My research into the philosophy and perception of time presented in Chapter One leads me to reformulate my thoughts on the nature and definition of real-time, above all to accommodate the way in which immediacy expands into the past and future beyond the immediate moment. Real time or immediacy is unperceivable without expansion as multiplicity and if we extend multiplicity in a cybernetic system beyond ourselves the scale or measure of real-time becomes dependant on the system under consideration. Our measure could well be that of natural cycles, seasons or even historical time. However, it is the mobility of this flux, the continuous 're-editing' of the present moment in relation to the past and future and ultimately the timeframe of human perception, that remain my principal concern in this research.

Audience Reception

I am particularly concerned with the possibility that real-time sonification can modify the equilibrium between the program and the music or ultimately (and it is one of the aims of my practice) replace it completely. This leads to the question of how the process of sonification is perceived or perceivable to an audience. If understanding the provenance of the data is integral to appreciation of the artistic proposition, how does the artist make this information available? Alternatively, if the provenance of data is not integral to appreciation, how can we consider that the data is significant? Does attaching a created sound to a source remove it from the realm of 'pure' music? I will discuss these issues further at the end of this chapter but first, to continue with this survey of practice, I will describe London-based composer John Eacott's work *Floodtide*.

I witnessed a performance of this piece in July 2010. The performance took place on a plaza in front of the Southbank Centre in Central London. In the place of music stands, the musicians had flat screen displays showing a 'score' generated by a computer in real-time. The program generating the scores was driven by tide-flow data gathered by a sensor plunged into the Thames below the performing musicians. Strategically positioned posters explained the process with the aid of visuals and a large screen indicated tide flow in knots (see Figure 4-2). The music was agreeable, engaging and minimal in nature. I would place it aesthetically in the school of repetitive music. The performance spanned the six hours of the tidal turn. Although I did not experience the whole duration of the piece I happily spent two hours, half paying attention to the music, half taking in the surroundings.

If there is no direct 'comprehension' of the state of the tide through *Flood Tide*, the ensemble –I understand by this the geographical situation plus the generated score plus the human presence of the performers plus the information provided by the posters– 'works' as a whole. The knowledge that the flow of the water next to us was participating in the performance introduced an extra dimension –an extension to the scale of the piece.

Figure 4-2: John Eacott floodtide, London Southbank, July 7 2010 (photo P. Sinclair).

John Eacott considers that data derived from the flow of tide is more meaningful than data generated by stochastic computer processes, but this is not his primary motivation: he willingly talks of his family background in show business and the importance he attaches to spectacle. It would seem that it is this aspect that has pre-eminence over a more esoteric significance that might be suggested by his choice of elements. In the interview conducted during the Symposium, Eacott suggested that if today it is necessary to explain to an audience that sonification is taking place, in the future the audience might automatically come to expect that something is being sonified (Sinclair, Research 2011). Perhaps, as John Eacott suggests, some day real time sonification will have become conventional to the point where audiences will be expecting the music to be data-driven. If this becomes the case, it will undoubtedly change the audiences' receptivity to this kind of work but it seems that the data keeps its 'program' status as a signifier, 'what is being sonified tonight? – Ah ok we are listening to …' although it might shift progressively to something which one might guess at without the necessity to consult a poster.

Another approach to time and place is manifested by real-time audification (see definition at the beginning of this Chapter 4.2.), which might be described as creating the acoustics for otherwise silent waveforms. In Valentina Vuksic's work, data flux becomes the actor rather than being –as is the case with most sonifications– an imperceptible vector that connects a computer to an external phenomenon. The complex internal architecture of a computer is the place where the action plays out. So, instead of proceeding from the analogical to the digital, from the environment to the computer program, she navigates within her chosen environment, which is the computer itself. In *Tripping through Runtime* this 'staging', as she puts it, involves audifying, the computer's processes as they expand from the program recorded on a hard drive through live memory executing their routines.

> The time and space of computer processes and memory span different levels of reality during "*runtime*". Software being processed within this system of coordinates creates its own temporal and spatial dimensions, which are staged for an audience to provide a sensual experience: that of logic encountering the physical world. (Vuksic 2012)

I will attempt to make this a little clearer by describing a performance of 'Tripping through Runtime' presented during the symposium. A full video recording of this performances is available online (Vuksic, 2010).

Four different laptop computers were lined up on stage. A video projector showed the 'print' window of the executing computer. Vuksic manipulated a transducer[78] which, when placed on the outer shell of a computer, captured the waveforms generated by the electronic components inside. Over the course of the performance, which lasted about ten minutes, she guided us through several boot processes. Each computer was equipped with a different operating systems, which created a surprisingly varied and beautiful sound environment: tones, rhythms, evolving patterns and suspensions of form, revealed the processes underlying the banal start up windows. The only actions that Vuksic undertook during this time were those of commanding the execution of programs and of shifting the transducer from one area of the computer housing to another. The audification process that renders this universe public, is a simple analogue process of transduction; the patterns and waveforms are not interpreted in any way, the signal from the transducer is simply plugged directly into the sound system. Vuksic's intervention has something of the 'soundwalker' navigating a soundscape, selecting what they wish to hear. At the same time it is a stethoscope revealing the rhythms and waveforms of the electronic 'organism'.

Christina Kubisch is an international sound artist who has also taken an interest in the invisible and inaudible dimension of electromagnetic waves. Her *Electrical Walks* project is probably among the best known and documented of sonification art works. Publicly presented for the first time in 2003, it predates this in forms that are more experimental[79]. In her description of *Electrical Walks* (Kubisch, Works with Electromagnetic Induction, 2011) Kubisch explains how, originally unsought after parasites that appeared in her installations[80] became the genesis of this work. As the quantity intensity and diversity of these parasites increased along with the proliferation of electronic apparatus, she became aware of the artistic potential of visiting this invisible and normally inaudible universe. She constructed special headphones equipped with induction coils, which allow the auditor to hear the electromagnetic waves emitted by different devices:

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[78] A microphone without a membrane that is sensitive to electromagnetic waves rather than sound waves.

[79] In the Catalogue dedicated to Kubish's works entitled 'Electrical drawings' Christophe Metzger mentions a 1993 experiment where Christina Kubisch and composer Alvin Lucier 'scanned the streets of Tokyo with these modified headphones' (Kubisch, Electrical Walks 2008).

[80] Earlier installations use induction headphones to capture deliberately transmitted sounds as the visitor navigates in a designated space.

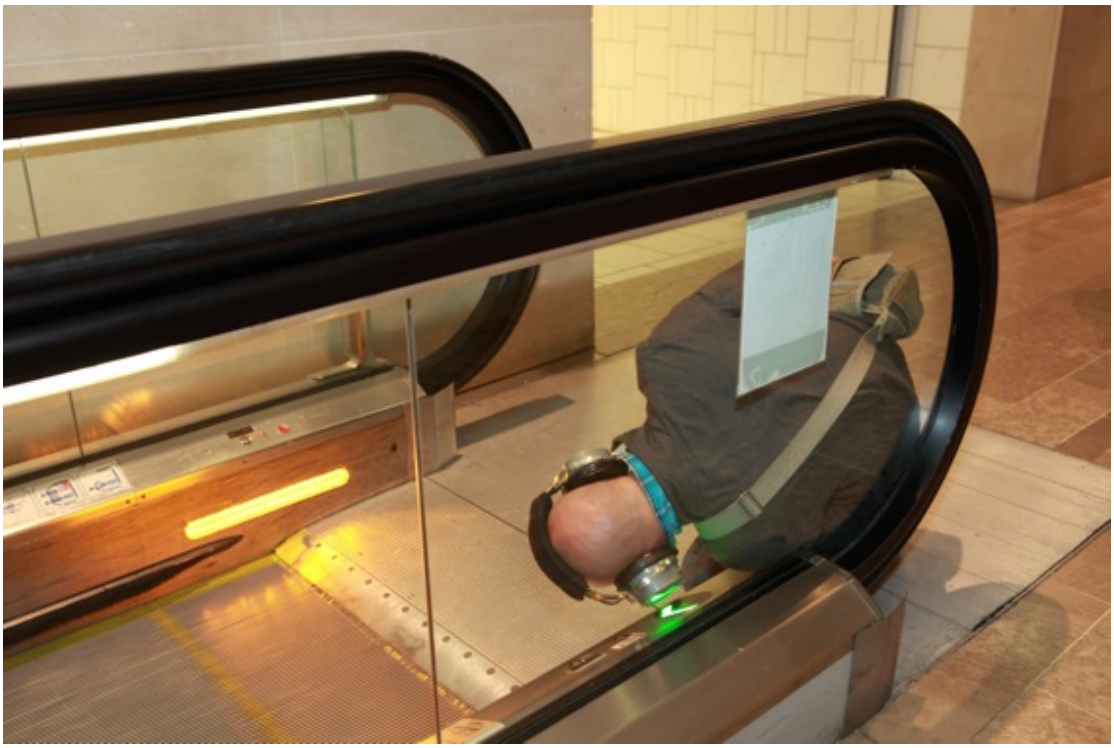

Figure 4-3: Christina Kubisch, Electrical Walks Nancy June 6 2011 (photo C. Kubisch).

> Light systems, transformers, anti-theft security devices, surveillance cameras, cell phones, computers, elevators, streetcar cables, antennae, navigation systems, automated teller machines, neon advertising, electric devices, etc. (Kubisch, Works with Electromagnetic Induction, 2011)

Members of the visiting public are invited to don these headphones (see Figure 4-3) and discover the hitherto unperceived but ubiquitous and pervasive dimension of electromagnetic waves. As Kubisch puts it: 'Nothing looks the way it sounds. And nothing sounds the way it looks (Kubisch, Works with Electromagnetic Induction, 2011).' Different apparatus generate different waveforms and the sounds resulting from their direct translation into the audio domain are, at times, formally quite beautiful (for someone who, as I do, appreciates electronic music). For public presentations of *Electrical Walks*, Kubisch helps the audience by providing a map indicating a varied electromagnetic route, with points of particular electromagnetic interest.

It is tempting to read a strong ecological message into this work. However, it is not a discourse on the dangers of electromagnetic pollution, but rather like other forms of sound walking (Andrea Polli uses the example of *Electrical Walks* to make the connection between Sound Walks and sonification (Polli, Soundscape, Sonification and Sound Activism , 2011)) an invitation to extend our audio consciousness. In answer to Angus Carlyle's question as to whether this work is related to the intensification of sound perception promoted by acoustic ecology she responds by saying:

> Of course that is the basis of my work. However, I am not a hardliner in this, telling you which sounds are 'good' and which are 'bad'. (Carlyle, 2007)

One might deduce a direct reference to Schafer's conceivably dogmatic stance on acoustic ecology, as discussed in Chapter Two.

Christoph Metzger (Kubisch, Electrical Walks, 2008) situates *Electrical Walks* in a contemporary art lineage based on cartography and cites such visual artists as Marcel Duchamp, Jasper Johns and Richard Long. The text which accompanies a catalogue presenting Kubisch's maps, diagrams and scores is possibly more an attempt to validate these elements as visual art works in order to canonize them in regards to the art academy than a real attempt to elucidate the artistic process. As with the presentation of John Cage's scores as visual artworks in their own right I find this difficult to accept. However, it does point to the fact that mobile, real-time sonification can be considered as a map on a 1:1 scale; I will discuss this further below.

The example of Kubisch's work is of particular interest in this research since it is one of few pieces, which, like *RoadMusic*, combines real-time and real-place in mobility. In these cases, the art is perhaps to be found in the holistic experience, in other words, it seems inappropriate in the case of *Electrical Walks* to separate elements from the whole: the apparatus plus Kubisch's map, plus the persons' freedom of interpretation of the map, plus the rendered results. Thus although I can appreciate the necessity to communicate and document the work, I would question the artistic value of these constituent elements taken separately. As Stuart Jones points out, this question also arises when Kubisch publishes a CD featuring audio mixes of different people's *Electrical Walks* (Kubisch, Invisible/Inaudible: 5 Electrical Walks, 2007):

> … So for example, yesterday some of Christina Kubisch's audio walks were played back. Now I don't understand that. For me that doesn't make sense

> because for me those sounds, although they are coming from an area we don't normally hear –from a sort of inaudible phenomena– they are particular to that place and to that action that that person was doing at that time: they walked in that direction in that place, they stood in that place, they moved at that speed and they were seeing these things and sort of experiencing these other things at the time when they were doing that, and for me that's absolutely crucial. You can't then repeat that. When you hear the sound what are you listening to? I'm not sure what you're listening to when you hear that sound without all the other things. So for me when you do this work with real-time, it's real time in a real place, you know, a real situation. If you take away any of those realities then I'm not sure what you're left with. I mean you're not left with anything that particularly makes sense (Jones, interview, 2010).

In a 2006 interview with Christoph Cox (Cox, 2006), Kubisch describes the experience of listening to a thunderstorm with her headphones: human voices are carried by the electromagnetic waves of the storm. The idea of the experiencing such a thing is fascinating, but Kubisch herself is the only person who has these special headphones to hand to experiment with on a daily basis (unless of course one makes them for oneself). This leads me to wonder if it wouldn't be preferable to have Kubisch's headphones at my disposal, rather than her CD and her catalogue (I would hazard that these could be roughly equivalent in terms of production cost). It is not my intention (or I think Stuart Jones' intention) to be unduly critical of what I consider a key artwork and I respect Christina Kubisch's right to distribute her work through ancillary productions. However, this example helps to illuminate the part of this discussion concerned with the construction the distribution and the status of real-time art that is central to my practice and this research.

Stuart Jones himself is engaged in real-time sonifications. For a 2006 installation entitled *bop!* which was installed in and throughout a building over a four-month period, Jones collaborated with a group of scientists, engineers, programmers, designers and architects to create a networked multimedia installation.

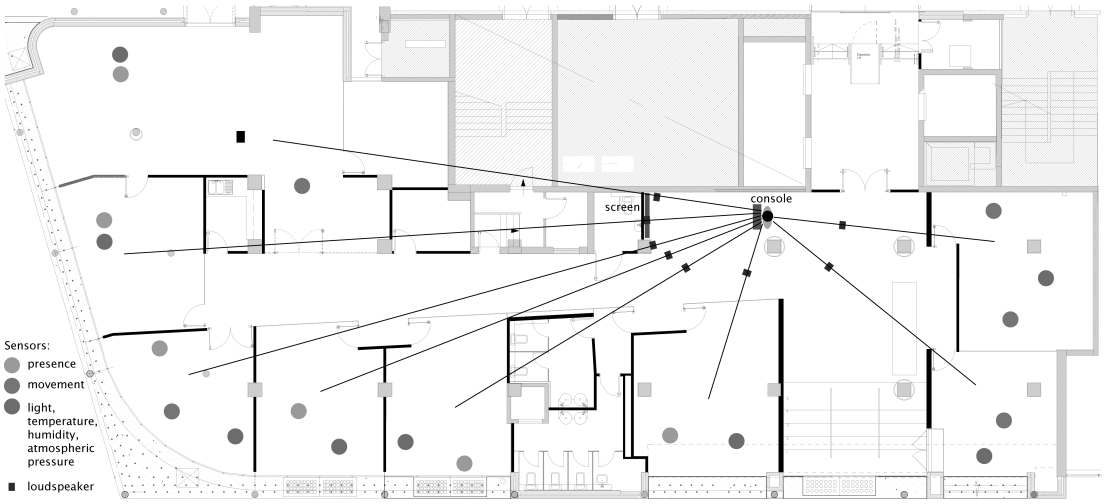

Figure 4-4: Stuart Jones schematic of Bop!

The system gathers data by using environmental sensors (room temperature, ambient light), human activity sensors (presence, the number of people in the building) and human interaction interfaces, where users were encouraged to communicate information concerning their mood or feelings (see Figure 4-4). All this information was correlated and compiled to create visualisations and sonifications[81]. The cybernetic inclusion of system and users (see Chapter One 1.3.1.) is all-important in *Bop!* The aim of which was to reveal the underlying life of a building thus defying architectural barriers created by such devices as walls and floors. Real-time feedback, Jones explains, was essential to create the engagement of the occupants necessary for the project to function: 'If users cannot discern the effect their behaviour has on the behaviour of the work, the thread is broken and the connection dies (Jones, space 2006)'. Thus, although reports from users were stored over longer periods and used to create more complex sets of data, their comments or captured presence also had an immediate effect on the rendered media. Sounds were carefully crafted to relate to their source or function, and virtually re-placed in relation to their area of capture using a multichannel, spatialised sound system.

Jones' *Bop* has, I think (I did not experience the piece first hand) the ingredients to become a conceptually autonomous environment. By this, I mean that if the installation

[81] In a footnote to an article, written while he was working on the piece, Jones explains that he prefers to use the term auralization since, like visualization, it better expresses an experience shared by the emitter and the receiver (Jones, space, 2006)

had stayed in the building, probably the inhabitants would have come to hear what the sound signified without having need for explications (the program). Unfortunately the project was temporary and this is not verifiable but it leads me to ask, what would happen if a sonification becomes permanent? To go back to the example of Eacott's *Flood Tide*: what would happen if the orchestra interpreting the tide did it all day every day for years? If we set aside the possibility that it could be a performance and rather consider it as permanent installation, surely the music would (rapidly) become the sound of the tide. The posters would cease to be necessary since everyone would know that it is the sound of the tide or even if they did not, it would not stop it being an integral part of the audio environment. Similarly, whether or not you can count the tolls of Big Ben and are thus informed of the time, either way it is part of the audio environment as opposed to being an exceptional musical event.

If something is permanent, it becomes environmental. There is, I think, a limit to how long we can 'listen attentively' or practice 'reduced listening'. Beyond this limit, the perceptual engagement shifts to become more properly described as 'hearing' the sound is perceived but not necessarily attended to and (as I showed in Chapter Three 3.3. Simultaneous Grouping) what becomes significant is deviation or change. I agree with Schafer that it is possible to practice attentive listening to an audio environment and that a possibly positive heightening of awareness can occur through this practice. On the other hand, I would suggest that this kind of conscious, sustained, concentration could not be permanent or if it were possible, it would surely become a cognitive handicap.

To summarise, my idea is that if a fixed-position sound source is to be 'really' as opposed to 'conceptually' environmental then a degree of permanence is I believe a requirement. Since a permanently playing and uncontrollable (for the auditor) sound source is likely to be unacceptable, it might be useful to think of environmental sonification in terms of the occurrence of sound objects defined and triggered by data (for example, clock chimes) as opposed to continuous mapping. Although this reflection has led me to develop ideas for future research, I will put it to one side at present, since in the case of *RoadMusic* an important difference exists with the examples given above (with the exception of Christina Kubisch's *Electrical Walks*) which is that the perceiver of the sonification is mobile as is the sonification itself. I will return to the specific nature of the mobility of *RoadMusic* but first I wish to extend this survey of the contemporary context to consider mobile media systems.

4.4. Mobility Maps and Mapping

> There is a reality that is external and yet given immediately to the mind. This reality is mobility. Not things made, but *things* in the making, not self-maintaining *states*, but only changing states exist. Rest is never more than apparent, or, rather, relative. (Bergson, Metaphysics 1912, 49)

Audio has always been mobile, if only through the fact that we generate sound through our own gestures, however there is a recent and rapid evolution of audio technology towards the portable, immersive and geo-located (smartphones equipped with headphones). This culminates today in what might either be considered as the detrimental isolation from the soundscape around us, or on the contrary, as the re-appropriation and augmentation of personal audio space. I propose to consider locative technologies from two different perspectives; these can be exemplified by maps[82] and sounding[83].

In the case of maps, we project ourselves in relation to a schematic representation. In the case of sounding, we activate the environment that we are in, in order to learn something about it. In reality the line that can be drawn between these two models is not quite so clear cut. For example, radar, which is a technology of sounding, is used to create projections or maps and we can 'ping' the network from our laptop computer or other mobile device, to find out if we are present (as a connected node in the network). However, I consider these two poles as significant in the construction of a sonic art of real-time and real-place.

4.4.1. Mobile Sound

Audio media players have been portable almost since they came into existence. Portable gramophones appeared around 1910 and the first car radio appeared in the early 1930's with, close behind it, the still not resolved, controversy about the safeness of listening to

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[82] I refrain from using the term 'mapping' here since I use this term throughout this study in its computer science definition. Also I am specifically referring to the immobilized nature of maps as an object or image.

[83] The action of measuring the depth of a body of water. A measurement taken by sounding. (Oxford 2010)

music while driving (I will discuss in relation to *RoadMusic* in Chapter Five). The appearance of the transistor radio provided handheld, battery powered, ubiquitous, audio media from the 1950's onwards and with it the possibility to influence, or invade the existing audio space. More recently, portable cassette players (the Sony Walkman) incorporated the private sound space into the public environment; a phenomenon that has been massively reinforced by the evolution of the portable media player (iPod) the mobile telephone and the fusion of these (iPhone or smartphone). Today, it is arguably no longer possible or useful to distinguish public and private sound-space. Most of the art works considered here, use mobile audio devices and headphones.

Empowerment Through Headphones

Sociologist Michael Bull has made prolonged studies into the use of portable music devices (Walkman and more recently in-car listening and iPods). He proposes that mobile audio devices construct a 'post-Fordist' soundscape, which operates to filter-out random urban sounds. The age of Muzak is past, we are no longer willing to accept being washed over by an anonymous blanket of sound, and the new audio practice is one of empowerment as the iPod user re-appropriates the sound environment. The statement that I made at the beginning of this chapter –that we cannot close our ears– no longer holds when wearing headphones. You can close your ears to your surroundings and simultaneously immerse yourself in an audio environment of your choice, simply by inserting 'earbuds'. This immersive quality of headphone listening influences the way in which people use their mobile players. As Bull puts it:

> This mediated experience of listening to something through headphones gives you direct access to the world and your own emotions, so it's a mediation that paradoxically conceives of experience in its immediacy. Music for many users has become such second nature, that it ceases to be recognised as mediation. (Bull, 2011)

The iPod is used aesthetically to reconstruct the meaning of the visual scene. Bull proposes that this form of mimesis is the opposite to the *flanerie* described by Walter Benjamin (Benjamin, 1972), where the 'flaneur' is the alienated subject who imagines what it is like to be the other. Here, the iPod user can appropriate a

person who appears in front of them and incorporate them into their reconstructed scene –an actor to go with their own sound track so to speak. Bull's conclusions concerning personal empowerment through iPod use are a little frightening, in the sense that they leave us with little hope for the future of public social space, but the empowerment they offer over the urban environment is also desirable. Curiously, although iPod listening is not technically geo-located the modification of perception it induces possibly makes it so. Through the act of personal choice, our soundtrack takes over from the naturally occurring environment and thus participates in creating our location. As I will develop further, my practice explores the possibilities offered by this phenomenon of music becoming a personal sound track for one's mobility while actually incorporating elements related to that mobility.

Ian Chambers –well known for his writings on popular music and popular culture– describes Walkman use in his short 1994 text *The Aural Walk*. The text underlines the interactive or active aspects of Walkman listening and ties them to then emerging activity of re-mixing and sampling:

> With the Walkman strapped to our bodies we confront what Murray Schafer in his book: The Tuning of the World (R. M. Schafer 1977) calls a "soundscape," a soundscape that increasingly represents a mutable collage: sounds are selected, sampled, folded in and cut up by both the producers (DJs, rap crews, dub masters, recording engineers) and the consumers (we put together our personal play lists, skip some tracks, repeat others, turn up the volume to block out the external soundtrack or flip between the two). (Chambers, 2004, p. 99)

So if the recorded media being played cannot strictly speaking be considered as real-time, in a sense the Walkman becomes a machine that produces real-time, since when the user takes it in hand they reintegrate recorded music into *their* time and *their* mobility.

In a 1994 study of Walkman users J.P Thibaud examines the way in which gestural behaviour adapts to meet that of the music being listened to. He suggests that this places the wearer of headphones in an "entre deux" which brings into question not only the sound and social space but mobility itself:

> Rather than the condition or the cartography of the itinerary, it is the action of walking to music, allowing it to penetrate us, lending our body to the voice of the Walkman which lends content to our movement (Thibaud, Les mobilisations de l'auditeur-baladeur: une sociabilité publicative., 1994)[84].

Audio Walks

A Canadian artist couple Janet Cardiff and George Bures Miller investigate the fusion between public and private, between actual and representational space. Janet Cardiff created her first 'Audio Walk' during a 1991 residency at the Banff Centre in Alberta, Canada. An audio walk proposes a hybridization of field recording and fictional 'sound-track' in a 'real-world' situation. Cardiff / Miller have enjoyed international success since their installation *PARADISE INSTITUTE* was presented at the Canadian Pavilion of the Venice Biennale in 2001 and their audio walks have been presented throughout the world most often as exhibits in contemporary art museums (Janet Cardiff, 2011).

The visitor is provided with a mobile audio player equipped with headphones. Typically the recorded ambient sound played through the headphones is that of the place where the person puts them on. A voice murmurs instructions, directions and suggestions. The auditor hears recorded footsteps and is asked to try to synchronize their own footsteps with those of the recording. An effect of 'real-time' is created by the voice 'pointing out' elements in the landscape including ones which are ephemeral but which are bound to be there: a pigeon or a scrap of paper on the ground, for example. Progressively, once the spectator has 'suspended their disbelief' the fictitious narrative takes over from the field recording, voices incarnate different actors and a drama unfolds, the pleasant walk might end up turning into a war scene. If the technical simplicity of Cardiff's invention is pleasing, it is obviously limited by the fact that it has to be 'manually' synchronised in a given environment. More recent and sophisticated geo-localisation techniques, offer new possibilities for linking recorded audio to place.

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[84] My translation : Plus que l'état du parcours ou la cartographie du trajet, c'est l'action de cheminer en musique, de se laisser traverser par elle et de prêter son corps aux voix du baladeur qui donne la teneur du déplacement.

4.4.2. Geo-localisation

GPS or Global Positioning System is a map-like representational system with an important difference, in that it places us (through technology) at the central point of that representation; in this sense it is that mythical object: the map on a scale of 1:1 (Cristofol 2011). GPS technology provides us with the new buzzwords 'Locative Media' and 'Augmented Reality'[85] where recorded media is tagged to location or situation. The appearance of mobile phones and tablets equipped with GPS or other positioning systems (such as the use of an IP address to locate a device) and that have the computing power to perform complex operations, means that these technologies are now available to the general public and with them an array of commercial or potentially artistic uses. However, as Jordan Crandall points out in his article "Operational Media" (Crandall, 2005) artistic usage of GPS is not without posing problems. Like other maps, GPS is a sophisticated form of symbolization and representation in its own right. It provides us with a reduction of the environment, which is dependent on intent and purpose. Maps create boundaries and limits, scales and points of view. We are all familiar with the Mercator projection[86], which makes our part of the planet seem more important.

Teri Rueb working with GPS triggered audio was already questioning these aspects of GPS technology in 2004 with *Drift*. Closer in her political and social engagement to Andrea Polli and sound walks than to Janet Cardiff, *Drift* combines GPS and tidal data to create a variable vocal narrative, which accompanies 'in-situ wanderings' of the auditor over the tidal flats of the Wadden Sea in Northern Germany:

> I integrated natural cycles (tidal phenomena) with the algorithmic cycles of computational media. Yet it was also unique as a moment of self reflection regarding my own use of GPS as an artist versus its then newly emerging status as a common household, or rather dashboard, technology. To create reflective and corporeally engaging experiences that encouraged physical risk,

[85] A technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. (Oxford 2010)

[86] This projection, made by Gerardus Mercator in 1569, became the standard map projection. It is still the primary model for mapping the Earth.

> experimentation and non-goal orientated movement was at odds with the commercial promotion of GPS as a technology of accuracy and efficiency (Rueb 2011).

Martin Reiser, Professor of Digital creativity at De Monfort University UK and Author/Editor of *The Mobile Audience, Media Art and Mobile Technologies* (Reiser, Media Art and Mobile Technologies 2011) is engaged in the mapping of narrative over urban topologies. A recent Manchester based piece *Riverains* involves GPS tagged cycle routes that offer the participant snippets of local history and folklore, with particular focus on stories relating to subterranean Manchester. Cyclists are lured into different locales along the cycle route and a story is recounted through the headset. Reiser evokes the 'problem' of real-time in geo-located art:

> Many of such projects are technically marvellous, but still often fall down on the actual content. Part of the problem is the one identified by Virilio, that of the change from considered diegesis to continuous and automatic present. Where the user is creating the narratives both as subject and object, a new 'pan-cinema'. (Reiser, Locative Media and Spatial Narrative 2005)

His vision of the problem is not so much how to construct from real-time as how to remove real-time from the construct, so to speak. Reiser's work into locative media, 'Riverains' and other large scale installations, certainly go beyond the gadget or the commercial use of geo-localisation, providing carefully researched insight into invisible (often historical) layers of the territory being navigated. However, I cannot help but see this as a technically sophisticated audio-guide. If audio guides have their uses, I would venture that they represent the extreme opposite of Bergsonian mobility and immediacy. By formatting the moment with recorded narrative, free will, which evolves from the expansion of the immediate, is short-circuited and mobility stopped. In my opinion rather than augmenting reality, this type of proposition might tend to mask or reduce it. With *RoadMusic,* I am primarily concerned with constructing from the immediate instant.

4.4.3. Sounding and Sensing

Active acoustic location involves emitting an audio signal and recuperating a modified result and with it information about the environment. Bat or whale echolocation systems are a well-known example, but a similar principle is employed by blind humans (human echo location) who create sounds by tapping a stick or by clicking their tongues. This

notion of activation that I will refer to as sounding, can be extended to incorporate more of our acoustic universe than we usually take into consideration. In his essay: *Towards a praxeology of sound environment,* social scientist Jean Paul Thibaud (Thibaud, The Acoustic Embodiment of Social Practice, 1998) draws our attention to the fact that listening to sound and making sound are most commonly a combined activity since we produce sound through gesture. Thibaud suggests that we have a tendency to consider sound reception as passive whereas in fact we continually activate our sound environment in a significant manner:

> In other words, listening requires our ability to orient ourselves towards the acoustic environment and move in accordance with it. On the other hand, gesture is the more basic means for producing sounds. Several possibilities can be distinguished depending on the level of control we have towards sounds and the degree of body involvement. First, we can make sounds directly with our own body: voice, hands, feet, etc. Before being speech, voice is first and foremost a sound gesture (Jousse, 1972). Similarly, feet cannot be reduced as merely a way of getting around, they are probably the most primitive means for producing sounds (Schaeffner, 1936). Secondly, we also make sounds in our use of and interaction with everyday life objects. In extending our bodily capacities, these manual devices produce sounds and provide acoustic information that help us to control in return the way we cope with the physical world (Norman, 1988). (Thibaud, The Acoustic Embodiment of Social Practice, 1998)

Thibaud extends this audio 'feedback' to our interaction with modern appliances and the fact that with a minimal gesture –the push of a button– we can greatly modify our acoustic environment. The modern definition of sounding: the act of dropping a weighted cord from a boat to test the depth of water is not actually sonorous, rather it has become a powerful metaphor for a technique that extends active perception beyond our bodies.

Sensing

GPS and other map-based locative systems are not the only means through which devices are mobilised. In the case of *RoadMusic* I have custom equipped a mini computer to detect movement and the visual field and recent mobile telephones or smartphones come equipped with a range of sensors: accelerometers (normally used to detect the orientation of a smartphone and adjust the screen accordingly), touch screens, microphones, cameras

and more. RjDj make use of the interactive possibilities integrated in the iPhone, or other smartphones (Rj in RjDj refers to 'Reality jockey').

> 'Smart music players like the iPhone, iPod Touch and iPad have huge potential to create totally new sonic experiences. RjDj is a small team based in London taking advantage of this potential and leading the development of exciting new music formats including augmented music and smart music. Our apps will give you experiences which take some people to outer space and others back down to earth. Try it!' (RjDj, 2011)

RjDj is not an artwork per se but rather a platform to develop and distribute interactive and locative music for smart phones. RjDj can process incoming sound (from the microphone) and/or recorded sound files as well as data from the movement sensors used typically to manipulate audio. It can also access the smartphones' GPS data. The project is Open Source so anyone who is capable of programming for it can propose a version. Some of these versions –which can be obtained via Apple's app store– are free others cost a few euros.

RjDj is the project that I know of which is closest in its configuration to *RoadMusic*. However, it differs in its aims, which –if I have interpreted their advertising pitch correctly– is more orientated towards creating variations in recorded music by well-known personalities of the electronica music scene than towards creating music with and from real-time and real-place. Besides these user-re-mixable pieces, RjDj offers more game-like apps such as 'Inception-the app'[87]:

> Inception – the app: This app is a dream machine that transforms the world around you into a dreamworld. It uses augmented sound to induce dreams through the headset of your iPhone or iPod Touch. It will change your perception of reality. (RjDj, 2011)

RjDj provides an Open Source interface to the smartphone that anyone can use to make projects. However, in reality, the part that they have developed is simply the final layer that accesses the audio interface of the smartphone and the marketing platform. Credit

[87] In reference to the 2010 science fiction film *Inception* by Christopher Noland.

should go to Miller Puckette, the experimental musician and original developer of Pure Data (Pd 2012) which is the underlying programming environment which RjDj interfaces (this is the same programming environment that I use for *RoadMusic*) .

4.5. Conclusions to chapter: Real Time, Real Place & Mobility:

In this chapter, I have separated the design aspects of 'technical' sonification from more conceptual, philosophical or socially engaged aspects of sonifcation by artists. In the case of *RoadMusic,* this separation is non-existent since I build on a basis of acoustic design in an aim to create an experience that is 'intuitively' comprehensible for the user, yet at the same time, *RoadMusic* is not completely estranged from the cosmological camp since I integrate the ideas of cybernetic inclusion in a larger system. However, this commences on an essentially human and local scale –from Bergsonian intuition shared with technology in a Batesonian system that includes the driver, the car, the road, the computer and its program. This is in contrast with many sonification artworks where data from outside of human perception is the explication, the program in program music so to speak. *RoadMusic* is perhaps closer to mobile, real-time audification works such as Christina Kubisch's *Electrical Walks.* Inversely however it is highly structured –or permanently under construction– the structuring method (the program) being included in the device itself, unlike Kubisch's maps which are external to the device. It is attached to situation but independent of the event or special occasion unlike Vuksic's or Eacott's performances.

If a sonification is to participate in activation through mobility, not only must it be mobile, it has to be to be mobile with us. It is the blind persons' cane described by Bateson (Section 1.3.1. Bateson's Cybernetics). If we automate the cane and it returns to the blind person with a delayed report, a symbolization of the path, this might be useful or instructive in some way but the cane is no longer part of the persons' mobility. In *RoadMusic,* the routine's sensibility comes from their mobility and mobility and thus the narrative is shared with the user.

Bull's and Thibaud's research shows that we can obtain a certain empowerment through the choice of our soundscape, but it is also the very fact of rendering this soundscape (literally) mobile that creates the mediated immersion. My hypothesis, then, is that it is

possible to generate an artistic mediation through the very act of mobility. Although an author defines the way in which it occurs, this mediation issues from the very moment as it is shared with the user. I believe that we naturally expect our auditory scene to correlate with our mobility; thus we have an intrinsic desire to associate movement and music. In the following Chapter, I will describe how a mobile computer can be used practically to operate this construction from the immediate in the case study: *RoadMusic*.

5. Chapter Five- *RoadMusic* (Review of Practice)

The reader is invited to watch the video documentation on the accompanying DVD-ROM *RoadMusic Four Excerpts 10'37"* at this point. I must insist however that listening to *RoadMusic* on the road is a very different experience and that documentation is to a certain degree in contradiction with the real-time aspect of this work. A brief subjective description of a possible *RoadMusic* trip follows.

Figure 5-1 : Driving with *RoadMusic* (photo Gregoire Lauvain)

5.1. Description Of A Journey

I start the car and after a few minutes booting a synthesised voice announces that the program is ready.

The first sound which distinguishes itself in the mix is a bonk or rather a series of bonks, which trigger as the car hits a bump, they accelerate and diminish like the impacts of a bouncing ball coming to rest. Small bumps make small bonks and bigger bumps make bigger bonks. Going into a bend I hear a whiny, whistling sound that rises in pitch with g-force as we corner, it seems to push against the limits of the walls of the car and makes me aware of the tactile force between the seat and my body. The road straightens out and a flurry of clicks seems to get tangled into a disorderly ball; as I accelerate they unravel and then settle into a fragile rhythmic pattern, I lift my foot off the pedal and they slow down then disappear. A sound something like a bass guitar has emerged now. It plays a repeating riff, but notes come and go, syncopating with the constant background melody. The bonks from the bumps are joining in with the bass notes, at times I'm not sure which is which. Sometimes the bass fades into the background to become hardly audible and is almost forgotten, then going up a hill it re-emerges and I realise it was there all the time, only playing from a different place. The road surface changes and the overall sound takes on a more metallic tone. It happens progressively as if the music was replying rather than reacting to the new conditions, the sound of the bass saturates and distorts, the bumps have stopped now.

I come to a red light and wait in line with the other cars, the different sounds seem to slowly settle then extinguish one by one, the bass is still playing, seemingly filling in for nothing much happening. Cars start crossing perpendicular (the light has turned green on their side); a grainy sound follows in the wake of each car. In the relative silence of the halt I now realise that this was present before but as chaotic as the passing landscape. It is the sound of what *RoadMusic* sees –I can understand this but realise by the same token that what it sees is different to what I see. A soft harmonious, but breathy sound, varies ever so slightly in the background, this is the constant sound of light.

The traffic-light turns green, I pull off. The soft sound has changed in pitch now and the rolling clicks return reminding me that I'm on the move. The bass has started a new riff, it is livelier with more notes; traffic has thinned and I'm making good progress. A new, up-tempo rhythmical element has joined in – it seems to be galloping in time with

something but its rhythm is constant and it is the timbre that is really sticking to the road. I can feel it changing with hills, corners and movement. As the road starts to wind, a bell-like sound seems to sway with the car, it is difficult to say if it's inside or outside. It seems to have its centre in the car but extend beyond it, it's playing in time with the bass but loses its footing a little with each bend, like a tape recorder with a slipping drive belt. A new bend and as blue sky and sea springs into view, the note of the bell changes, it changes back again as the road turns and the car faces inland towards the rocky cutting once again.

On the return journey the motorway animates a drone sound it's monotonous but then again so is the road. But perhaps there is something to hear in the texture; it is the sound of the road surface and when I start listening more carefully I can identify variations under the surface; undertones. The bass is playing again changing the odd note when a bump breaks the monotony. Patches of shade and sunlight interrupt the sameness of the sound, as do the other vehicles overtaking me. Its not particularly eventful but it sounds like the road and in a strange way I find it soothing.

5.2. Art In Flux

A question that might come to mind when evoking an art of flux is 'Why bother? What's so great about real-time anyway?' I can remember talking to a specialist in holographic images who pointed out that being able to create images in 3D is conceptually less of an achievement than creating them on a flat surface. One might consider that a similar paradigm holds between real-time sound art and composed music or recorded sounds: isn't being able to write notes on a piece of paper and then have them interpreted as sound in differentiated time, or spending hours carefully mixing sounds together in a studio, creating hitherto unheard of combinations, more interesting than listening to everyday sounds or incorporating the everyday in music? Surely art can only come from human imagination and surely it takes time to perfect such a work to reach the projected equilibrium?

Posed a century or so ago, these questions would have undoubtedly received a resounding "Yes" but since that time knowledge of ourselves, our surroundings and our perceptions has evolved. As humans, we have perhaps started to doubt that our superiority is unquestionable; we have a growing awareness that winning the battle between man and nature has its downsides. Individualism is also evolving, the artist is losing his / her status of genius to the genius of social networking where everyone provides the content and this awareness of the 'ecology of mind' has its effects on aesthetics. I showed in Chapter Three how John Cage is able to tell us that when he listens to music it sounds like someone is telling him something whereas when he listens to traffic he hears a whole universe of sounds. Xenakis has shown us how to create audio forms stochastically, borrowing techniques from the domain of science where they are used to understand and simulate natural systems. Schafer attracted our attention to human domination of the Soundscape. I have shown in Chapter Four, that one of the leitmotivs of artistic sonification is the deliberate shifting of 'content' away from the author and towards the environment or the everyday and my own work is no exception. This does not in itself represent an ecological doctrine (in the sense of being 'green') but rather a questioning of the artistic individualism of the second half of the 20th century and the now banal, individualised self expression through consumption / creation of media that might be considered as one of its consequences.

Having grown up in the seventies, I incorporated the lessons of Cage and Fluxus during my formative years but remained dubious as to the relationship between their ideal and

the subsequent forms they produced. Why not do everyday art everyday, rather than making a performance or an object out of it? As the son of a modest (but fulltime) landscape painter, over the years I came to see my father's activity, which I previously considered as the production of images, as a permanent 'slow scan,' a sublimation of the flux of difference in the environment and in the painter. Today's computers provide us with a multitude of sophisticated methods for generating media in real time and the purpose of much of this thesis has been to determine what type of relationship it is possible to establish via such tools between user, immediate moment and situation.

Of Media and Mediation

Media saturation is a particularity of contemporary times. Most of the theorists and artists evoked in this thesis have something to say about it, much of which is negative in tone. Bergson with his 'élan vital' was perhaps predicting and warning against the dangers of losing our personal perception to what he considered as the facile codes of society; Lefebvre clearly considered that the rhythms imposed by modern civilization (and notably the media) were dysfunctional and in need of a rhythmanalysis. While Dennett's evocation of the force of memes is not necessarily judgmental in nature, the hypothesis that we are above all hosts to viral ideas, good or bad, that piggyback our consciousness is a little unnerving, in particular when we consider the communicational vectors that we have put at their disposal.

John Cage is critical of contemporary music, which he describes as the communication of ideas:

> I could not accept the academic idea that the purpose of music was communication, because I noticed that when I conscientiously wrote something sad, people and critics were often apt to laugh. I determined to give up composition unless I could find a better reason for doing it than communication (Cage, An autobiographical Statement, 1991).

Cage proposes in its place experimental music where the composer discovers the music along with the listener (Cage, Silence, 1971, p. 13). One of the particularities of real time sonification is that this simultaneity of discovery / creation becomes the standard mode, since at least part of the rendering will be determined by the incoming data. This is particularly true in the case of *RoadMusic*, which abstains from using recorded sound.

Augmented Reality

Today augmented-reality offers us non-linear ways of navigating information that can be used for technical, commercial or artistic purposes. AR applications currently being democratised by their inclusion into smart-phone platforms might also be considered as indeterminate at least in regards to 'performance' and they are evidently mobile. However, there would seem to be an overall tendency to incorporate the existing media sphere, as this extract from the Wikitude (one the of the first AR applications for mobile phones) web site demonstrates:

> Search through lots of exciting content and points of interest from Wikipedia, Youtube, Twitter, Flickr, Starbucks and thousands more. Use Wikitude to browse through what's around you or to specifically search for places you are interested in. Craving sushi? Just type "sushi" into Wikitude's search box, hold up your phone and see all the sushi restaurants around you. Looking for special offers near your home or nearest shopping centre? (Wikitude, 2012)

The functioning principle of these applications is an extension of recorded media: they do not really adapt to us, we adapt to them; rather than informing us of the present they inform us of a temporality detached from the one we are 'really' navigating. Most AR is based on high-level pre-recorded information where the sense is provided to us in a highly symbolized form, which is likely to influence our perception, our opinion or our behaviour from the top down; as with an audio guide in a contemporary art museum we are taken by the hand, and told what to think. From this point of view AR is a classical example of Marshall McLuhan's idea that by extending our bodies through technology we simultaneously undergo amputation.

> For example, In the case of the wheel as an extension of the foot, the pressure of new burdens resulting from the acceleration of exchange by written and monetary media was the immediate occasion of the extension or "amputation" of this function from our bodies. The wheel as a counter-irritant to increased burdens in turn, brings about a new intensity of action by its amplification of a separate or isolated function (the feet in rotation). Such amplification is bearable by the nervous system only through numbness or blocking of perception (McLuhan, 1964, p. 47).

If we take reality from Bergson's point of view –that of the infinitesimal point of contact with the immediate that expands from that point outwards– clearly what we currently call augmented reality would tend to be a reduction of *that* reality and an amputation of intuition. The question, then, in my practice is whether it is possible to invert this tendency: to expand from the immediate situation in an on-going construction (mediation) rather than presenting pre-prepared symbolised form (media). My aim with *RoadMusic* is to create a device that augments mobility rather than freeze-framing it; that proposes a process of formation rather than fixed form; that rather than downloading information, builds information from the immediate situation that it shares with the user in a symbiosis of mobility.

McLuhan, although undoubtedly delivering this with a certain sense of irony, offers a possible description of such a media:

> For now it is possible to program ratios among the senses that approach the condition of consciousness. Yet such a condition would necessarily be an extension to our own consciousness as much as a wheel is an extension of feet in rotation. Having extended or translated our central nervous system into the electromagnetic technology, it is but a further stage to transfer our consciousness to the computer world as well. Then, at least, we shall be able to program consciousness in such wise that it cannot be numbed nor distracted by the Narcissus illusions of the entertainment world that beset mankind when he encounters himself extended in his own gimmickry (McLuhan, 1964, p. 67).

Another, less cynical way of considering the human computer relationship is that suggested by Bateson, where man and machine participate in a larger cybernetic system (see Chapter One: 1.4. On Flux).

Muzak

Awareness and appreciation of the 'natural' sound environment evolved along with the media that can record, modify or replace it. This appreciation often goes hand in hand with an aesthetical rejection of the latter; in particular, when they are imposed on us. Muzak is perhaps identified as the worst culprit in terms of imposing media rhythm over those that we might otherwise perceive within the environment or indeed produce through our own presence or being. One of Schafer's pet hates, Muzak, must surely be the ultimate in what Lefebvre calls 'false presence'.

The status of Muzak merits more careful reflection, after all Muzak shares with many of the sonification works described in the Chapter Three and indeed with *RoadMusic*, the characteristic of being specifically designed for a situation, so why is it bad? One of the reasons is bad press; we know, or it has entered our collective consciousness, that Muzak is deliberately manipulative: its rhythms were originally designed to increase productivity on factory lines and more recently to coerce us into the right mood for buying consumer goods, in a way that appears to us as particularly underhand. Another explanation is that, as Michael Bull points out, we have entered an era of the individualised sound space, albeit a media space, and with it the rejection of the uniform and the socially imposed. Today, iPods provide us with new power to control or eliminate the 'Fordist' soundscape so aptly represented by Muzak, where we were all treated not so much as equal as identical.

The Effect Of Mobility On Media

Michael Bull provides me with an interesting variation on the theme of 'bad' media. The iPod user –and indeed the car stereo listener– replaces what they often consider as an unpleasant sound environment and in some cases an undesirable social situation (if being in a car in traffic is counted as a social situation) with their chosen sound track. The overall effect of this is of gaining or regaining possession of urban time and space –considered as oppressive– by turning it into personal time and space. If the consequences of headphone listening in public spaces can sometimes be frustrating for the person who is not using a similar prosthesis (since it reduces sometimes necessary or sought after interaction between individuals navigating the same environment), it can also be considered positively as a useful form of stress relief. This occurs through the combined effects of the pleasure of listening to music (and with it the recuperation of otherwise lost time), the filtering of unwanted noise and the perceived transformation of excessive proximity with others; the latter two being symptoms of an environment which has become far from 'natural'.

It is interesting to note that empowerment through headphone listening is modified by mobility: Bull makes a distinction between iPod use in the workplace that is commonly to do with the privatisation of audio space and the practice of listening when on the move which has a greater tendency to include the construction of narrative:

> iPod users, rather, construct a mono-rhythmic aesthetic narrative to the street deciphered from the sounds of the culture industry emanating from the iPod in

> their pocket. Theirs is a hyper-post-Fordist street of potentially multiple audio-visual – with each iPod user constructing their own singular mediated dream world simultaneously. (Bull, 2007, 48)

In his survey of Walkman use J.P. Thibaud (Chapter Four: 4.4.1. Empowerment Through Headphones) underlines the strength of cohesion between movement and music. Although Thibaud himself doesn't make a connection between this mobile media listening and his concept of praxeology of sound (see Chapter Four 4.4.3.), I would suggest that one does exist. We are less proactive in creating our soundscape when we are 'normally immobile' than when we are 'normally mobile' –if we are sitting still and listening, we are essentially paying attention to the variations in the world around uninfluenced by our own presence whereas when walking or running we are activating the soundscape. We do this firstly through our own production of sound with our body and its contact with the environment and secondly through the fact that we are moving our ears through that environment so that even continuous sound will become a localized and changing encounter, rather than a permanent fixture. These two phenomena related to mobile listening have become key to my compositional process.

If we are sitting down in an auditorium and we are listening to a musical 'journey' (and how often have we heard this used as a metaphor for composition) there is necessarily a strong element of suspension of disbelief. We are not travelling the journey; we are listening to a journey being simulated around us, or more often in front of us. Take the example of Charles Ives' *Central Park in the Dark*: Ives creates a soundscape from musical references and sound 'effects' that combine to successfully narrate movement. However, this is clearly a narration in the strictest sense of the word because we are sitting still listening in an auditorium.

To invoke the automobile: there is a strong culture of listening to music while driving or being driven, in fact according to a recent ICM survey for Omnifone it is where the most musical listening is done[88]. I would suggest that the fact that the auditorium is mobile

[88] Omnifone/ICM: February 2010: sample 1000 UK adults: car- 71%; living room – 66%; PC - 35%; ipod – 33%; mobile – 15%.

enhances musical experience and as Bull points out there is a strong cultural correlation between the windscreen and the cinema or television screen.

> Cities are said to float by as some kind of filmic embodiment. The daily act of television viewing shifts to the mobile spectatorship of the occupants of automobiles, who are thought to watch the world through the transparent barrier of the automobile's windscreen, hermetically sealed off from the duress of the world beyond the screen. (Bull, 2007, 48)

This leads us to the slightly doubtful ethics and aesthetics, which project the car as a hermetic bubble dedicated to pleasant sensations often epitomized in car advertising, an example of a scenario might be: a harassed executive in a noisy urban environment gets into his car and closes the door with a solid clunk. From there on he is cut off from the noisy, dirty, peopled outside world which becomes reduced to the status of visuals for his personal chosen soundtrack.

> The outside environment suffers degradation both material in relation to the automobile and cognitively in terms of the occupant's relationship to the outside world. A sensory reorganisation occurs: one of sensory enhancement (private automobile experience – often sonic) and sensory diminishment (the outside distanced, flattened, imaginary). This diminishing and enhancement of sensory experience relates to both the controlled sensory experience within the interior of the automobile and the experience of movement itself. (Bull 2007, 88)

Beyond the question of music and sensation, new developments in car infotainment systems may be considered as criticisable for other reasons, in particular when they involve human/computer interaction and internet-connected activities, which integrate the driver's personnel communicational sphere. Indeed the public reaction (outside of the industry) to this fast developing sector is often one of concern as this extract from an Internet forum illustrates:

Comments: in response to a web posting concerning Vauxhall's development of a smartphone infotainment system for Adam city car

> *chebby Wed, Jul 11 2012, 5:36PM*

> "The driver can then play and control apps – such as music, video and navigation – via the screen."
>
> Brilliant idea. Drivers watching YouTube and not the road.
>
> *GetCarter Thu, Jul 12 2012, 8:33AM*
>
> This is part of a very worrying trend, that along with the Skoda Citigo, where cars are being sold as entertainment hubs, or as an accessory to a phone, rather than as a vehicle for driving from one place to another. (HiFi, 2012)

I will return to the particularities of in-car listening in regards to *RoadMusic* in my conclusions but I should mention here that the audio environment of the automobile is of particular interest to me *because* it presents the particularity –arguably the problem– of being, by default, isolated from its acoustic surroundings. This separation is increasing with climate control (which means that the windows are kept shut) and more efficient soundproofing. The sound system has gradually taken the place of the outside soundscape or the sound of the car's functioning and with electric cars, as I will develop further, this isolation takes on a new dimension. With pedestrian iPod listening, a potentially dangerous (because it diminishes our audio alert system)[89] and possibly socially questionable choice is made, on the user's part, to isolate him or herself from the normally occurring sound environment. With the in-car environment, this choice is to a large extent non-existent, since at speeds beyond fifty km per hour or so, even with the car's windows open, we cannot hear much beyond the turbulence created by the car's movement. It is difficult to imagine an acoustic equivalent to soundwalking (see Chapters Two and Four) that we might call sound-driving.

Unlike the disconnected media experience that Bull describes, *RoadMusic* responds to this problem by creating a holistic situation in which the sound experience is always in relation to the environment –it is created by the moving box of the car itself, its contact with the road and that which it traverses. Although the experience might at times resemble the cinema sound track phenomena (especially for first time users, and probably

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[89] Research by Anthony Pecqueux (CRESSON) reveals the dialectic experienced by subjects in the opposing interests of Ipod use (listening to chosen music and isolation from the undesired audio environment) versus attention to useful audio cues in the environment. (Pecqueux 2009)

due to the cultural references that Bull cites), its relation to the physical environment modifies the 'isolated bubble' and tends to place the driver in a heightened perception of the driving experience itself. Part of *RoadMusic* is a mediation of the visual field, however, a major portion of the sound is generated by the physical movements of the car (G force) and the road's relief. The driver senses an augmented contact with the road (inhabits the road) and simultaneously an enhanced experience of musical mobility as it is cross-referenced with tactile sensation.

Sympathy, Sounding, Mobility.

One of the questions posed by this research is the position or status of the sound being produced; from what perspective should it be considered. Is it the voice of the car, the sound of the environment through which the car is passing, a band in the boot of the car improvising as if the road were a score or indeed an extension of the car's occupant's tactile and visual senses. As this research has advanced, I have come to consider that although these distinctions are useful because they provide different perspectives, they can also co-exist within a real-time and mobile sonification. Streams can be allocated according to different criteria and still co-exist in the audio environment.

Bergson puts us inside Zeno's arrow from whence rather than observing form, we perceive mobility through intuition. It seems evident that once the arrow is immobilised in the target there is little to be intuited –the arrow can only be in a state of passive perception of the exterior, whereas when it is in flight it activates all which is around it by its own passing-through. We might consider that, in a manner of speaking, there is an analogous difference between listening to the soundscape when immobile in an armchair and traversing a sound environment on foot. In the first case, we are listening, observing and in the second, we are participating in the activation.

Bergson's hypothesis was that all things in the universe are there, 'virtually' present but inactive and that we activate them as if directing a beam at them which is bounced back to us. I would venture that this is a vision-centric theory of our relationship to the world. If we take this activation from a sounding/listening position, two important differences appear. Firstly, we literally, activate the sound space around ourselves by generating sound waves through our actions, which come back to us as reverberation and echo informing us of the environment all around us (whereas we do not literally generate a beam of light rather we direct our regard). Secondly, we share the audio scene with other sound emitting agents, which activate the environment as well (here too there is a

difference with light which is reflected off objects and on to our retina). Sound is produced by actions in our surroundings (the atmosphere), both ours and those of other things. All reach our ears in the same vibrating air mass to which we must then apply auditory scene analysis. It is perhaps more evident to consider our cybernetic inclusion in environment from the starting point of sound rather than from that of vision.

Rhythm And Sympathy

If Lefebvre's rhythm it is not specifically related to our audio experience the choice of metaphor is essential to the understanding of the Rhythmanalysis concept. Musical listening and audio perception in general are seldom inherently passive. It is natural to respond to music by moving, singing or playing. To take an obvious example when dancing, our bodily movements and rhythms adjust to those of the music, as if we were entering into 'resonance' with it. We become increasingly aware (or perhaps increasingly sensitive, without being aware) of subtle variations or changes in pattern. From the Batesonian point of view, we can include the human and the music in a single cybernetic system and the augmentation of sensation as a feedback loop.

We might liken this metaphorically to sympathy, defined as 'the state or fact of responding in a way similar or corresponding to an action elsewhere (Oxford, 2010)'. The term applies more concretely to the sympathetic resonance of stringed instruments that vibrate in unison without being touched when excited by an external force (see Hermann Helmholtz *On the Sensations of Tone* for a full technical explication (Helmholtz, 1885 , pp. 36-49)). Sympathetic vibration of a string is a particularly pure form of resonance; however, taken figuratively we might consider this exchange of energy between systems as a basis for approaching all types of sound space from the physical reality of acoustics to sonification.

Sounding

Lefebvre includes the individual in the environment through rhythms. These extend outwards from ourselves seamlessly and we are incorporated in them. If for Lefebvre, rhythms are not necessarily musical, in terms of acoustics we can also consider the activation of the sound environment literally, through our own actions which return to us as a modified audio impression of that environment through echo and reverberation. According to Thibaud, audio praxeology, the activation of the environment by one's

actions in space, can be considered as our primordial sound producing activity (before language or even vocalisation).

Imagine, for example, running up a flight of stairs and entering an empty room out of breath. Our panting would return to us with information about our body state and simultaneously, through reverberation, about the space which we just entered (we might add that it also informs us of the past instant of our climb and thus the architecture). In our natural audio mobility there is no barrier between sounds produced by our bodies (voice), those generated at the point of contact between our body and the exterior (footsteps) and those caused by actions external to us[90]. These all mix in the instant of varying pressure that activates our eardrum. Thus if the door squeaks as we close it behind us, we add to the perturbations of the same mass of air caused by our panting. If as we catch our breath the quiet sound of a ticking clock becomes audible, it will also reveal the space we entered albeit from a slightly different (audio) perspective.

I draw a parallel between the internal, caused-by and external sounds that we experience as humans and *RoadMusic's* digital sounding of the car's environment. It is the tread of the tyre on the road that sets the (virtual) audio space into resonance in its micro-sonic detail. Events echo, their influence slowly dying away. Each curve and bump is reflected in the musical structure as it is playing and as it will continue to play. Sonification of the visual field brings outside objects and atmospheric sound into the mix. As the car becomes prosthesis, an extension to our body, the music played through its loudspeakers becomes the reverberation of the re-calibrated space that the car / person(s) occupies. Alternatively, to put it in McLuhan's terms it could be considered as a sound environment that responds to the amputation of our feet. Unlike recorded music in the car, *RoadMusic* is a sympathetic system that by generating music from the route incorporates the driver and passengers into the environment.

After initial concerns that *RoadMusic* should be one thing or another, I have arrived at the conclusion that, on the contrary, activation through mobility can be all these things at the same time: sounds which somehow we experience as interior; our activation of the route; the echo of that activation in space; sound objects encountered through mobility and all

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[90] It might be argued that sounds internal to our bodies are transmitted as vibrations via our bone structure, however apart from very low frequency sounds, these transit via our cochlea and are heard in the same mix as external sounds.

the feedback loops which are created by these different levels of experience and their interaction. *RoadMusic* is simultaneously soundwalk (in the sense of a heightened awareness of the environment), it is playing an instrument and it is moving in sympathy with sound. It is also musical form, which incorporates musical knowledge or culture, used to introduce elements of anticipation –what is likely to happen– through recognisable pattern or convention.

One of the moments I enjoy the most when listening to RM is coming to a halt. Some sounds stop immediately others seem to hang on the brink for a while as if hoping that this is just a pause, that they will be able to gallop off again rather than giving up and starting over, others slow down or gradually settle to a monotonous, unchanging pattern. It's important not to indulge in anthropomorphism but then again the whole idea of *RoadMusic* is that there is a sense of shared experience; a possible parallel to ones perception which mirrors the frustration of interrupted movement, the switch to a state of rest and a sort of acceptance of that state. Of course the machine does not always exactly reflect how I feel but in this too –even in this difference– there is something that, optimistically perhaps, I feel can be considered as dialogue rather than dichotomy.

5.3. Kinetic-Syntactic Composing With Flux – Scene Analysis And Scene Composing

RoadMusic is always in flux, it is never the same and ultimately it has no beginning or end. If some of the sound is the direct mediation of incoming data, the music itself might be considered as being the wake of the vehicle; in fact, I might add the bow wave and perhaps the eye on the never-reached horizon to this metaphor. The sound of *RoadMusic* cannot be known in advance (as it is in many forms of music) since even the overall structure depends on the path taken by the car. There is no fixed score to be interpreted, the program 'makes decisions on the spur of the moment' but they are informed by the larger moment of the unfolding journey and projected towards the future from the recent past. I refer here to the fact that when the programme generates a new set of notes and defines rhythm for forthcoming music, it does so from data about the preceding route.

Meyer shows how each note prepares us for the next and how it is in the unfolding path and our expectations arising from that unfolding that we find musical sense and emotion.

If for Meyer this has to do with cultural code, with *RoadMusic* (although it does make use of modes and other familiar musical structures) the rules are perhaps more rapidly (almost immediately) learnt sound patterns rather than a cultural schematic –this learning being all the easier because these patterns are associated with tactile and visual sensations. The user quickly understands that going round a roundabout and off in a new direction will provoke certain significant changes in the music, without knowing exactly what these are going to be (even when driving exactly the same route repeatedly, conditions are never quite the same), and it is this expectancy which creates the 'spice' in *RoadMusic*. The use of ASA principles helps with this rapid comprehension of *RoadMusic's* audio 'codes' unknown to the user at the outset. The use of rhythm and repetition as vehicles for difference are intuitively understandable; one gets the feeling that the music goes with the road. It is a participative form of listening that has something akin to dancing to or playing music and at the same time, it is a different sensation; there is a singular degree of autonomy. Using Audio Scene Analysis as a basis for composition also provides a way to work with dynamic structure since it is possible to have a good idea how the different streams will interact, in spite of the fact that the overall result is never the same and is only discovered by the composer as it unfolds.

5.3.1. *RoadMusic*: How It Works And Composing

RoadMusic as it exists today is the result of a long process, which has taken place parallel to and in interaction with my theoretical research and it will be understood much of this process is indescribable. It consists of (hundreds of hours) programming, driving, listening and subsequently adjusting sound processes; this research is essentially non-verbal in its very nature. Other more technical aspects of the program development will be readily understood by someone with PureData programming skills code and they are invited to view the demonstration of the program that figures on the DVD-ROM. Here I will describe the broader principles, how they have evolved and the nature of the different instruments.

Help in finding hardware solutions and Linux OS setup was provided by Guillaume Stagnaro. The GMEM (Marseille's Experimental Music Group) have been co-producing *RoadMusic* since February 2012, with the aim to invite other artists and composers to create different mediations of *RoadMusic*. Since then Charles Bascou, their staff programmer, has assisted me in optimising the programs so that they can be used by invited composers (I will describe this in detail in Conclusions). For these reasons, when appropriate, I will use the formulation 'we' in the forthcoming sections.

Overview

In *RoadMusic* two separate, if immediately associated, operations are being carried out simultaneously. In the first the non-audio flux of information about the drive is being analysed in real-time, in the second music is being composed, digital audio synthesized and rendered as flux in real-time. Significantly perhaps, working on the program with the aim to opening the project up to other composers, we have split the program at this dividing line, proposing a communal system of data analysis and inviting composers to create their own audio processing part. This separation into two parts is an obvious but important choice.

The first part concerns how the system makes sense out of the flow of raw data; it is where the Bergsonian duration expands into space as structure. As in Dennett's theory of consciousness, a single flow of raw information can be tapped in different ways and on different time scales, thus extracting information that has different significations and will serve different purposes. In the second part, multiple audio streams are being created from this data; each one combining selected information in different ways to create separate audio identities. These identities are forged according to different criteria, which can be considered both as analogical to perceptions of the journey and as complementary musical elements in the orchestration. The reader will recognise that a number of different aesthetic strategies are employed for sonification. The description that follows is divided into four main sections: the hardware setup, the software setup, data processing (the *Host* program), composition (the *Audio* program).

5.3.2. Hardware

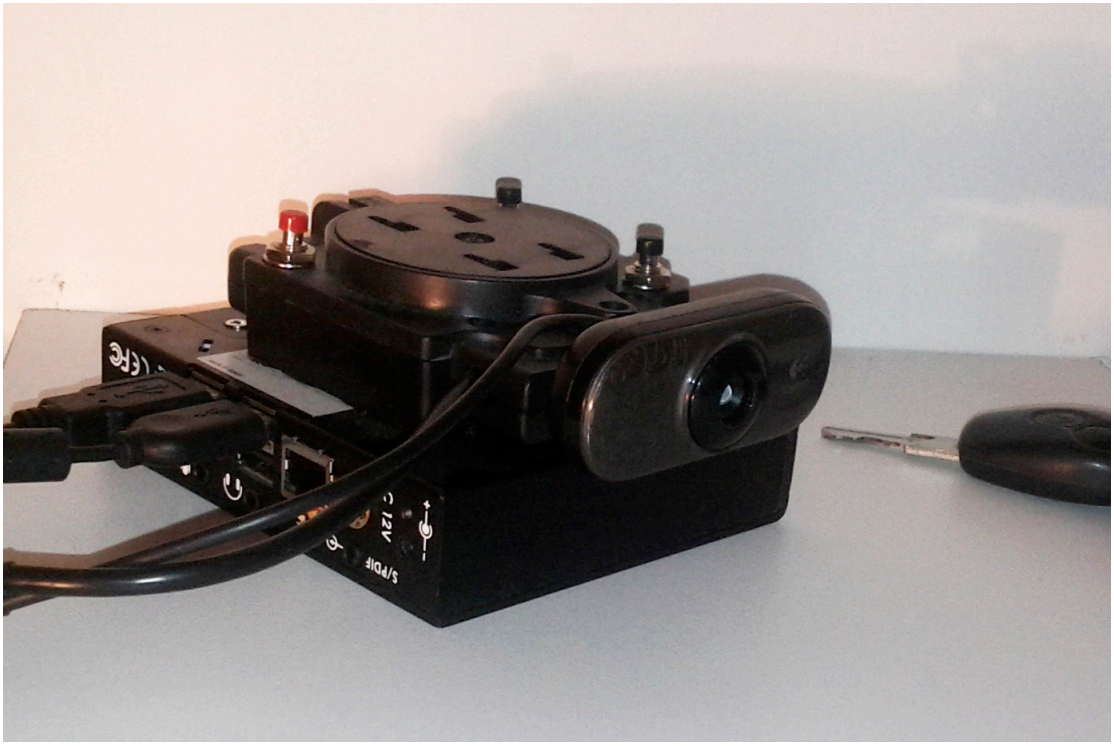

Figure 5-2: *RoadMusic* hardware

RoadMusic is a mini-computer equipped with accelerometers (movement sensors) and a camera. The first measure G force on the X, Y and Z-axes, capturing the cars movements ranging between vibrations and details of the road surface to larger, bends, bumps, accelerations and braking. Video capture provides additional information about the journey; the changing colour of the landscape and moving objects.

Running a computer in a car is not as simple as one might imagine. At the outset of this thesis I was testing on a cumbersome machine, custom assembled for in-car use. This fitted under the front seat of the car, the motion sensors were built into the box and the USB camera was fixed to the windscreen. Since then, I have made several important changes to hardware reducing it to a box barely bigger than a typical GPS device.[91] I have installed a smaller and more efficient camera[92] and I am using a USB interface equipped

[91] fit-pc2 by CompuServe.

[92] Logitech - Webcam C210.

with accelerometers[93] which after some experimentation, I have found to be the most efficient sensor solution. The whole system is now fixed inside the windscreen of the car with a suction cup.

We are now working on adapting a version to run on a mobile phone and or on the emerging car infotainment systems, which integrate a small computer similar to the one I am using. With this end in mind, we have limited the processing power of the prototype machines, although this constitutes a constraint in terms of real-time analysis and synthesis.

5.3.3. Software

RoadMusic is programmed in a language called Pure Data [Pd] which is an open source platform initiated by Miller Puckette in the early 1990's. Pure Data was conceived as an environment for digital audio processing and control, however there are now additional libraries for image processing. Programming is accomplished via graphical interfaces, where 'objects' (functions), 'messages' and 'GUI (graphical user interface) objects' are interconnected by 'wires' to create 'patches'. This graphical approach makes programming more user friendly for non-professionals –who might otherwise be daunted by more abstract lines of code– Pd is thus widely used by composers and sound artists. Pd has recently been ported for use with mobile phone platforms as 'libpd' (Pd, 2012).

Wavetables

Values from the accelerometers are continuously written into tables. The wavetable (a simple array of numerical values) is a central concept in digital audio processing. Often wavetables are used to import pre-recorded, digitalised, sound waves (samples) into a program, which can be 'read' in different ways, and at different speeds. They might be rendered as recognisable chunks of sound or as micro-sonic loops or grains that can be combined to produce new sounds. Granular synthesis based on Xenakis' 'clouds of sound' described in Chapter Two (2.2. Granular Sound) is often used in combination with wave tables to this end.

[93] JoyWarrior24F8

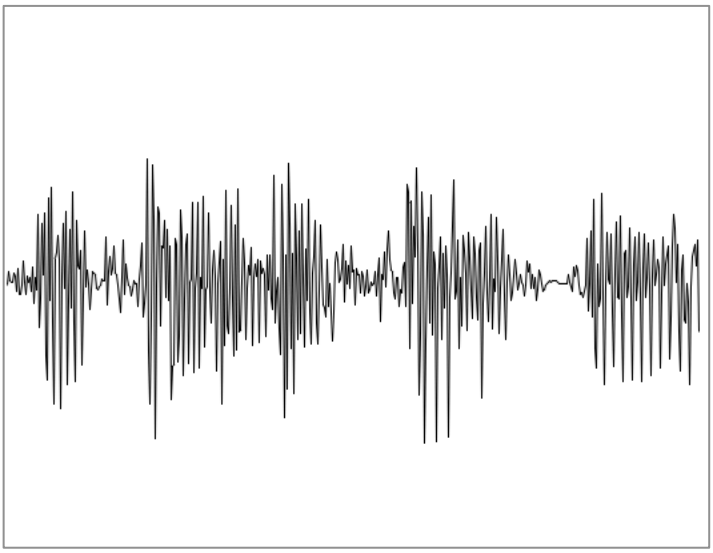

Figure 5-3 : Wavetable containing sample

Wavetables can also be used to store algorithmically produced waveforms providing an economical way to generate an audio stream: rather than calculating each individual value of what is often a simple repeating wave-form (a sine wave for example) the table is filled once and then read using a looping process.

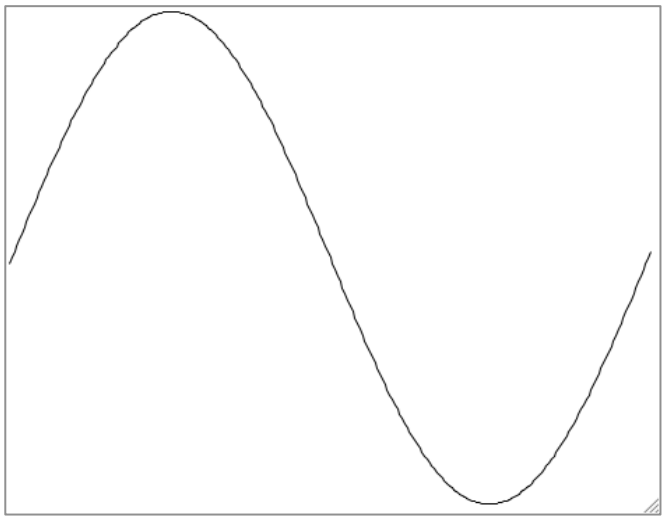

Figure 5-4 : Wavetable containing sine wave

In the case of *RoadMusic,* the values filling the wavetables are the input from the accelerometers so rather than starting with a fixed (recorded or generated) waveform

RoadMusic uses measured values of the vibrations and movements of the car itself as a starting point for synthesis. Data from the accelerometers fill the wavetable progressively, incrementing an index with each new value. When the maximum index is reached it starts again from zero, overwriting previous values –thus the wavetable is always filled with the most recent data. To produce an audio stream the values of the wavetable are read at a much higher rate (44100 hertz) than that at which they are written from the accelerometers (10 hertz) so the waveform changes relatively slowly and the sound is in

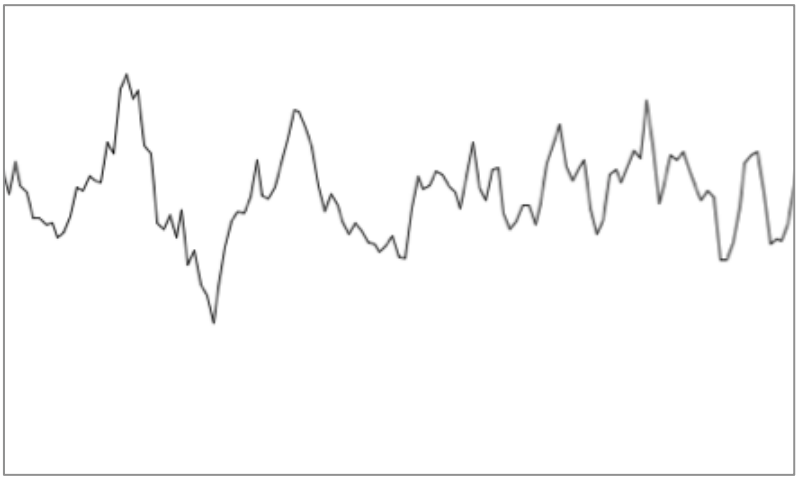

Figure 5-5: Wavetable containing data from accelerometers

continuum. This is a variation on the principle of audification described in Chapter Four. I stumbled upon this principle when using a graphical array to study incoming data. It struck me that the patterns I was seeing tended to resemble an audio wave form –or at least looked as though they could be read as audio which turned out to be the case. What makes this of particular interest in this context is the fact that the incoming data immediately influences sound quality or timbre. This content of the wavetable does not influence the fundamental pitch of the sound (that is defined by the frequency of the looping playback); however, the evolving data 'colours' this frequency, changing its timbre according to road surface, vibrations of the car and other, larger movements. Whatever the complexity of the audio processing and musical organisation that follows, the sound always bears the imprint of the road and even if it is not always (consciously) discernible to the ear, this slight but continuous variation lends a live quality that (in my experience) is difficult to obtain through audio synthesis. Each new data value adds to the existing pattern while gradually erasing the memory of what came before.

These wavetables are the core material from which the sounds evolve. Different wavetables have been allocated to the different accelerometers and are thus sensitive to movements of the car on the different axes. The use of wavetables of different sizes influences the acoustic qualities and the reactivity of the subsequent audio stream. I have also evolved this technique of filling wavetables in such a way as to create a variation in frequency rather than in amplitude within the waveform (by applying a modulo), creating shifting harmonics over the fundamental pitch.

5.3.4. Data Processing (The Host Program)

Data Analysis

For sonification purposes, beyond audification, it is possible to use a stream in many different ways extracting different significations. I will explain the different processes used in *RoadMusic* below but to give a general picture these involve smoothing or filtering, event extraction and derived data sets. Event extraction is the detection of a significant change in a data stream and a derived data set is a new stream of data generated from analysis –statistics for example.

These streams of data can then be mapped to audio processing in different ways 'Fanning' uses a single stream to influence multiple streams of audio and 'funnelling' applies multiple streams of data to a single stream of audio (Barass 2004). This type of converging and branching would appear to correspond –albeit in a highly simplified manner– to the relationship between our minds and our senses as we saw with Dennett's pandemonium theory of consciousness and Bregman's ASA. From the following discussion I had with nano scientist James Gimzewski, it would appear that my application of these principles in *RoadMusic* is perceivable in the end result:

> If you think of human intelligence, its usually multi-sensory inputs you know? Constantly we're bombarded by so many sensory inputs and we don't process them individually we process them in a collective; in a kind of strange collective manner, we don't really understand it, we're trying to understand it. And so, the way your system is working is almost resembling a human brain in some respects. It doesn't drive the car, it doesn't make decisions necessarily but it's

taking all these inputs and it's giving an output, a music… (See Appendix Two for the integral conversation).

When I explain the principles behind *RoadMusic* prior to a demonstration people often retain the idea that music is constructed from an image. This is possibly due to the familiarity of the synchronised audio-visual experience, or to the culturally indoctrinated parallel between media screen and windscreen discussed by Bull (5.2. The Effect of Mobility On Media). More difficulty is encountered when projecting a correlation between sound and movement. In the actual situation of driving in the car and listening to *RoadMusic,* the opposite tends to be true: the mapping of physical and tactile sensations to the sound is perceived as something natural and comprehensible whereas the mediation of the visual image is perhaps further removed from what one would expect. I would tend to put this down to the fact that our visual sense is selective and we direct our regard towards objects that are significant to us whereas the camera does not have this capacity of discernment and does not 'see' in the same way as a human. One way in which I have responded to this paradigm is to combine information from the camera with that of accelerometers in a single audio stream. I will develop on the methods used to analyse the video stream further below, but first I will return to the way in which the accelerometers are used.

Accelerometers

Data from each of the accelerometers is processed in two different ways (excluding the wavetables already described). The first uses a self-adjusting system to calibrate the maximum and minimum of the sensor (adapting it to the limits of the car) then the signal is smoothed to eliminate vibrations and 'noise' leaving only the larger movements. This modified stream is then suitable for parameter control (continuous variation of characteristics such as pitch or amplitude). The second process is that of detecting events within the raw data. A threshold level is defined; if the difference in the value of the incoming data over a given time passes this threshold then an event is considered to have taken place. These events are cornering left or right on the X-axis; accelerations or braking on the Y-axis and large irregularities such as bumps or potholes on the Z-axis. These can be used in turn to trigger musical events such as percussive sounds, new notes, or a change in key. On a third level, these events are counted to create derived data streams –continuously updating (moving frame) averages– the values of which reflect

slowly evolving characteristics of the journey. As an example, driving along a winding road will progressively push the flux of the x statistics to its maximum value whereas a straight road will reduce it to a minimum. All the data streams are scaled to a standard –a floating point value varying between 0 and 1– in such a way as to be interchangeable for parameter control mapping. Events are transmitted via a simple activation signal known in Pure Data as a 'bang'.

Finally these derived data streams are divided into threshold values which generate new events: from 0 to 0.33 equals 'calm'; greater than 0.33 equals 'increasing'; greater than 0.66 equals 'nervous'; less than 0.66 equals 'descending'. To use the example of the straight and winding road again, this means that the transition from a straight to a winding road will signal an 'increase' event whereas going from a winding to a straight road a 'decrease' event. I added this simple function that detects directionality since it provides more significant information about the way in which the drive is evolving than the simple division into three segments. An important innovation has been the introduction of the event 'no-event' which I have called *global.inactive*. This mechanism detects that no event has occurred within the last several seconds. This generally occurs when the car comes to a standstill at a junction or traffic lights and I use it to structure on a large scale –to finish what might be considered as one musical movement and start afresh with a new key and rhythmical structure.

These different levels of data analysis have evolved progressively over the course of this research in response to my reflections on the way in which the present instant can expand through memory and how music can be structured dynamically. At the outset, I was simply mapping incoming data to a parameter of sound; it is easy to imagine that this produced a result of limited scope. I created different levels of analysis of movement in response to the questions raised (section 5.2 Sympathy, Sounding, Mobility) concerning what the role of the sound of *RoadMusic* is or should be: an extension of corporal sensation / perception, the road as a score, or a soundscape being traversed. *RoadMusic* has become a perceptual system counterpart to that of the auditor, it expands outwards from the car and the driver and incorporates a range of sensations from the instantaneous tactile vibration to the memory of the winding road we left behind. These different perceptions take place simultaneously as multiplicity and are recombined in the resulting audio, in what one might compare to a musical form of Dennett's *Joycean Narrative*.

Video

It is important to distinguish the use of video capture in *RoadMusic* from the production of images, since it is never rendered to the person driving as such. An anecdote underlines the difference: at one point during the development of this program, after adjusting the camera analysis, I was working at home using video files recorded with the *RoadMusic* computer and camera (in other words with the same type of image as the device 'sees' when installed in the vehicle). When I tried out the program while driving, the resulting sound failed to correlate with the landscape the way it had seemed to in the studio. To unravel this enigma I placed a computer screen showing the video image on the back seat of my car, visible in the rear view mirror, whereupon the relationship between the sound and the image was immediately perceivable –simply it did not correspond to what I, as a driver was seeing. This might occur in any situation where a sonified video stream is not visualised but I would postulate that when driving ones vision is particularly strongly adapted or adjusted to that activity and thus particularly selective in what it retains. A possible response to this problem might be to accept that we are dealing with 'machine vision' –it is what the computer sees and the way it interprets the data and that is that. However since I am interested in the communion that can be established between *RoadMusic* and the listener I continued to work on this interpretation establishing (to date) two techniques which tend work with the car occupant's visual perception of the journey the first based on colour and the second on moving objects.

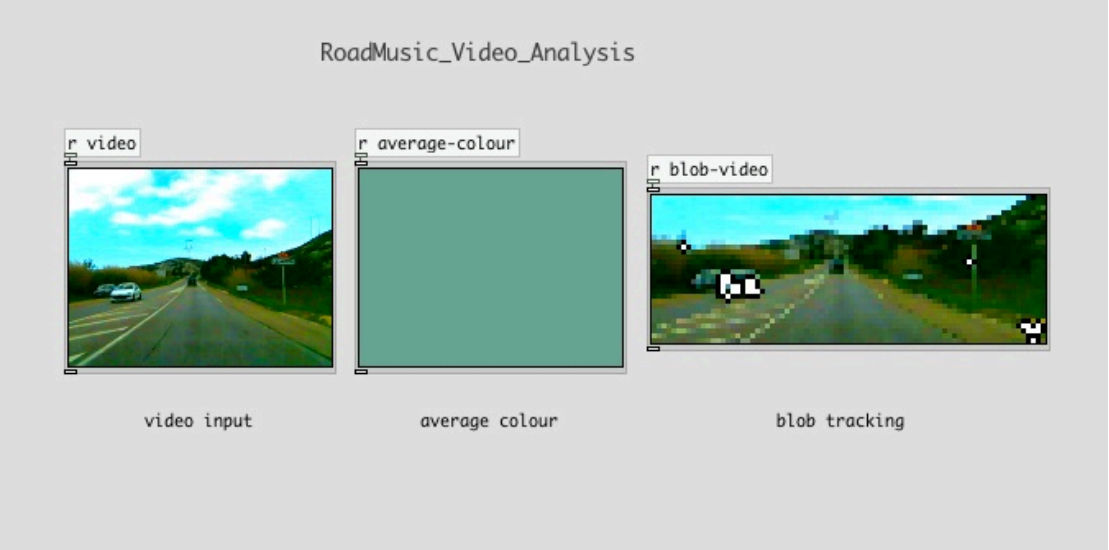

Figure 5-6: *RoadMusic* Video Analysis

Colour analysis is accomplished by reducing the video-capture to a single average pixel and then extracting its RGB (red, green and blue) colour component values. These values are formatted in the same way as the other data streams (between 0 and 1) and made available for parameter control. The dominant colour is deduced by comparing these values and a change in dominant colour creates an event. This has proven to be a particularly valuable function: although colour change is not in itself particularly meaningful to the driver, it generally corresponds to a significant change in scene, provoked by going round a corner or over the brow of a hill for example and it is based on a sensation which is independent of detail or form.

Moving objects are detected by using a blob tracking technique based on degree of difference from one frame to the next (a blob being consecutive pixels which can be considered as a group according to a given criteria). Concretely, the faster a group of pixels is moving the more likely it is to form a blob, the moving coordinates of which (x and y giving the position in the frame and z the size) are extracted as data streams. Although this system translates the movement of the camera itself (particularly lateral movement when cornering since stationary objects become mobile in the camera frame), most often it detects other moving cars. As described in the narrative at the beginning of this Chapter, this turns out to be particularly noticeable when the occupied car is stationary (at traffic lights for example) and other cars are crossing perpendicular to it.

There are many other methods for computer vision such as shape recognition or blob tracking based on colour rather than movement. However, real-time video analysis is very 'expensive' in terms of processing power and it has been necessary to limit this expenditure since the resources of a small portable computer have to be shared in a critical balance between data analysis and audio processing. We are however continuing to explore potentially interesting solutions such as the detection of repetitive visual elements (for example, white lines or lamp posts) that could be applied to the generation of musical rhythms[94].

5.3.5. Composition (The Audio Program)

Until this point, this section has been dedicated to the data processing part of the *RoadMusic*, or the *host* program. I will now go on to describe the second part, which

[94] I am currently working on this with programmers Charles Bascou and Guillaume Stagnaro.

generates the actual audio result. Versions by composers other than me are now being produced but here I will solely describe my own version.

The real time generation of sound through computer programs shifts the notion of composition away from the 'traditional' writing of scores, to the creation of routines –I proposed this interpretation of Cage's more radical approach to composition in Chapter Two (2.3 *4'33"* And *4'33" n°2*). To put it another way, the instructions, rather than being fixed in a linear time mode –as is the case when using methods such as (standard) scores, timelines or sequencers– are transformative modules that accept variable inputs and in turn produce modified outputs. Routines of the sort used in *RoadMusic* generate what Cage calls 'experimental music' in the sense that the composer discovers the result of the routine along with any other listener. We might also consider Xenakis' symbolic music, where fixed scores are replaced by variable parameters as a precursor to this method. Unlike cage and more in keeping with Xenakis, in *RoadMusic* the routines themselves are carefully tailored in order to produce a result that while being indeterminate remains within the confines of the role allocated to it. On the other hand a core concept in *RoadMusic* is that it is driven by 'everyday' data in real time, so possibly, it can be situated somewhere in between the two composers' approaches.

As already evoked one of the particularities of my project is that unlike (I would venture) the majority of interactive sound art, *RoadMusic* does not function by playing back existing recorded sounds but rather its processes of transformation are entirely driven by the data and accumulate to produce complex sounds. I insist on this point, which is both acoustically and conceptually important to me. Unlike typical wavetable synthesis which takes a sophisticated waveform (recorded sample) and transforms it, in *RoadMusic* the signal from a simple varying input becomes progressively more complex from the bottom up, passing through multiple stages which use the streams of data in different ways, to modify, shape or envelope[95] the sound stream. It is in this construction from the lowest level of incoming data that I consider that *RoadMusic* operates a shift with most current digital media-art.

My *RoadMusic* audio processing program is organised as an ensemble of different modules of synthesis each of which can be considered separately as independent

[95] The electronic music terminology which designating the form of a sound occurrence or note ; typically its attack, sustain and release.

instrument or stream. Each has its own logic as to which data it uses and how. At the time of writing there are thirteen such modules but before describing what they sound like, how they work and how they have evolved, I will first describe the technique I have developed for mapping the inputs to the 'instrument' parameters.

Data Mapping Or Routing

Each instrument has between five and fifteen variable parameters. Some of these such as: pitch, amplitude, position in stereo field or echo/delay, occur in most instruments, others such as the number of notes, pitch bending or syncopation might be specific to a particular instrument. Mapping the various streams of data described above to all these parameters has become a major task and I have developed tools to facilitate this mission, which have become essential to the compositional process.

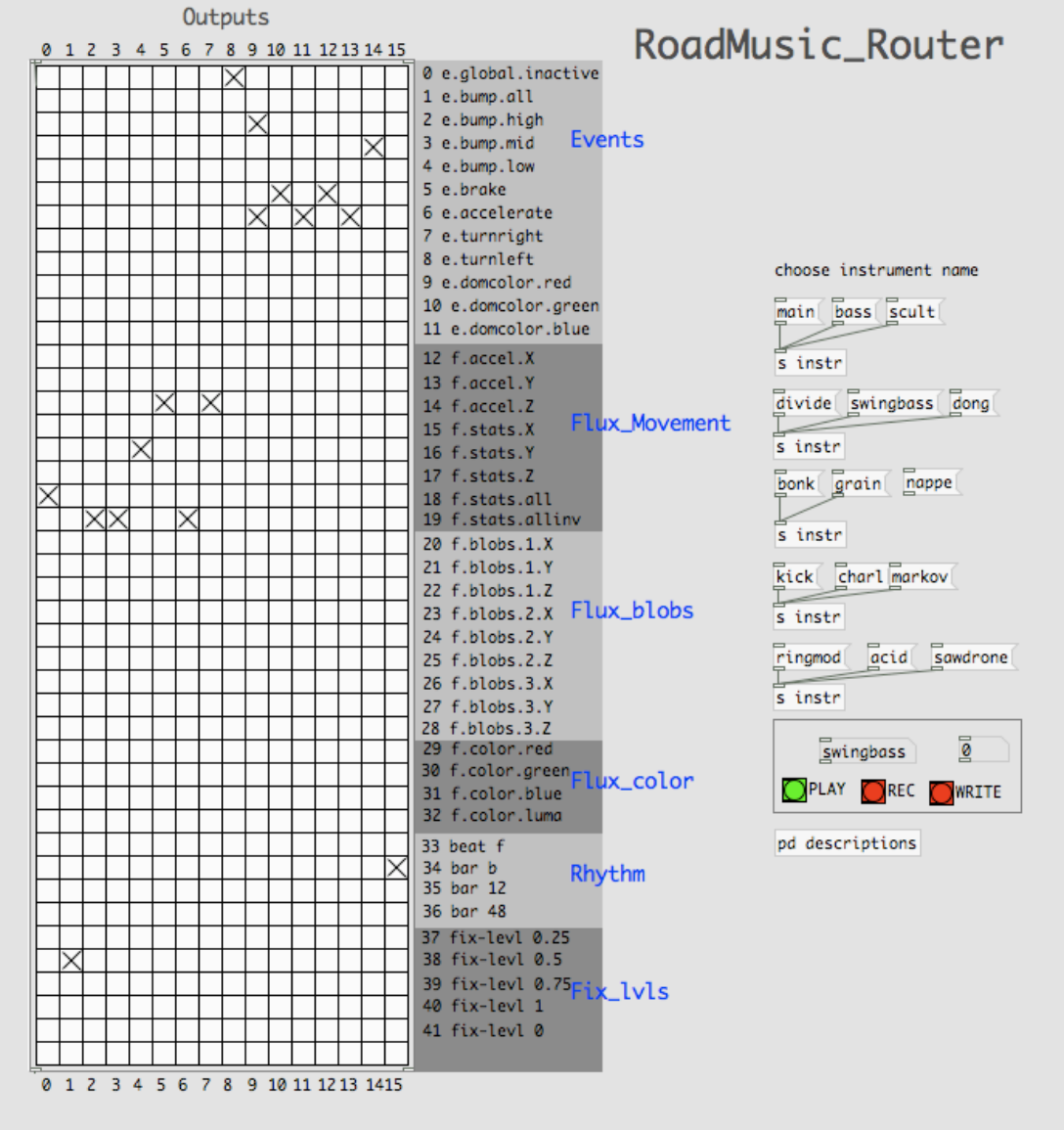

Figure 5-7: *RoadMusic* router

The matrix shown in Figure 5-7 is the graphical user interface of a small patch or program which allows me (and now other composers) to create the links between the modified input streams and events listed on the Y axis and the instruments parameter reception –listed as a number on the X axis. The user checks boxes to choose the desired routings, and then clicks the 'rec' button on the interface to generate the code, which is automatically included in the audio program. This operation can be repeated for any given instrument and different versions can be stored and recalled. The advantage of this system is that it makes it possible to test different mappings easily, without modifying the

main program. It also provides a useful visualization of existing mappings that can be displayed, or printed to paper.

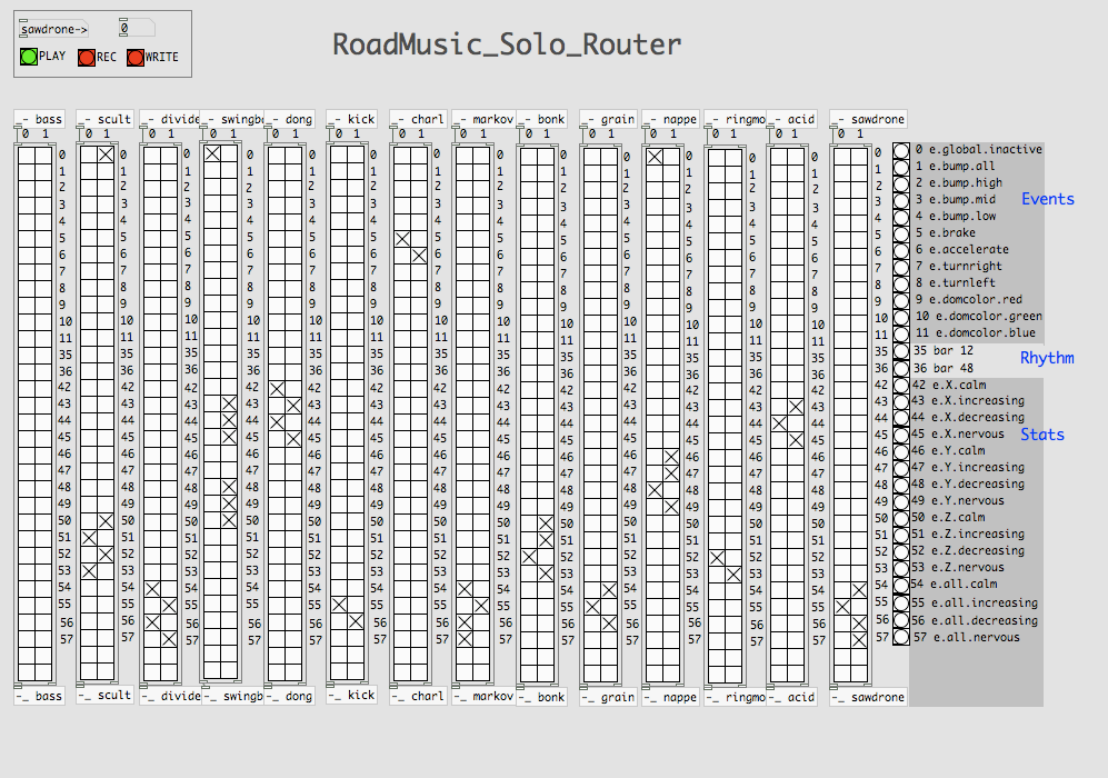

Figure 5-8: *RoadMusic* solo router

A second, similar external patch is used for 'orchestration' (Figure 5-8); it defines which instrument will play when. Only event information is available on the Y-axis and each instrument has two outputs 1 and 0, which respectively switch that instrument on and off. When composing, this matrix accords an overall idea of which instrument will play under what conditions and which instruments will play together. These routings are saved to the main audio program in the same way as instrument routings (described above).

Instrument Descriptions

If the instruments can be considered individually nonetheless the ensemble shares some global parameters, common to all the instruments, which allow them to play in time and

in tune. These are a metronome and rhythm box: the tempo and the number of beats to the bar of which are defined according to statistical data; and a function that generates a set of notes in a key that is chosen according to dominant colour. The program uses simple pentatonic scales guaranteeing that these notes will always be in a harmonic ratio to one another. In the instrument descriptions that follow, I will refer to these as *global rhythm* and *global scale*. Both these functions are triggered by the *global.inactive* event that occurs when the car pauses as described above.

The choice of names in the descriptions that follow might sometimes appear ambiguous. This is due to the programming process: once a named routine is embedded in the program, it can be difficult to rename it to comply with the way in which the resulting sound has evolved without re-writing the entire code. I have preferred to use these names here since they can be cross-referenced with the actual program or the video documentation. For the sake of clarity, each description is divided into two parts: a subjective description followed by specifications of how the data is deployed. The reader is invited to listen to the audio files which are presented in the same order and with the same names on attached DVD-ROM

Ringmod

Description: *Ringmod* makes a sound reminiscent of an electric lead guitar that runs up and down the *global scale* following acceleration and deceleration (the Z axis).

Mapping: Modulation is created by multiplying a sine wave by values from a wave table of data from the Z-axis accelerometer transformed into the frequency domain. Pitch of the chosen note is defined by the smoothed and de-noised Z accelerometer. Position in the stereo field is defined by the X accelerometer.

Dong

Description: *Dong* is a bell-like sound that tolls at a steady rhythm from one *global.inactive* to the next. The pitch of the bell wobbles as the car corners and the note changes with (abrupt) changes in the landscape.

Mapping: Rhythm is defined by *global rhythm* and the pitch of the sound changes with each change in dominant colour, as does its position in the stereo field. Echo delay-time and feedback are mapped to the X-axis, generating a pitch distortion effect (like a tape

speeding up or slowing down) when going round corners. This couples with the fact that a change in dominant colour often corresponds to a change of direction to make *Dong* doubly sensitive to cornering.

SwingBass

Description: *SwingBass* sounds similar to a bass guitar although its qualities vary considerably according to road characteristics and driving. Generally speaking, the sound is related to the Z-axis. A new melody is generated randomly from the *global scale* when the car stops or gives way. Part of this melody plays permanently until the following stop, while other notes are added or removed from the riff as the car accelerates and brakes; the bass 'improvises' on the melody with the movement of the car.

Mapping: The adding of a note is triggered by acceleration or a big bump, deceleration removes a note. Acceleration and deceleration events also switch on and off a harsh attack (which gives the instrument more presence) and distortion. Timbre (frequency filtering) and distortion level are mapped to the Z accelerometer stream. The melody is generated randomly from notes of the *global scale* when a *global.inactive* occurs.

Charl

Description: The sound is a rapid, dry, clicking sound that is linked to the car's acceleration. Unlike other instruments where rhythm is stable, here the tempo increases with acceleration. At the same time it multiples and thickens. Upon releasing acceleration, the sound thins and fades away.

Mapping: almost all functions are mapped to acceleration on the Z-axis.

Sculpt

Description: *Sculpt* is a continuous breathy, whistling chord, obtained by filtering white noise[96]. It is the one instrument that does not comply with my principle of using only incoming data as an audio source. The reason behind this choice is that since it mediates the ambient light it has its own relationship to the environment and by extension to

[96] Random sound composed of all frequencies of the spectrum.

movement. This association is confused when it is combined with an audio signal coming from tactile information (I will discuss this further below). When the car is immobilised, *Sculpt* will often be the last sound remaining in the mix.

Mapping: Three band-pass filters are mapped to colour component levels (red, green and blue). These sculpt the white noise creating a simple triad chord the notes of which are defined by the *global scale*. A change in the dominant colour reorganises the triad so that the frequency assigned to that colour becomes the fundamental or base note. The amplitude of each of the three filtered signals is regulated by the relative level of the colour component.

Kick

Description: A bass-drum-like sound that switches on when an acceleration event occurs and switches off after twelve bars.

Mapping: Pitch is controlled by Z-axis statistics. Tempo is controlled by global rhythm.

Nappe

Description: *Nappe* is a noisy drone sound where the 'grain' of the wavetable is audible (it is possible to distinguish variations due to road surface). The drone has a 'phasing' effect –it sounds as if it is resonating in a pipe of varying length. It is overlaid by a rhythmical pattern; the basic rhythm is stable but multiplication of the tempo and its syncopation change with the different movements of the car. The sound seems to be independent because the rhythmical pattern is dominant and yet the sound it carries is sensitive and responsive to the drive.

Mapping: X, Y and Z events modify the multiplication of the basic tempo (double or quadruple the beat). The Y value flux varies the phasing effect and the mixture between the basic drone and the enveloped rhythm. The wavetable being read is filled with data from the Z-axis.

Markov

Description: *Markov* generates small high-pitched 'plinks' that seem to shift around and warp in a more or less orderly fashion, depending on the variability of the landscape. When the car is stable or the landscape uneventful they settle into a recognisable pattern.

Mapping: *Markov* is actually a two-channel sequencer that generates a rhythmical sequence through a stochastic (weighted aleatory process[97]). It is one of the techniques used by Xenakis. The generation of a new sequence takes place every time there is a change in dominant colour, thus the number of repetitions of a same sequence depends on the monotony of the landscape. In a changing and varied landscape, the pattern is no longer recognisable as such but rather seems to change randomly. The plinks also vary in pitch and timbre according to the overall light level and individual colour components.

Bonk

Description: *Bonk* plays an impact sound when the car goes over a bump. The sound repeats, seeming to bounce (like a rubber ball) and gradually settles –the bigger the bump the louder and deeper the sound.

Mapping: When the value of the Y-axis shows a difference compared with the previous value that is greater than a given threshold, *Bonk* is triggered. The size of the bump is mapped to pitch, amplitude, and decay (the time that the bouncing sound takes to diminish and fade out).

Sawdrone

Description: *Sawdrone* is a simple drone sound a little reminiscent of a didgeridoo[98]. Its melody seems to ride on the relief of the road.

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[97] Hence the name: A Markov chain is a 'stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event. Named after Andrei A. Markov (1856-1922), Russian Mathematician. (Oxford 2010)

[98] Australian Aboriginal wind instrument.

Mapping: The drone sound is generated by a reading a wavetable where varying amplitude of the Y accelerometer is transformed to varying frequency. The same Y axis information is reformatted and varies a resonant filter providing the didgeridoo type harmonics

Acid

Description: *Acid* is a windy whistling sound that follows the curves of the road.

Mapping: *Acid* uses a bank of oscillators reading the X-axis wavetable at different frequencies coupled with a bank of filters with varying centre frequencies. These increase with left or right movement of the car.

Divide

Description: *Divide* plays a wide variety of sounds in the upper-mid range the sounds follow a melodic pattern (ranging between a harmonium and a siren). There is little immediately perceivable correspondence between the drive and the sounds.

Mapping: A melody is generated at each pause in the drive the parameters of which –the number of notes, note length, tessiture and rhythmical structure– are based on preceding statistics. Other parameters such as echo, pan and distortion, evolve and vary continuously but slowly because they are mapped to statistics.

Grain

Description: *Grain* is a cloud of sharp grainy sounds, which seems to follow in the wake of passing cars. It can also produce a more chaotic, fragmented presence when driving in a contrasted landscape.

Mapping: *Grain* uses granular synthesis (see Chapter Two 2.2. Granular Sound). Three 'clouds' are spatialised according to the blobs detected by the video analysis. Variable delay mapped to the changing size of the blob creates a Doppler effect, which associated with a change in pitch, loudness and pan in the stereo field creates an illusion of movement.

5.3.6. Evolution Of Compositional Process

Over the course of this research, my compositional method has evolved from a largely intuitive and experimental approach to a more structured one. This has taken place as the number and complexity of different streams or instruments has increased and as my idea of real-time has evolved. As an example, I realised the need to create a switching system to orchestrate the different instruments after the first long road trip that I did with *RoadMusic*. As it happened it took us through major changes in climate and scenery as we climbed to almost four thousand meters from LianJang Yunnan China to Zhongdian Tibet. It was then that I started to think that in order to get a sense of the journey it was necessary to incorporate slowly changing characteristics and unique combinations on a structural level, the memory of the road so to speak, this structure might be traced to Bergson's cone metaphor for the relationship between duration and memory. The questions posed in section 5.2. Sympathy, Sounding, Mobility, which pertain to the nature of the listening induced by sonification in general and *RoadMusic* in particular, have also been important in driving this practice and consequently the type of auditory logic or musical aesthetic to adopt. Auditory Scene Analysis and Kinetic Syntactic theory have helped considerably in formulating this method that enables me to incorporate both musical and soundscape listening (if we take as a reference Andrea Polli's separation between these two (Chapter Four 4.2.2 Time And Place).

In early versions of the program, mapping was done arbitrarily as I experimented with different types of synthesis. The creation of the matrix programs came when this experimentation had sublimated into more stable modules allowing me to isolate the process of mapping from the rest of the program, which in turn helped me with the fine-tuning of each instrument and the interrelationship between instruments. At this point, I reworked the program to give some functional-coherence, separation and independence to each instrument or stream. By functional coherence, I mean that it becomes possible to identify a specific sound in the ensemble and sense that its behaviour is in cohesion with some aspect of the drive. One might argue that because the sound is all driven by data it is inevitably coherent. Possibly this would be the case if each data sensor were to be mapped to a single stream of sound; however, as already discussed, the principles of analysis employed extract several different levels of signification. In most cases, each instrument combines several of these different streams in a multiplicity so the audio result is what Deleuze would call a composite (even when it sounds simple). The aim in

creating these routines is that the audio scene be sufficiently complex to maintain the listener's musical attention and enjoyment while keeping enough direct mediation for it to be experienced as the sound of the situation; partly in correlation with kinetic and visual sensation, partly a construction about that situation. These stream identities might be related to the idea of *chimera* developed by Bregman (Chapter Three, 3.3. Virtual Sounds), however, it is the accumulation of multiple inputs, multiple influences on a single sound that creates a new 'fictitious' entity rather than the accumulation of physically separate instruments to create a new sound.

The different instruments of *RoadMusic* follow different (audio and musical) methods. The simplest is the (almost) direct audification of *Sawdrone* that can arguably be considered as being the digital equivalent of the acoustics of the car on the road (it is feasible that one might produce a similar sound with simple mechanics and resonators). Others like *Bump* while being triggered directly by an incident in the road's surface, offer a metaphor for that event –your car does not really bounce like a rubber ball and slowly settle after it hits a pot hole but the analogy is readily understandable and acceptable. Instruments such as *Swingbass* or *divide* are melody based and their metaphors (if metaphor there be) are musical. The bass provides us with continuity and an idea of movement through melodic and rhythmic pattern. By using this continuity and repetition as a vehicle for variation and change, they can be considered to generate 'purely' musical emotion (as I have shown through Leonard B. Meyer's kinetic syntactic theory in Chapter Three). Other instruments start from an abstract idea: for example, *Sculpt* mediates light. The sound of light is non-existent and has to be invented –this diverges from those instruments related to physical movement, where the sound is either induced by (see *Bump)* or driven by (see *Sawdrone)* the source of data. For *sculpt* I used a technique know as subtractive synthesis that, rather that accumulating oscillators obtained by reading input wavetables, starts with a permanent source of neutral sound (white noise) and shapes or colours it using filters. Thus if the qualities of the light sonification vary with the journey it is constantly present, even when motion ceases.

Thus, several different things are happening at the same time in the audio sphere of *RoadMusic*. Yet this is perhaps relatively close to a naturally occurring sound environment where we are listening out for different sorts of signification: potentially dangerous events, patterns on different time scales or spoken language. Our auditory attention is drawn to specific streams while remaining sensitive or in readiness to others. However, in order to recognise the significance of a change in a sound or indeed to create continuity or recognise repetition, an audio stream has to form in the mind of the listener.

The difficulty is that neither the instrument's sound nor the mix of the ensemble is rigorously predictable (If I was using recorded samples or fixed modules of synthesis as a basis for this work this would be less important, since a sound that repeats has a natural tendency to form a stream). This is where ASA provides the basis for a method to organise the density of information in *RoadMusic* and still create the conditions necessary to maintain cohesive identity for each instrument.

The first step of this method was to make some decisions about the identity and the role of each sound stream. Prior to this, I was mapping intuitively, essentially seeking a result that sounded 'good'. I arrived at a point where it was no longer even possible to remember all the mappings and since the sounds were at times similar and their functional modes confused, it became difficult to distinguish between them. I started to nominate audio streams according to function. For instance, one instrument might be inherently to do with acceleration, another with moving objects in the visual field or yet another with cornering. In some cases the function is very clear and simple, as is the case of the *Sculpt* instrument that sonifies light colour, in others it is more ambiguous, sometimes just an idea which I can build around. This is the case for instance with *Nappe* –I have an idea of something which walks, trots or gallops, it is an identity before being mapped to an input. In the first case, I made the sound from scratch in response to the function, in the second, the function emerged through experimentation, and I consolidated it, pushing it in a given direction. Another example that of *Swingbass* implies a projected musical function: I want a bass that provides continuity over segments of the journey. What is the best way to map melody, rhythm and timbre to data in order to reflect a segment of road, while maintaining sensibility?

Incoming data is 'funnelled': several data streams converge to generate one audio stream. If arbitrary funnelling of different data streams can create results that are in turn, to all intents and purposes, random, careful funnelling can, on the contrary both enrich and reinforce the defined role. For example, *Dong* has ended up combining X movement and changes in dominant colour (and it sounds a little like a bell). In fact this works rather well because often as one goes round a bend or a corner there is also a notable change in scene and with it a change in dominant colour and this all comes together nicely in the swaying sound of the instrument.

The final level of composition is deciding which instrument plays under what conditions. Before I introduced my system for orchestrating the ensemble I was faced with certain uniformity in the music played since all the instruments played at the same time albeit at

varying amplitudes. The solo matrix allows me to designate which instrument is switched on according to different thresholds of statistics. This is chosen according to the general identity of the audio stream so for instance *Acid,* which reflects turns and curves, only switches on when the average number of X axis events passes a certain threshold thus it plays only on a winding road. *Grain*, mapped to the blob tracking of moving objects responds to the average of all types of events and will switch on when there is relatively little kinetic variation, typically on a straight road or when the car is at a standstill. Since all the switches are visualised on a single graphical interface it is possible to balance the activation of the different streams and decide (to a certain extent) which will play together.

5.4. The *RoadMusic* Experience

My version of *RoadMusic* has now been presented (live) in its different stages of development in a number of artistic events (a complete list of these presentations is available on page xiii). Beyond this, I take every available opportunity to demonstrate the device either by submitting it to passengers in my own car or by lending it to other people who set it up in their own car for a short period. The extracts of interviews and correspondences in this section cannot be considered as user testing per se, since, for the most part, they were conducted with people who are either directly involved with *RoadMusic* (composers of future versions) or who know me and my work. However, they do provide some insight into the way that *RoadMusic* is experienced beyond my own perception (complete transcriptions of these interviews can be found in Appendix Two).

I have discussed at some length how I consider that sonification in general and mobile sonification in particular modifies the musical paradigm. The question "Is it music?" might be considered as a false problem, since *RoadMusic* is far from the degree zero of music explored by Cage, Schaeffer or Boulez. However, I am less concerned here by an aesthetical or conceptual position concerning the limits of musical expression, than by how anchoring sonification to the flux of the unfolding situation influences the perception of the result (aesthetical concerns occur as a consequence of this).

Dominic a fifty-year-old bank manager drove with *RoadMusic* in his own car during a day out with his children. He differentiated what he heard from what he normally listens to in the car but was generally positive about his experience.

> Well, in the beginning it's curious to have that instrument in your car because it's a new sound. It's something that we're not in the habit of listening to, (of course – with the children). Then you get used to it –well not used to it... One knows that its the device that's providing the sounds; sometimes sounds that combine very well, and we forget its there –no one doesn't forget it, that's not what I meant to say, is that the sound is there and it's part of the atmosphere (ambiance) in the car I think. And it's soothing; I mean it's not aggressive at all.

Andrea Cerra is an Italian composer and sound designer who is working on his version of *RoadMusic*.

> At the beginning of the first trip (train station to GMEM) I didn't know I was listening to *RoadMusic*, the traffic was very slow, and my first impression was to be listening to a very cool radio program about electronic music. After a while, when I realized that the nature of the sounds, the mixing, the musical form was quite weird (it had a raw "live" quality, non refined, living...) so I asked to Peter (who was driving) if it was *RoadMusic*.

I might add to this that I once picked up a hitch hiker who after a quarter of an hour driving started questioning me as to where the music was coming from, so this recognition of the music being 'different' is spontaneous and not simply due to Andrea Cerra's expertise and his awareness that *RoadMusic* existed. James Gimzewski is a Nano scientist, professor at UCLA and member of the Royal Society. He experienced *RoadMusic* during a three quarter hour trip driven by myself in Marseille where he was doing a residency at IMERA.

> Maybe I should have used the word music, I'm not really a musician so it's hard to define it but I think it's music that is created by what the machine senses, in a complex way because it's not a simple input, it's many inputs and you're a composer in the way that you program the various algorithms, the way you do the computation to produce the sounds. I mean I should say that it is a piece of music but it's a very new form of music to me. It's my first experience of anything like that and as I said, because of my research into brain and multi sensory inputs, it's very intriguing that way you as a composer set the stage, but the machine makes the decisions, but the decisions it makes are fairly um… Let me ask you actually —if you use fuzzy logic... (We go on to discuss the decision-making programs of *RoadMusic*).

Anne Lovell is researcher in sociology living in the Aix en Provence area. Anne was not so sure that she would want to drive with *RoadMusic* herself, but put this down to particularities of her own perception (which she refers to as a form of dyslexia).

> Well it depends on how one listens to music normally, but definitely for me it has nothing to do with putting on the radio or even to listening to pieces but that don't require active listening, you know just listening as background while you work or you go into a store or you're sitting in a café. This is active listening, which is why I don't think I could use it when I was driving unless I was really in an automatic mode. It's active listening and it also makes me, or made me aware

> of the environment in a different way. Now that's maybe because it's the first time I'm doing this, so I'm very tuned in to why a certain sound is the way it is. I want to understand what is it in the environment, or the speed, you know. But it's not at all like "normal listening".

On a less expert level this was the description given by an 8 or 9 year old child interviewed after a brief demonstration trip (Pole technologique: Cas2interview3):

> I can't say that it's music because, I don't know, because there's no singer, there's no… But it's ok, yes; we heard sounds as if we were in the countryside see? (quoi) It was like we heard things coming see?

A question that is, inevitably, raised by *RoadMusic*, is whether it has an effect on driving and more concretely, whether it might not incite people to exaggerate their driving in an attempt to augment the music with possible negative effects on safety. First, we might consider the effect of 'normal' in-car entertainment listening, bearing in mind that this has been an issue in the road safety debate, ever since the first car radio came out in the 1930's. Early research concerning the effect that listening to music and other audio cognitive tasks have on the drivers' concentration (Brown, 1965) concludes that listening to music is beneficial since experimental results showed that it reduced the frequency with which the accelerator and brake pedals were used. More recent research underlining the influence of the genre and overall amplitude of the music is less conclusive: 'These findings support evidence for music as a source of in-vehicle distraction, which can have both positive and negative effects on driving performance' (Dibben, 2007). It seems that listening to audio distracts driving concentration slightly, while there might be a relaxing influence related to musical listening, generally considered positive. Bull describes how adapting driving to music can be part of the 'cinematographic' experience:

> Many drivers report moving or manoeuvring through traffic in a dance-like manner, as if the relation between the driver and the act of driving were essentially aesthetic. (Bull 2007, 90)

When driving with *RoadMusic* for the first time there is undeniably a desire to test the system, by exaggerating acceleration and cornering or seeking out potholes for example.

Oceane**,** Dominic's thirteen-year-old daughter informed on her father:

> Then we tried it out, we tested it on the road by accelerating (Laughter).

Charles Bascou is a programmer now helping with development of the *RoadMusic* system. He has done more driving with *RoadMusic* than anyone else (other than myself) this is how he describes his experience:

> I get the impression that you seek things out. At one point you tickle the system – inevitably. You try accelerating, braking; well it's a basic thing, to see how the thing reacts.

But he goes on:

> I know that the way (of driving) is different because, we drive differently depending on the attention we pay to the road and I think that with *RoadMusic* attention is really increased. It implicates your presence at the wheel of the car in a way, and legitimizes it. Let's say that you're more respectful towards the exterior.

Sounds resulting from immediate feedback are of limited importance in the musical result and overall, more information from the sensors does not necessarily result in more sound (some instruments start, as statistics diminish). Consequently testing soon gives way to a different type of experience where the music is integrated into the drive, enhancing it, rather than being perceived as the direct result of the action of driving.

Atau Tanaka, composer and professor of Media Computing at Goldsmiths, University of London was quick to analyse this in *RoadMusic* analysing it in terms of design efficiency:

> And what struck me immediately about *RoadMusic* was the directness of the experience and the things which I value in an interactive music system, which is the physicality of it, the kind of viscerality of the experience and this, in some ways, was more than I expected —that the dynamics of the car, the translation of the road conditions and the light could at once give an immediate sonic result but could also work at this other level to shape something which we could actually consider as a piece of music. That was a pleasant surprise.
>
> But if for example by going over a bump, there is a bump in the music, you sense it, you get it, it’s funny and by then believing, it gets you engaged in believing

> the less physical stuff. And having that second level, longer term reaction and so fourth, is none the less extremely important because if it was only bumps that go bang then the system would be a bit trivial and it would very quickly become tiring.

I think what Atau Tanaka refers to as 'viscerality', is present in all the different levels of *RoadMusic's* sonification because from audification to structure, all flows from the immediately captured data. My hypothesis is that this provides a continuous, preconscious monitoring of the driving environment through musical listening that might have an overall beneficial effect on the user's awareness of that environment. This is in comparison to normal in-car listening, which unless it is traffic warnings on the radio or the minimal sonifications of indicators and other alerts, has little to do with the situation or the task in hand. We might compare this to the awareness of a pedestrian (unconsciously) hearing his or her naturally occurring audio environment versus that of a pedestrian listening to music unrelated to that environment through headphones.

RoadMusic however, is a hybrid between these two situations: unlike inevitable urban 'noise', the sound is chosen and therefore presumably welcomed, but at the same time, it conveys information about the environment. To clarify, I am not suggesting that a listener might for example, perceive that there is gravel on the road and therefore avoid an accident through attentive listening. Rather I propose, that because the music is intrinsically related to the road, there is an augmented perception of the driving experience and that through this the driver's or passenger's engagement with the driving situation is increased. More so, because it is through what I hope is a pleasant listening experience.

This is what Vasco, Dominic's ten-year-old son had to say about his experience:

> All the same, it puts us in the rhythm of the road so that we know how to deal with it, when we accelerate or slow down or overtake. Anyway I felt that the music changed a little to warn us that we were becoming a bit cut off (fermé) for example –I don't know, that's how it felt to me anyway.

James Gimzewski picks up on this idea of preconscious perception:

> Sinclair: It's sublime like in Kant?

> Gimzewski: Exactly, like sublime has a kind of sense of awe and a kind of sense that makes me little bit scary in a strange way because this music is talking to me and what I'm visualizing and experiencing in terms of acceleration and all these different things; it's giving it an auditory interpretation which is —I'm going to use the word subliminal in a different sense from sublime but subliminally being interpreted by my brain. And so it's like a new layer of awareness, that's how I would describe it, but a very integrated sense of awareness. Integrated with the environment as it changes –it's actually the change because there's two ways in which we can look at something you can say ok there's the road but the human brain doesn't really care about a static picture of the road, it's the change right?

This integration through listening, in my experience, over long drives does actually have a positive effect on my mood and maybe (just maybe) reduces road-rage. It is in opposition to other types of in-car entertainment that arguably transport the listener elsewhere –into another dimension detached from the outside environment.

Charles Bascou

> No that's just it, because you are a bit in reality, you are much more attentive to your environment, in fact you are really in your environment. And it augments your perception and even your diligence, whereas in general music in cars really transports you elsewhere, at least it does me.

Dominic Lefrere

> Myself, I would listen to it on long journeys it wouldn't bother me personally. I could see myself listening to it on a night-time road with every body else asleep; it would be perfect.

With experience, it may be possible for a driver to recognize, and possibly interpret, complex configurations and combinations, but this tends to happen through the global recognition of a previous similar sound experience as opposed to the immediate, conscious tracking of a given signal.

There is also a perception of *RoadMusic* as a sensitive entity. It is as if there was something next to you describing the journey from its point of view, but since you (the

driver) are responsible for the choice of route and style of driving it is a shared experience; maybe something like John Cage's conch shell performance.

Andrea Cerra

> I had the feeling that RM spoke to me more about the car, made me conscious of the forces (gravity, road irregularity...) that the car has to deal with, and in some way showed the soul of the car. I had the impression to be riding a live animal, not a machine.

This brings us to interesting interrogations concerning authorship and the everyday. *RoadMusic* rather than being the interpretation of the ideas the composer has in his head is the mediation of the road. Then again, this mediation is organised by the composer and is performed by the driver.

Atau Tanaka

> —It's interesting to think about where the boundaries are of what constitutes the instrument. Is the instrument the computer with the sensors that's in the car or once its armed with these sensors does the car become an instrument? Or that Pd patch that has been created, it's a pretty specific patch; it creates music in a certain way, in a very musical way, is that an instrument or is it part of the composition? Has the system designer taken a certain authorship over the resulting music or by creating the system in that way do we have a body of work, that's similar, that's self consistent so that a composer coming in, being asked to make works for this system may be making variations or may be making entirely new works? Certainly the notion of authorship has changed, the notion of instrument has changed from a self-contained thing to a system that includes the environment.

These questions are all the more interesting in the light of the future research which I (we) are now engaging in and which I will describe in conclusions.

6 . Conclusions

This dissertation began with an interrogation of the fundamental nature of time and indeed my understanding of real-time or (real time) has evolved during the course of this research. Bergson's duration provided me with a different definition of real time to that which I used when dealing with computer technology: a specific dimension that is known only through intuition. An understanding of Bergson's ontology has consolidated a basis for thinking about art in flux. Bergson's time however can only be perceived through its incorporation into the spatial dimension via memory. Similarly, my conception of an art of real-time requires a process of symbolisation that continuously builds from and beyond the immediate moment. Each individual piece of data –if taken apart, without the preceding or the following value– is without meaning since context is necessary to create significance. For the same reason while music is necessarily ongoing, a melody only occurs because the preceding notes lead to the current one and that this infers what the next note might be. Thus if my notion of an art of real-time places immediacy at the centre, it necessarily expands from there and the dimension of that expansion is potentially limitless. It is a question of the limits of the system under consideration rather than an absolute value.

The data driving *RoadMusic* is captured independently from any artistic decision, and outside of the artistic 'object' or the voluntary action of the user. I evoked the question as to whether this could produce an artistic result. This has been considered from several angles. Firstly, I have considered the thinking of the precursors to such a form of art and discussed the reasons that pushed these twentieth century composers to integrate environment into music and the different methods they employed to do so. These shifts in the artistic thinking, away from the expression of the artist and towards the 'everyday', find echo in the evolution of post Bergsonian time through Rhythmanalysis and Ecology of Mind. They question the human-centric point of view replacing it with a more open idea of system. I retain principles of indetermination in composition, stochastic composition (creating audio form through algorithmic means), soundscape listening and (above all) Cage's notion of experimental music as fundamental historical mainstays to *RoadMusic*. I associate Cage's indeterminate scores, which allow the composer to

discover the music along with the audience, to real-time computer routines where instructions applied to variable input produce modified output. *RoadMusic* can be considered as an accumulation of such routines.

Another approach to this question has been to consider how the human mind constructs narrative (in real-time) how we make sense from our mobility. For this I have considered Daniel Dennett's theory of consciousness –his Joycean narrative and multiple drafts theory. More concretely, related to my practice, I pursued these ideas through more specialised theories of musical perception and emotion that have enabled me to create a compositional process (kinetic syntactic composing) that, while being in flux, has form and structure.

Today there is a strong interest in 'technical' sonification and arguably, existing documentation on the subject is sufficient. However, I was able to contribute to the field of knowledge by organising and chairing a symposium dedicated to a specifically artistic approach to sonification and subsequently by guest editing a comprehensive guide in the form of a special edition of *AI&Society*. My own use of this materiel has been to trace the ideas of the composers described above through the sonification works of my fellow artists and to identify responses that might collectively answer the interrogation as to whether the fact that sound is a sonification constitutes a change in paradigm *vis a vis* composition or sound art in general. In effect, it would seem that this anchoring in the 'real' is often considered as being of primary importance. It is seen by some as an extension to J. Cage's ideas of the everyday, by others as a form of soundscape listening and others consider it as modern form of cosmology finding its origins in *Music of the Spheres*. The response to my hypothesis then is perhaps uncertain. I sense that there is continuity with the principles developed by pre-sonification composers and certainly, as Paul Vickers points out, it is possible to listen to (any) sonification as music if the listening attitude is a musical one. On the other hand, in all the cases of sonification that I have encountered, the origin of the data and the fact that it drives the music is considered as artistically significant and this is independent of aesthetic considerations.

I have paid particular attention to those sonification works, which take place in real-time and in real-place; works that capture the data about the situation in which the audio is rendered. I have studied several examples, which can be considered within this category, however they all raise a question, to my mind important, which concerns the influence of the non-permanence of a sonification on its perceived significance and which possibly provides grounds for future research.

More germane to *RoadMusic* I have considered the influence of mobility on audio and musical perception. Today this appears to me as possibly the most important field emerging from this research and one in which much remains to be explored. We are at the beginning of an era where computers capable of running the types of programmes described in this thesis are becoming readily available (in the form of mobile phones and other nano computers). This evolution has taken place during the course of this thesis, few artworks exist that exploit this functionality and inevitably, even less documentation. For this reason I have evoked examples of artworks that combine audio with mobility and theoretical studies concerning iPod usage. I associate these ideas with Bergson's mobility (the very basis of élan vital) and Lefebvre's rhythmanalysis. Beyond *RoadMusic*, through the use of 'intelligent' (or perhaps sensitive) mobile devices, we might consider forms of artistic mediation that construct from the instant shared with the user in a sympathetic relationship to environment –a metaphor to our natural sounding of our surroundings. User responses to the *RoadMusic* would tend to indicate that this is in fact the way in which people perceive the musical result. There is a natural quality to the overall experience that makes it intuitively understandable.

6.1 Limits Of This Research

It should be underlined that the objectivity of the testimonials in this thesis is questionable, since most of the people I have interrogated had some insight into the project and do not represent a cross section of the population. However *RoadMusic* is an artwork, appreciation of the music it generates like that of any other music is subject to taste and cultural preference and thus objective user testing is arguably of limited importance.

A criticism that has been levelled at *RoadMusic* is that it applies solely to the situation of driving a private automobile. The concern is that it might condone car driving and the environmental problems that go with it. I have been asked whether it could not be adapted to function for pedestrians, cyclists or use in public transport. While it would be technically feasible to respond to these requests, my reason for not doing so is that although I have no desire to promote car driving, the existing situation of the modern car is one in which the car occupant(s) might be considered as deprived to a large extent of a naturally occurring audio environment. Where a pedestrian or cyclist hears the soundscape around him/her and the traveller on public transport is in a social environment, it might be argued that in the modern car, the by-default audio environment

has come to be the car's sound system. This notion of an artificial audio environment, is becoming a concrete reality. In the case of electric cars which lack audio feedback, manufacturers are adding electronic sound to the otherwise silent acceleration. *RoadMusic* considered in this light, enlarges the otherwise closed audio environment of the car to the landscape and road outside, and I would argue, an awareness of the driving situation, whereas a similar device when walking, cycling or in a bus would replace the existing soundscape. I will discuss the context of electric cars further below.

There are two important limits to *RoadMusic* as it is described in this dissertation. These are essentially to do with the way that other people experience *RoadMusic*. I declared at the outset of this thesis that my aim was to create an art form that exists independently of the special occasion or the consecrated art space. *RoadMusic* answers these conditions hypothetically in its current stage of development: it is possible to install the apparatus in any car in a matter of minutes and it can run continuously on any journey, (in my own car *RoadMusic* is a permanent fixture). However, the fact that only a small number of prototype machines exist (six to date) and that they are relatively expensive to produce (approximately four hundred Euros) means that the only practical way to offer the *RoadMusic* experience to a larger audience is by organising an event or special occasion. I consider that today this is an acceptable and necessary compromise but I am seeking a solution that is better adapted to my project, as I will explain below.

Secondly, as I described in these pages, *RoadMusic* composes music, which while being indeterminate, generated by the journey and ever different is still framed by my own aesthetic choices made during the process of programming. While this process is both essential to my artistic reflection and a pleasure, if only my version were to exist *RoadMusic* would, from a certain standpoint, maintain the status of the unique art object. The ideas developed in this thesis are more about working principles than aesthetics and this is why I am now opening the project to other composers and sound artists, as I will describe in detail below.

6.2 *RoadMusic* Context, Distribution and Future Areas Of Research

Cars And Electric Cars

Until recently, we used to hear the motor of the car; we heard the rpm (even over the sound of our music) and through that sound, we gained extra information about our driving. Efforts have been made on most modern cars to insulate against this engine noise and electric or hybrid vehicles are, at low speeds, practically silent.

Although an immediate reaction to the silencing of cars might be one of relief, this absence causes two problems. Firstly there is a danger for other road users, notably pedestrians and cyclists, who are no longer warned by motor sounds emitted outside the car —having driven an electric car (Peugeot O2) in the context of this research, I can confirm that pedestrians find the silent apparition of the car extremely startling. Secondly, removing the sound of the revving engine means less feedback information for the driver inside the car. Car manufacturers are approaching this second problem, which is more germane to my research, in different ways. For electric cars, there are currently several projects to map synthesised sound (with no direct relationship to engine noise) to acceleration. In the course of this research, I have made several contacts in the field of audio research for the automobile. In France, PSA (Peugeot Citroen) are working on this question. On one hand they are in partnership with a LMA (Laboratoire de Mécanique et d'Acoustique), a national research group who are conducting fundamental research in the domain of audio sensation in relation to movement, on the other they have commissioned a sound design company *Creative Diffusion* to provide audio textures created by composers of electronic music for testing as audio feedback. I met with both parties and through *Creative Diffusion*, with PSA's permanent sonification researcher. All these displayed considerable interest in *RoadMusic*. LMA (who incidentally collaborated with me by submitting an article for AI&Society) have recently invited me to be on the organisational committee for their upcoming symposium CMMR2013 (Computer Music Modelling and Retrieval) dedicated to sound music and motion (CNRS, 2013).

Renault is working with the IRCAM[99] and composer Andrea Cerra, on a project that will allow the driver to choose between several different sounds that can be mapped to acceleration. Andrea Cerra is among the composers who are now working on a version of *RoadMusic*, which provides him with the opportunity to develop artistic ideas that he had been obliged to quell in the narrower context of his commissioned sound design. The leaders of Renault's design section are equally enthusiastic about *RoadMusic* however to date there is no official proposal for collaboration or sponsorship coming from either of these manufacturers who are possibly wary of the artistic goals of this research or who conceivably consider it as a project which is concurrent to their own. If at the beginning of this research a partnership with an automobile manufacturer seemed preferable, in view of the projected evolution of *RoadMusic*, which I will describe below, I no longer consider this absence as a handicap.

Figure 6-1: Atau Tanaka with Newcastle University's electric car (photo P. Sinclair).

[99] Institut de Recherche et Coordination Acoustique/Musique, Paris.

In 2011, Atau Tanaka, then chair of Newcastle University's *Culture Lab*, proposed a collaboration based on *RoadMusic* between *Culture Lab* and the transport section of the university TORG (director Dr Phil Blyth). This led to our testing *RoadMusic* in the University's Electric car and subsequently to the presentation of a paper for the Automotive UI 2011 symposium 'Automotive User Interfaces and Interactive Vehicular Applications' (AutomotiveUI , 2011). The paper entitled *RoadMusic: Music For Your Ride From Your Ride* proposes a hypothetical subliminal perception of the driving experience through using *RoadMusic*. I presented the paper in person and it was co-signed by Tanaka and by Dr Yvonne Hubner of TORG. It is soon to be published in Special Issue of the MIT review Presence: *Teleoperators and Virtual Environments: Subliminal/unaware cues and perception of presence in virtual, tele-presence, and automotive environments.* I have also been made a member of the selection committee for AutomotiveUI. Unfortunately, the collaboration with Newcastle University (which originally projected user testing in electric cars) has ceased since Tanaka has stepped down (He is now professor at London Goldsmiths University). However, our collaboration continues since he is one of the composers I have invited to develop a version of *RoadMusic*, as I will describe below.

During the AutomotiveUI conference, keynote speaker Bryan Reimer (MIT) insisted on the fact that today we are not only faced with the problem of cognitive overload but also with that of cognitive 'under-load'. In other words, research proves that more automation does not make for safer driving, since at times less demand on the driver's concentration can mean that s/he is less attentive to the situation. It would seem that part of this problem is related to our isolation from the environment. Reimer insisted on the fact that future car interfaces should consider the situation holistically – driver, car and environment. I feel that this is encouraging for *RoadMusic* where if the sonification is non-informative in the sense that it does not provide deliberately symbolic information it certainly establishes a direct rapport between driver, vehicle and situation.

Production And Presentation

Throughout the duration of this research *RoadMusic* has been the object of different forms of presentation a complete list of these can be found at the beginning of this thesis (see page xiii). In brief these started with a one month residency in Rhizome Art Centre in Lijiang, China which, led to a collaboration with video director Peggy Arraou and the production of a documentary video of a journey *RoadMusic from to ZHONGDIAN TO LIJIANG*. I have presented successive versions of *RoadMusic* live in festivals, including

Mois Multi Quebec 2010, *Figures of Interactivity*, Poitiers France 2010 and *Electro Pixel* in Nantes, France 2012. During these events the audience were taken for short (20 minute) demonstration drives. I have also presented my research publicly in other forms. I have demonstrated the code for the benefit of other specialists in audio programming at informal computer programmer meetings such as *Code Lab* in Marseille in 2010 or the Pure Data group in Montreal (Pdmtl) 2011. Beyond AutomotiveUI described above, I have presented conferences based on this research at UQUAM Montreal in 2011, OPS/IN (National School of Photography in Arles 2011 or The Contemporary Art Museum in Toulon for an exhibition entitled *l'Automobile Dans Tous Ses Etats* (The Automobile In A State) in 2013. Recordings of *RoadMusic* have been played on France Culture (French national radio) and I have contributed articles based on *RoadMusic* and my research into real time sonification to several publications. Beyond those already mentioned (AI&Society and AutomotiveUI) these include the conference proceedings of Obs/IN (Sinclair, 2011) and an article co-signed with Scot Gresham-Lancaster in the 2012 edition of Leonard Music Journal (Gresham-Lancaster & Sinclair, 2012) (see page xvi for a list of publications).

Opening The Project To Other Composers

As mentioned above I consider that at this stage in the development of *RoadMusic* and my ideas concerning real-time, it is preferable to open the project to other composers. As explained in Chapter Five the program has been organised in such a way that the parts that analyse and format the incoming data are separate from the part that generates audio. Thus, an invited composer can benefit from the 'host' program and apply the different levels of analysis to his or her own audio aesthetics.

There are multiple reasons for this decision: the ideas which I have developed concerning forms of art which are open to the everyday are better represented by an open ended project than by one which concerns only my own creative contribution. The existence of multiple versions shifts focus from a single musical aesthetic to better promote the principles of real-time composing which are my main concern. As a participant in the open source software community, I have adopted the practical and ethical position that software should be shared. If *RoadMusic* is to exist in the way that I anticipate –in such a form that it is available on an everyday basis to as wide an audience as possible as opposed to the special occasions described above– then it has to expand and adopt a model of distribution and dissemination which is adapted to this aim. I sense that this is more likely to come about if several versions of *RoadMusic* are available and the future

user of *RoadMusic* is able to choose with which version s/he wishes to make a journey among a variety of musical offers.

Since 2011 *RoadMusic* has become the object of a co-production lead by Marseille's Experimental Music Group (GMEM, 2012), including *Seconde Nature* (SecondeNature, 2012) a not for profit association based in Aix En Provence showcasing electronic music and new media and *DaisyChain* (DaisyChain, 2002) an association which essentially serves as a platform for group or collective projects which I have initiated. The GMEM are missioned by the French Ministry for Culture in musical research, development, and transmission. They are specialised in electronic musical interfaces and have a Pure Data programmer, Charles Bascou, as a permanent member of staff.

Marseille and Aix en Provence are a 2013 European Capital for Culture and within this context, we have been able to raise funds and organise a program of development for *RoadMusic*. A series of residencies have been organised at the GMEM during which Charles Bascou and I worked with a group of invited sound artists and composers all of whom are adept in Pure Data programming. Prior to this, Charles Bascou helped to develop the 'host' program to make it easier to use for others.

Invited Artists And Composers:

Figure 6-2: *RoadMusic* Workshop. From left to right Peter Sinclair, Marine Quiniou, Charles Bascou, Mathias Isouard, Atau Tanaka. Marseille February 20012.

Atau Tanaka – Adam Parkinson

Atau Tanaka is Professor of Media Computing at Goldsmiths College, London. A composer and musician his work mainly focuses on gesture in computer music and he is an expert in both sonification and in mobile computing. Previously a researcher with Sony CSL in Paris he was involved in early artistic experimentation using mobile phones (Tanaka, Atau Tanaka 1998). Adam Parkinson a post doc at Goldsmiths College has been collaborating with Tanaka for several years. In a recent performance piece: *4 Hands iPhone* (Tanaka, Adam & Atau 2012), Parkinson and Tanaka use iPhones (4, one for each hand) running Pure Data to modulate granular synthesis by 'hijacking' the accelerometers built into the phones to mediate gesture.

Andrea Cerra

Andrea Cerra is an accomplished composer and sound designer who navigates between commercial sound tracks and experimental research. He was nominated by IRCAM to work with the French car manufacturer Renault on the sonification of electric cars both inside and outside the vehicle. Cerra has also worked with the IRCAM on an interactive basketball game where music is generated from sensors integrated in the ball itself.

Charles Bascou

In addition to being employed by the GMEM as a computer programmer specialized in digital audio, Bascou also has an artistic activity as an electronic musician and composer. He will be changing roles to create his version of *RoadMusic*.

Mathias Isouard

Mathias Isouard is a young sound artist and a former student of mine. His installations focus on real time and in-situ, generated sound. In one such installation *Point d'Ecoute*, it is the presence, position and activity of the audience within a multi loudspeaker sound environment, which drives the synthesized sound.

Marine Quiniou

A clarinettist, Quiniou also trained as a composer of electro acoustic music. In addition to her studio productions, her work involves live electronic sound performances using custom built devices, which respond to the situation or the environment. She is founding member of a sound collective *Collectif 201* who organize participative performances with electronic sound devices in real-time. One such project involved a fleet of sound-bikes equipped with FM radio transmitter-receivers.

My decision to invite these particular artists was guided by the desire to incorporate a variety of singular approaches and aesthetics while maintaining a group of people who have both a cultural and technical background in real-time composition and computer programming. The collaboration began with an initial three-day residency at the GMEM in February 2012 (see Figure 6-2). I explained the basic ideas and principles behind *RoadMusic*, we worked through the program together and the guest composers were able to experience my version first hand. The workshop ended with a conference in the

GMEM's *Reevox* festival where we presented the project and the different individuals artistic strategies and intentions.

Figure 6-3 : Workshop two: Andrea Cerra, Charles Bascou testing *RoadMusic*. Marseille April 2012 (photo P. Sinclair).

During the period between February 2012 and February 2013, the composers, accompanied by Charles Bascou and myself, worked on elaborating their audio programs and testing then on the *RoadMusic* (see Figure 6-3). A first presentation including the six different versions took place during the 2013 *Reevox* festival (see Figure 6-4). I will not go into the finer points of this presentation which are beyond the scope of the current research, I should mention however that it attracted a large audience (roughly four hundred rides) and an enthusiastic reaction. All the composers are motivated to continue development of their respective versions. Two additional presentations are programmed during MP13. The first is in July 2013 during *La Nuit Pastré* a nighttime event dedicated to open-air sound art installations and performance, also organised by the GMEM (Culture, 2012). The second is during *Innovart*, organised by Seconde Nature in and around Aix-En-Provence in October and November 2013. Seconde Nature has also

invited me to direct a master class based on a research that we hope will participate in propagating the project further.

Figure 6-4 : *RoadMusic* presentation during Reevox, Mareille, Friche de la Belle de Mai, February 2013 (photo Willy Legaud).

Porting the program to lib pd. Smart Phones and Infotainment systems.

To return to the problem of distributing *RoadMusic* in a form that an audience can experience on an everyday basis, technology has now caught up with the project. Over the period of this research the prototype hardware has evolved from a rather large car PC, which had to be installed under a front seat of the car, to the small box which includes sensors and camera and which can be fixed to the windscreen in a couple of minutes. It is now becoming feasible to run our programs on non-dedicated hardware. Two solutions are now becoming available which could be used separately or in combination. High-end Smart phones now come equipped with the same type of sensors as *RoadMusic* –XY and Z accelerometers and a camera. The latest smart phone models actually have more

processing power than the fit-PC that *RoadMusic* currently uses[100]. Pure data, the programming language used by *RoadMusic* is now available for Android (Google phone) or IOS (IPhone), in a new version called LibPd (Pd, 2012). Thus today there are no major technical obstacles to porting *RoadMusic* to a mobile phone operating system and to making it available as an 'app'.

The second solution lies in the shift from car radios to car infotainment systems. Such systems are in fact small computers, in some cases they are designed to be paired with a mobile phone and in others rendered autonomous by the inclusion of mobile telecommunications technology (GSM card). Car manufacturers are currently concentrating their efforts on developing these infotainment systems considered as an important selling point. However, apart from playing music, displaying GPS and other data about the cars functions –all of which were already available through older technology– they essentially offer a dashboard interface to communication networks such as email, Twitter or Facebook. As described in Chapter Five (5.2.2. The Effect Of Mobility On Media), using social media while driving is understandably criticized, and guidelines are being introduced to regulate such activities (Holmes, 2013). I would venture that an application such as *RoadMusic*, which arguably, brings the drivers concentration back to the road without causing visual or tactile distraction, might be a useful addition to car infotainment software.

Porting *RoadMusic* to libPd requires re-writing and re-compiling code and a specialist in mobile phone operating systems. Financing this development is part of the production agreement that I have with GMEM and Seconde Nature and we hope to have a Beta version ready for the master class in October 2013. In the foreseeable future, we expect to be able to make such an app publicly available. Finally, on a more theoretical note I am now organising the eighth Locus Sonus symposium, programmed for spring 2014 which will be based on the particularities of mobile sound generation and listening evoked in this thesis.

[100] *Samsung Galaxy S4* has a cpu which runs at 1.9 GHz with 2GB of ram, whereas the fit-PC we use has a cpu running at 1.6 GHz and 1GB of ram.

6.3 Closing Remarks

The principal aim of this thesis has been to question the notion of real-time in artistic practice –more precisely in the context of artistic sonification– and to develop a practical method in response to and in parallel with this interrogation. Throughout the process, I have accumulated knowledge and developed my practice around a central artistic project entitled *RoadMusic*. The result today is my response to an art of the here and now, one that does not necessitate the spectacular, the special occasion or the consecrated space[101]. The device itself is now fully functional and being presented publicly.

If today certain aspects of my initial aim are not completely resolved, they can be considered as in the process of being so. However, a successful computer program is one that adapts and evolves. In fact, unlike artworks that have a fixed form, one might consider that development is paramount to a program's continuing existence –if only to adapt to evolving technology. I embrace the idea of this continuity, which is in keeping with the whole of this project; I am looking forward to developing new versions of *RoadMusic* and above all listening to those created by others.

[101] If the car is a specific space it is not specifically designed to reveal this artwork.

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Appendix 1: Artistic Sonification Key Works

1.1 Artists who participated in the Locus Sonus Symposium and who have contributed to the Journal:

Lorella Abenavoli

Lorella Abenavoli is a French artist sculptor and researcher. She lives and works in Montreal, Canada. Her installation — *The Pulse of the Earth* (*Souffle de la terre*) (Abenavoli 2004) — invites us to listen to the earth by transposing bass vibrations of the globe into the audible spectrum.

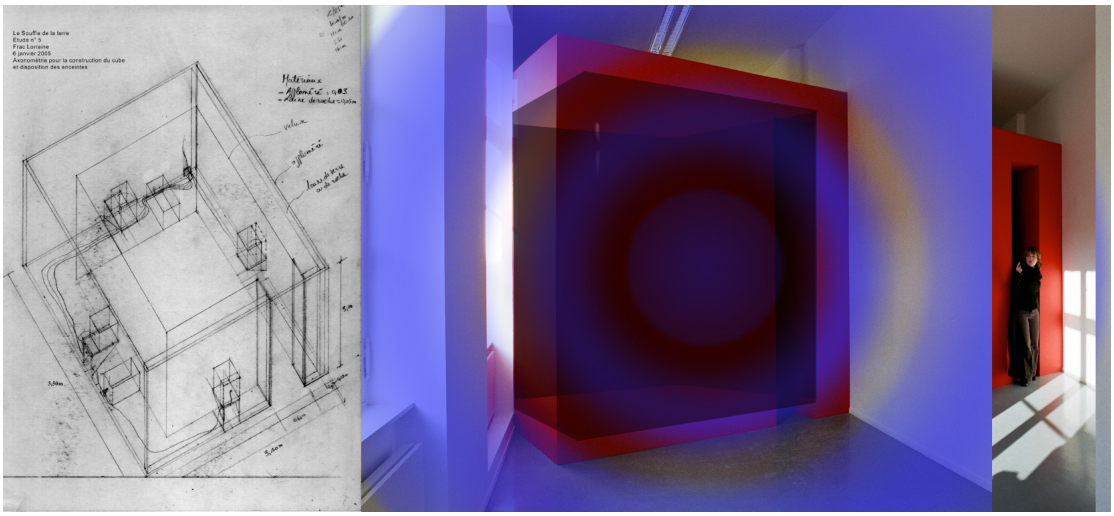

Figure 7- 1 : Basic diagram of the process of sonification for *Le Souffle de la terre*/*The Pulse of the Earth* © L . Abenavoli

Jens Brand

Jens Brand is a German composer, and visual artist, living and working in Berlin. His *G-turn* products (Brand 2004) "play the world in the same way a record player plays records". He makes use of relief data from global satellites to sonify a trajectory chosen by the user.

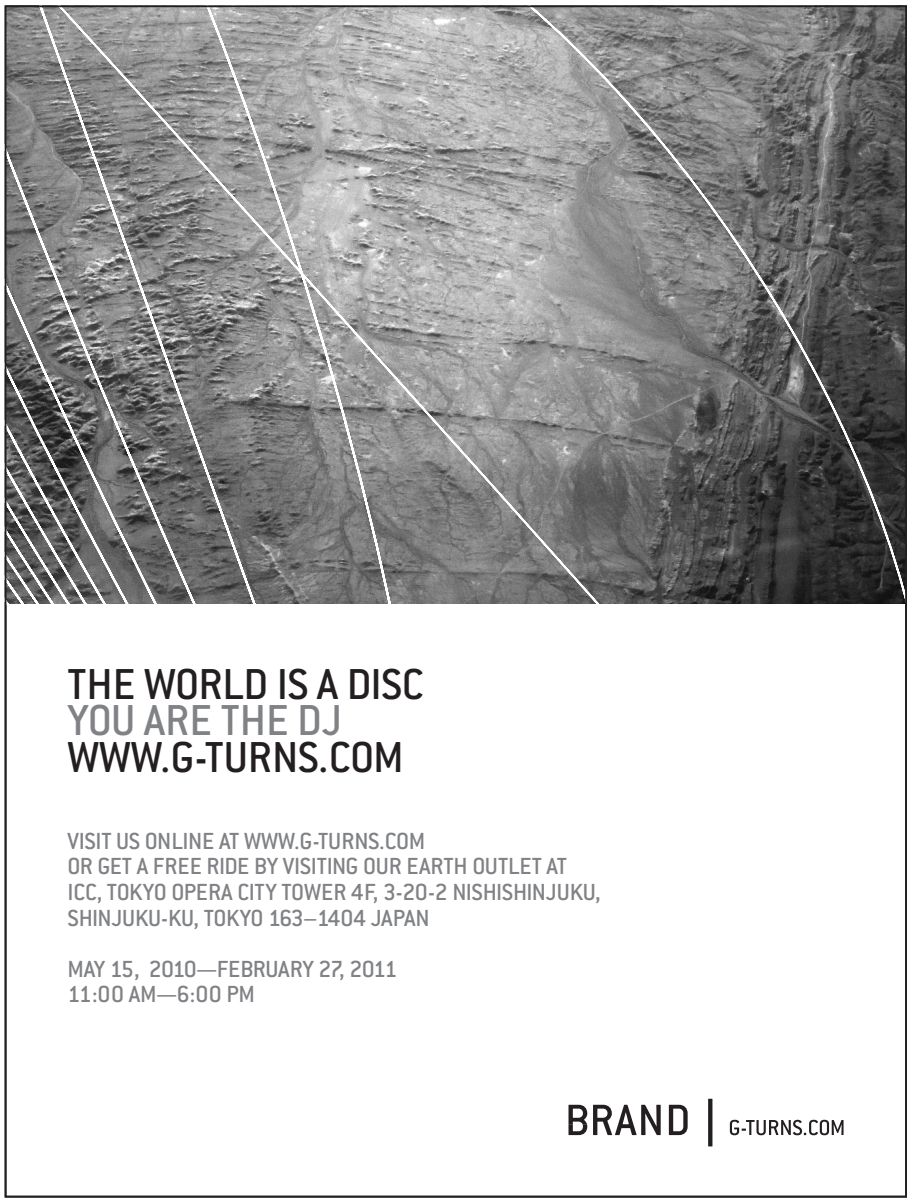

Figure 7- 2 Jens Brand, Brand - finest Global Players since 2004.

John Eacott

John Eacott is a British composer and performer. He is Principal Lecturer in Music at the University of Westminster. *Flood Tide* (Eacott 2009), featured in the 2009 Thames Festival, uses data from the tidal movement of the Thames to drive algorithmic composition, interpreted in real-time by a group of musicians situated on the riverbank.

Figure 7- 3 : John Eacott, *Flood Tide*, See Further Festival, Southbank Centre, July 4, 2010.

Peter Gena

Peter Gena is an American composer. He is professor at School of the Arts Institute of Chicago. Involved in computer music since his formative years he is particularly attentive to the relationship between computer programming and composition. Finding that there is a similarity between computer code and DNA he has used data from the human genome (Gena, DNA Music 1995) to generate his compositions.

Figure 7- 4 : Peter Gena, *DNA Music for Genesis*, 1999. Berkeley Art Museum, Berkeley, California, 2003

Scot Gresham-Lancaster

Scot Gresham-Lancaster is an American composer, performer and installation artist. In *Remap (McCall.DEM)* (Gresham-Lancaster, Remap [McCall.DEM] 2010), which he performed during the symposium, he used the terrain data from a geographical map as the basis for sound synthesis navigating a visual representation of the terrain in video game mode.

Figure 7- 5: Scot Gresham-Lancaster — *Remap (McCall.DEM)*, Locus Sonus Symposium n°6, Aix-en-Provence 2010.

Florian Grond

Florian Grond is a German artist and researcher. His work on aesthetic strategies in sonication is situated at the cross roads of art and science is the subject of his forthcoming PHD. At the Locus Sonus symposium Grond Performed Safety Certificate (Grond, safety certificate 2010), sonifying data from train security systems recorded during a journey.

Figure 7- 6 : Florian Grond, The Manta control interface for *Safety certificate*, Locus Sonus Symposium n°6 Aix-En-Provence, 2010.

Stuart Jones

Stuart Jones is a composer and media artist. He has made different performance and installation works that make use of sonification notably *Bop!* (Jones, Bop! 2005-2007), which combines data about the environmental conditions of a building with data provide by users of the building —their physical movements and also subjective data, their moods — to create a real-time composition.

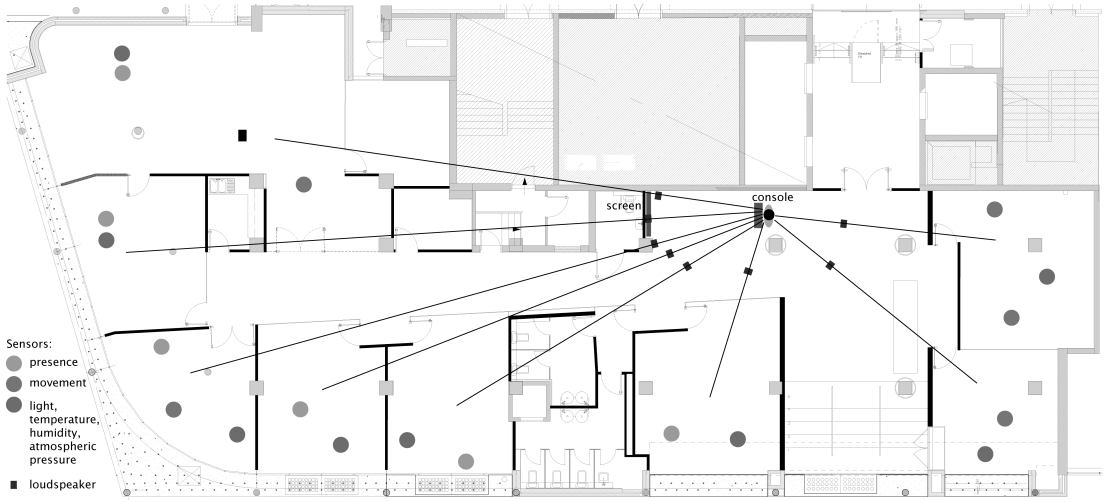

Figure 7- 7 : Stuart Jones, Sensor and speaker layout for *Bop!* 2005-2007.

Marty Quinn

Mart Quinn is an American Musician and Computer scientist and Founder of *Design Rhythmics Sonification Research Lab*. *Walk On The Sun* (Quinn, Walk On The Sun 2009) benefitted from NASA funding to interpret images of the suns activity as sound. His sonification orchestrates pixel values in a video image.

Figure 7- 8 : Marty Quinn, *Walk On The Sun*, McAuliffe-Shepard Discovery Centre in Concord, New Hampshire, USA, 2009.

Atau Tanaka

Atau Tanaka, composer and researcher is currently Director of University of Newcastle's Culture Lab. His installation *Bondage.rmx* (Tanaka, Bondage.rmx 2004) combines information concerning the spectator's presence with data collected by scanning an image by Japanese Photographer Nobuyoshi Araki to create a voyeuristic, interactive, audio experience.

Figure 7- 9 : Atau Tanaka, *Bondage*, La Villette Numérique, Paris, 2004. Photo: Pierre-Emmanuel Rastoin.

Victoria Vesna

Is an American media artist and Professor at the Department of Design |n Media Arts at the UCLA School of the Arts. She collaborated with Nano scientist James Gimzewski to recuperate the vibrations of a metamorphosing butterfly chrysalis that she transposed into the audio domain and included in her installation *Blue Morph* (Vesna, Blue Morph 2007).

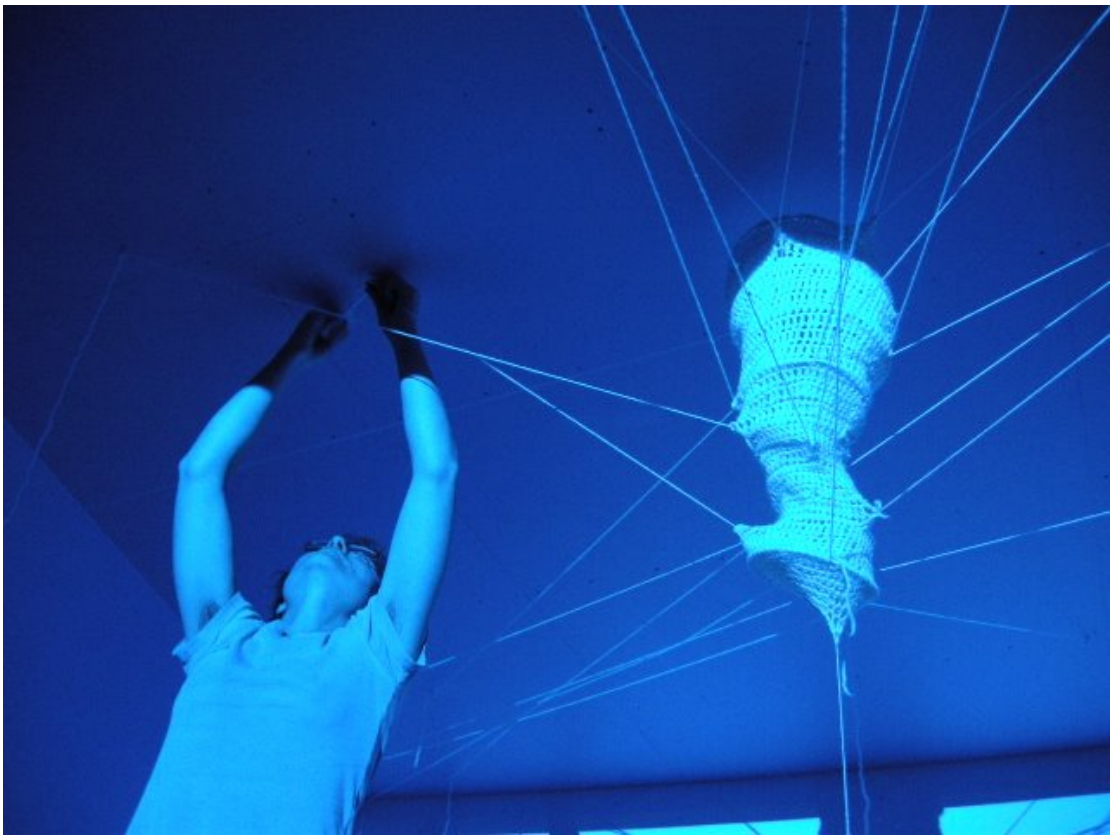

Figure 7- 10 : Victoria Vesna, *Blue Morph,* Hybrider, Trondelag Centre for Contemporary Art Trondheim, Norway, 2008

Valentina Vuksic

Valentina Vuksic is a Swiss artist who sonifies the functioning routines of computers. During her performance *Tripping Through Runtime* (Vuksik 2009) she approaches a transducer to the computer casing thereby capturing electromagnetic waves generated by the executing programs and revealing their evolving structure through sound.

Figure 7- 11 : Valentina Vuksic, *Boots*, Bewegung Museum, Switzerland, 2010.

1.2. Other Artists (not present during the symposium).

Stephen Barrass

Stephen Barrass is co-director of the Sonic Communications Research Group, University of Canberra. *Listening to the mind listening* (Barass 2004) uses recorded data of the activity of the human brain. The electrical brain wave data was recorded as a subject listened to a piece of music. It was then given to a number of composers who used different sonification strategies to mediate the data in different ways. Ten of the pieces were presented before a live audience.

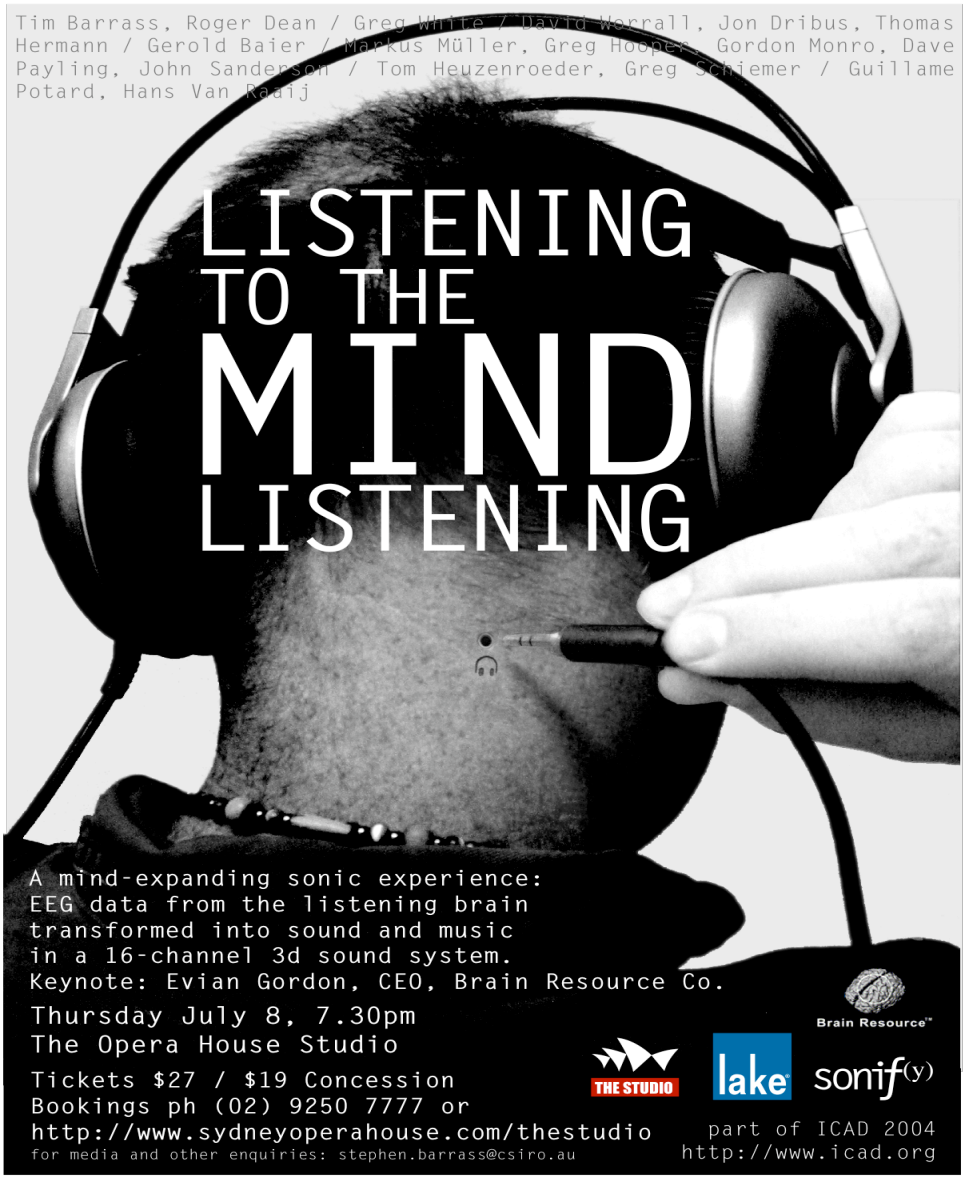

Figure 7- 12 : Stephen Barrass, *Listening to the mind listening,* (poster) Sydney opera house, 2010.

LMA: Richard Kronland-Martinet, Thierry Voinier, David Calvet, Claude Vallee

The *Cosmophone* (Richard Kronland-Martinet 1999) is a sound installation produced by the SM2, LMA research unit. The installation sonifies, cosmic particles that are detected in real-time. Psycho-acoustic cues and audio spatialisation are used to induce physical sensations deemed appropriate to represent the otherwise unperceivable elementary particles.

Figure 7- 13 : Richard Kroland, *Cosmophone,* Ville Européenne des Sciences, Grand Palais, Paris (France), 2008.

Andrea Polli

Andrea Polli is Mesa Del Sol Endowed Chair of Digital Media at the University of New Mexico. Her use of data draws attention to climate change and other local or distant weather phenomena. She collaborates with meteorologists and climate scientists to recuperating data that is used to generate the audio environment of her installations such as *Sonic Antarctica* (Polli, Sonic Antartica 2007-2008).

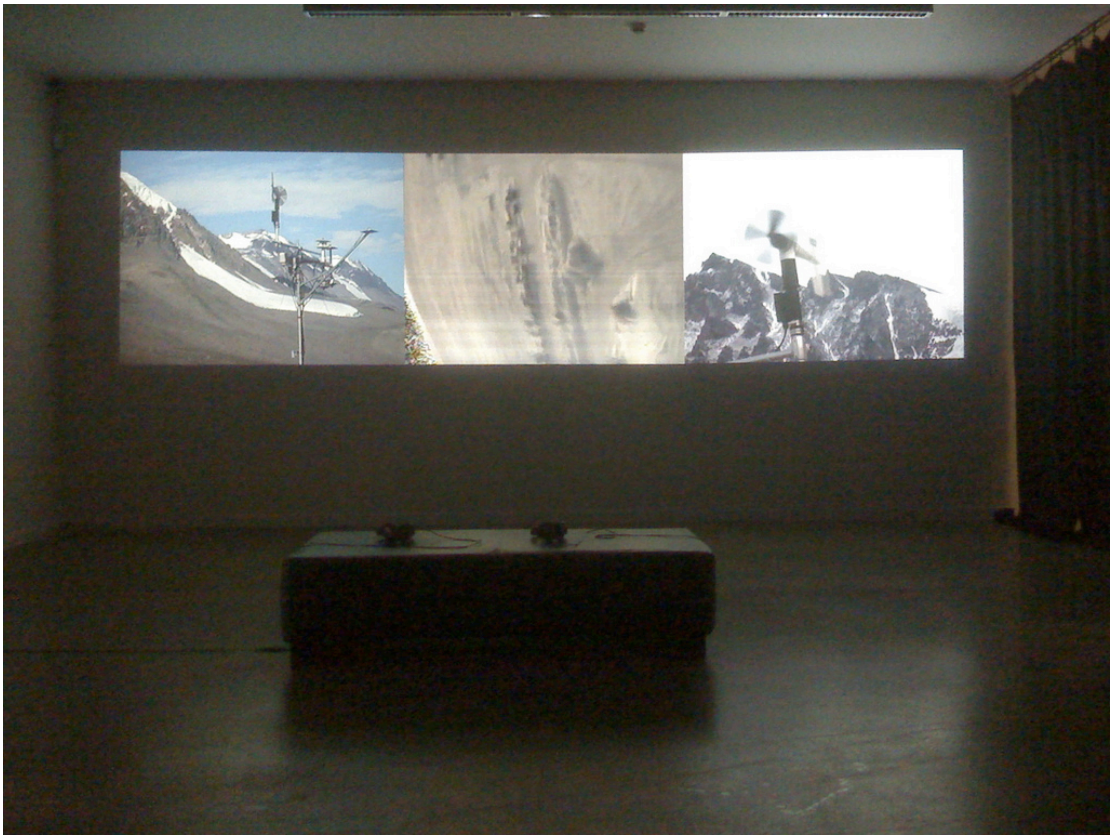

Figure 7- 14 : Andrea Polli, *Sonic Antarctica*, 2008

Kubisch Christina

Christina Kubisch is a German Sound Artist and Professor at the Academy of Fine Arts in Saarbrücken. One of the first German Sound artists in 2004 she invented what she calls her Induction Electrical Walks (Kubisch, Electrical Walks 2008). Specially designed and manufactured headphones are worn which reveal to the walker the sound of the otherwise unperceivable electro magnetic, waves that populate our environment, generated by modern technology.

Figure 7- 15 : Christina Kubisch — Electrical walks, Mexico City, 2008

Nicolas Reeves

Nicholas Reeves is a Canadian Artist, Architect and Researcher at UQAM (Université du Quebec à Montréal). His *Harpe à Nuages* (Cloud Harp) (Reeves 1997-2000) uses multiple laser beams to measure parameters of overhead clouds such as density and altitude then transforms this information into music in real-time.

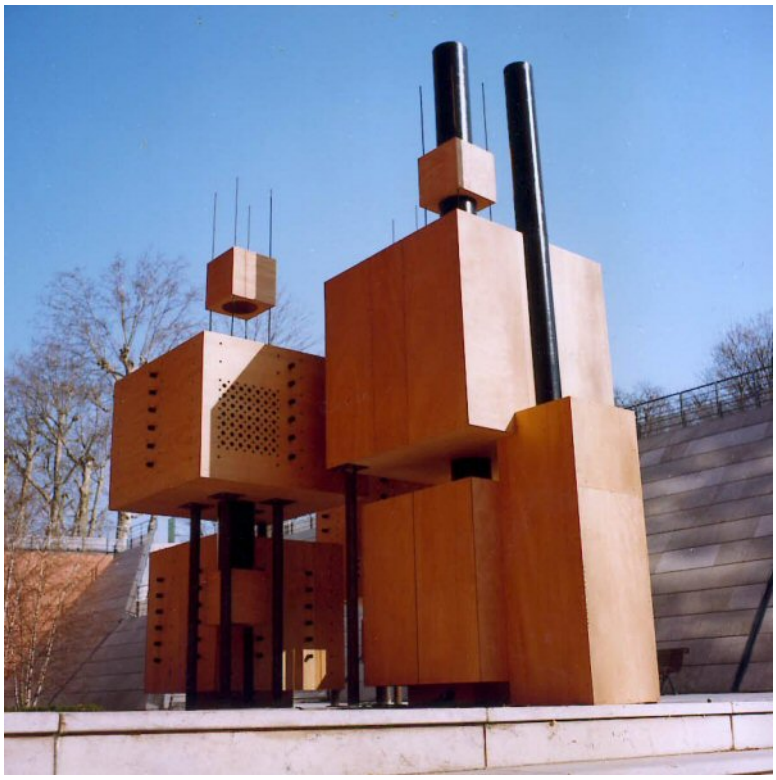

Figure 7- 16 : Nicolas Reeves and the Laboratory NXI GESTATIO *La Harpe à Nuages*, 1997-2000.

Appendix 2. Testimonials

Lefrère Family: Video Interview following a day out in the family car using *RoadMusic* July 25, 2012. Translated from French.

Dominic Lefrère: (father) fifty is a bank manager living in the Marseille area. Océane Lefrère: (daughter) sixteen, schoolchild. Vasco Lefrère: (son) eleven, schoolchild.

O.L. Then we tried it out, we tested it on the road by accelerating (Laughter).

P.S. So you found that it influenced your fathers driving a little? Does he drive better or worse with that?

V.L. He goes a little less fast and that's a good start.

O.L. Except when we were on a straight road and he tested the accelerations (laughs).

V.L. He goes less fast so that's good. I mean that might happen with other people but it might not.

D.L. Yes you're right I find it quite soothing compared to music, it's a good alternative.

V.L. It puts you into the rhythm of the road for good orientation... you (addressing his father) what did you feel when you drove?

D.L. It's a good alternative in the sense that it's quite soothing and perhaps I had a tendency to limit my speed and perhaps be a little more attentive to what was going on, while having that sound which varied -we didn't have the same type of sound. I think there was a lot of shadow when we tried it the first time (referring to a previous test drive): there was a lot of sunlight; it was very luminous so I do not know if there was much variation in the sounds. Well we really had the impression –but maybe it was just an impression– that the sound increased with the acceleration of the vehicle. Were we imagining it? I don't know, since we know that the car influences the sound –not just the car there is also everything around the car, its environment and also the perception of the people inside the car. For long distances I think it could be pretty good, because it's true that sometimes when we listen to music or the radio, sometimes it captures your attention and it's tiring for the ear it's very tiring for the ear, more than this, it's quite varied it's...(Vasco interrupts)

V.L. All the same, it puts us in the rhythm of the road so that we know how to deal with it, when we accelerate or slow down or overtake. Anyway I felt that the music changed a little to warn us that we were becoming a bit cut off (fermé) for example –I don't know, that's how it felt to me anyway.

P.S. After two hours of driving did you feel that there had been a change in your relationship to the machine?

D.L. Well, in the beginning it's curious to have that instrument in your car because it's a new sound. It's something that we're not in the habit of listening to, of course - with the children. Then you get used to it - well not used to it... One knows that it's that apparatus that is providing the sounds, sometimes sounds which combine very well, and we forget it - no one doesn't forget it that's not what I meant to say, it's that the sound is there and it's part of the atmosphere (ambiance) in the car I think. And it's soothing, I mean it's not aggressive at all; I didn't find any aggression in that music.

O.L. I did.

D.L. You found the bass aggressive this morning, I know but it's much less aggressive than the radio for example. I think it could be nice for long distances.

P.S. Why is it more soothing than the radio for example?

D.L. I find the sonorities less aggressive.

P.S. Ah it's the actual sonority?

D.L. Yes I find it less aggressive than the radio. Since it moulds itself to the road a bit, as it moulds... Well it's a question of ambiance; I find that it flows more easily.

V.L. Yes it gives another system of sounds because the music we're used to isn't very varied -within the limits of rock music.

D.L. It tends be melodic.

V.L. Yes whereas there we're not expecting it, it plays surprises on us, and so we say 'what's going to happen next' it gives you a sort of varied music, a bit oriented towards technological music, that gives a sort of listening effect.

D.L. My feeling is one of atmosphere (ambiance). The sounds it emits, we got the impression that it was really a score (une conduit). The music was –well the sounds; one can also call it music; I'm hearing music in my ears– the composition of sound is music too, but after all, there were things which created a certain ambiance with a certain tension, it was... Myself, I would listen to it on long journeys it wouldn't bother me personally. I could see myself listening to it on a nighttime road with every body else asleep; it would be perfect.

Anne Lovell 64, is Medical Anthropologist and Research Director at the French National Health Institute (INSERM) and at University Paris Descartes, she is bilingual (the discussion took place in English). She experienced *RoadMusic,* driven by myself during a forty-five minute journey across Marseille.

Interview via Skype 19-07-12

A.L. I was very surprised because you had told me a few years ago when I asked you what the experiment was about that it was a kind of guy thing. So, my assumption was that it was for people, who really like cars and driving and I absolutely loved it and I'm not into cars and driving. I mean sometimes I enjoy it but… But I saw it as art and not as accompaniment. I didn't see it as turning the car radio on and listening to the music, I saw it really as a unique kind of experience, sort of being inside of a mobile art piece.

P.S. I wonder when I said it was a guy thing?

A.L. Well, I thought it was going to be basically percussion and that it was going to be very much like techno, and I loved the details of it, I loved the different kinds of sounds —I don't have the musical language but the colour of the sound— I don't know how we would say that musically.

P.S. Could be timbre possibly…

A.L. Possibly, possibly. And the variations, I love the fact that every time you stop you're starting a new bass line so it's not repetitious —I really thought it was going to be repetitive techno.

P.S. Does it differ from normal musical listening?

A.L. Well it depends on how one listens to music normally, but definitely, for me it has nothing to do with putting on the radio or even to listening to pieces but that don't require active listening, you know just listening as background while you work or you go into a store or you're sitting in a café. This is active listening, which is why I don't think I could use it when I was driving unless I was really in an automatic mode. It's active listening and it also makes me, or made me aware of the environment in a different way. Now that maybe because it's the first time I'm doing this, so I'm very tuned in to why a certain

sound is the way it is. I want to understand what is it in the environment or the speed, you know. But it's not at all like "normal listening".

P.S. But what you call active listening is something that you do if you go to a concert of something you particularly want to hear, or maybe something a bit challenging? Or is it different from that?

A.L. It doesn't have to do with challenging it depends on what kind of music one likes and I would say that most of the music that I like is eliciting me, I subjectively prefer to listen to it actively, that's why my repertoire of what I use when I'm working is very limited, because it would be very distracting otherwise. So I will listen to Goldberg's variations or some sort of enjoyable, interesting, repetitive music but not something that will distract me because you know I just find I'm, I'm…

P.S. Yes it takes too much of your concentration?

A.L. Yes.

P.S. So do you think it has an effect on your perception of the journey itself?

A.L. Definitely definitely.

P.S. How?

A.L. Well I know that drive we took, um I experienced in a totally different way to that in which I'd ever experienced it. Now was that because of the newness of listening to your mobile art piece or was it because of the art piece itself? I mean I think it's both. I have to admit that usually when I'm driving in Marseille I have very long vision. I'm looking at things that are far away and I'm glancing at the sea or the skyline or the whiteness of the calanque; aspects of Marseille that are very aesthetically pleasing to me and there I was maybe narrowing my perception to the road, to the way we were moving to what was in a much smaller visual scope.

P.S. Did you perceive the audio as Fact or Fiction?

A.L. Well it was structured sound so for me it was fiction. I think all sound is constructed but I think this was particularly so because I really sensed your composition in it. I really

sensed what you've put into it and you have programmed it so that there is an aspect of it that is aleatoire –that doesn't have to do with you because it has to do with the chance of a car coming behind us, or your having to slow down, rather than choosing to slow down because you want to go slowly, because something is in front of you, an obstacle say. And I was very aware of that but, and this really surprised me, I was very aware of the composed part of it, and when you said you were going to ask other composers, that made me very curious and even more aware of the composed aspect of it. Your choice, you know the bass… The bass in jazz, which is one of my preferred genres, the bass in jazz holds the entire jazz piece together, so that's why I was very interested by the bass line.

P.S. Yes it has a role.

A.L. And I loved the timbre of these other percussion sounds which were instruments that I couldn't recognize or they were simulating instruments that I could not recognize but which are played in the "world" you know I don't know if it was … or Brazilian but I was aware of these sounds which to me sounded…

P.S. Exotic?

A.L. Well exotic for me. So, for me it is definitely fiction. Or lets put it this way: the fiction overwrites the fact.

P.S. Do you think that having this machine makes a difference to the drivers behaviour or driving.

A.L. Probably for guys –that was just a joke… Oh obviously, I mean I can't imagine it would not.

P.S. Ok so what would you imagine it would be?

A.L. Oh I imagine it would be a sort of enhanced experience of driving… I was just thinking about sort of long trips you know a long trip on the autoroute (motorway) I wonder if it would become monotonous. I mean it couldn't because it's interesting music but I wonder what it would become.

P.S. I'm the only person who's experienced that… So you think it would have an enhancing influence. But that would presumably be the same whether you are a passenger or a driver no?

A.L. No… I don't know, I think I could use it on the autoroute (motorway), but I would have a really hard time driving in a city like Marseille, it's partly me, part of it is the way I perceive things. First of all, because I am slightly dyslexic, and one of the reasons I have problems driving is my perceptions are –it's hard to explain– but I have perceptions that I think are hard wired even though I could adjust if I wanted to, so I have to be very careful when I'm driving because I tend to … and my brother is this way too and he drives hours every day. We have to adjust our sense of space because we don't sense space the way "normal" people do. If I were driving in heavy traffic and I really had to pay attention, that would be a very different experience with the mobile art piece (laugh) than it would be if I were on the autoroute (motorway).

P.S. So you're slightly worried that you would get caught up in it or something like that, is that it?

A.L. Ya, I mean I don't know for example if I am perceiving –I'm embarrassed to say this– ok I have to stay more left — I mean a lot of this I've developed into automatisms (reflexes), my adjustments in terms of space, sometimes I have to consciously adjust… I mean I would have to separate and I assume that once you've had this experience with this mobile ambient music, once you adjust to it, I think perhaps it wouldn't happen but I think that in the beginning, I might be adjusting to what the music is telling me about the environment more than what I need to do, or I might get into the music in an active way which takes me away from —wait a minute, there's a truck that's trying to cut me off and I need to adjust. But I think it's me, I don't think I'm a good subject.

P.S. But presumably that could be the same thing if you were listening to a particularly engaging piece of music on the cd player of the radio.

A.L. The difference is that I'm aware that the music is changing in relation to space, in relation to what's happening in the environment. Now sometimes it changes in a way that's really interesting and pleasant or it can be dissonant – I mean dissonant is pleasant for me too it doesn't matter— I mean it's changing in a way that doesn't take my attention away but there was a moment when the change —I mean I loved the sound —

but I was wondering why is it doing this sound, it was kind of a low, what was it —I mean I think of it as a murmur…

P.S. A kind of drone sound?

A.L. So maybe my attention is, what's making the drone sound? But perhaps it's also because I asked too many questions and you explained too much. You know I'm aware the bass line is going to start up every time we stop so when a drone comes in that's not because we've stopped, it's a new… it means something different is happening.

P.S. Any other comments?

A.L. Yes: I loved this experience that's all, and I like the idea also that you will use other composers. I mean I think I could listen to this and do driving many times but I like the idea that a some point you could change the —how would I put it…

P.S. The aesthetic, possibly?

A.L. Yea possibly, I mean that's interesting… But aesthetically as a sound piece it's very exciting to me. I'm thinking about other things of yours I've seen —you probably don't have to write this into your transcript but you know streaming and sounds, most of what I've seen that you've been involved in is streaming and existing sounds — this is such a step beyond and you're streaming in movement and translating it into a sound that bears your signature, because you've composed the elements, it's so beyond what I've seen of your other work.

P.S. It's probably the most musical thing that I've ever done, in the sense of really composing and there's a lot of reference to music, you know (laugh) "normal" music.

A.L. Yes that's part of why I was so pleasantly surprised, I loved the aesthetics of it. I mean one can enjoy the aesthetics of a stream and existing ambient sound but. I'm thinking of that thing that one stood on — I mean it's interesting that thing one stood on or the thing at 3bisf with the wires: very interesting pieces and therefore aesthetically interesting in very different ways; this is musically aesthetically rich — this is not a way to express it but… and therefore would I enjoy this so much with another composer? I have no idea but it makes me very curious to try. But I loved the aesthetics the musical — the aesthetics of the whole experience—but I loved the musical sounds, the instruments

or the simulation of instruments or whatever that you put into it, the way it weaves together, according to this aleatory aspect of what's going on in the environment. I really truly enjoyed it.

James Gimzewski, fifty eight, is a Nano scientist, professor an UCLA and member of the Royal Society. He experienced *RoadMusic* during a forty five minute trip, driven by myself in Marseille where he was doing a residency at IMERA. Interview via Skype le 20-07-12.

J.G. For me - I spend a lot of time in the car because I live in live in Los Angeles – a couple of hours a day so I know what it's like sitting in the car all the time; I'm also interested as you know, I work with Victoria on art science projects and we've done also sonification: butterfly sounds and so on - So particularly interesting for me to be in the car with you and actually experience it first hand. I was actually very amazed, it seems like it's very unique you know, the concept — that nobody's done it really before— the concept of using multi-sensory inputs to create some type of, I guess you'd call it entertainment or music or some type of almost feedback system you know? Because my research in science is trying to develop this artificial brain and one of the things that's important and it's very hard to do is to —if you think of human intelligence it's usually multi-sensory inputs you know? Constantly we're bombarded by so many sensory inputs and we don't process them individually we process them in a collective; in a kind of strange collective manner, we don't really understand it, we're trying to understand it. And so the way you system is working is almost resembling a human brain in some respects. It doesn't drive the car, it doesn't make decisions necessarily but it's taking all these inputs and it's giving an output, a music which is —as we discussed later music is very different from visual information in a way, you're constantly bombarded by it. So in an intellectual and an artistic way I found the piece to be really very imaginative and creative and also technologically, you've made a very beautiful implementation. It's not obvious from the sound that it's some kind of synthetic artificial, like computer game sounds; it's like when you drive actually you have a feeling that music is, I don't know, connected somehow to the environment, and of course it is but it's not done in an obvious way. That was my impression and I would love to have it in the car you know. I'd love to try it and I'd love to see what it would do in Los Angeles in particular. Because the driving in LA is not very linear, I mean it's —you're always stopping and people are hooting their horns, then moving and the light changes a lot in LA, and you explained some of the inputs so I'd love to try it there some time.

P.S. Do you think there is a difference between *RoadMusic* and "normal musical listening".

J.G. Well there are different types of music: like composed, pre-composed music where either people (use) normal instruments or electronic instruments to reproduce the piece and the piece is dependent on the environment right? Dependent on the human feedback —there's improvised music like some jazz music that is very connected to the audience and then like techno music, it's also got some relation I think to the audience and the person although it's very pre-canned … But what's unique about… — maybe I should have used the word music, I'm not really a musician so it's hard to define it but I think it's music that is created by what the machine senses, in a complex way because it's not a simple input, it's many inputs and you're a composer in the way that you program the various logarithms, the way you do the computation to produce the sounds. I mean I should say that it is a piece of music but it's a very new form of music to me. It's my first experience of anything like that and as I said, because of my research into brain and multi sensory inputs, it's very intriguing that way you as a composer set the stage, but the machine makes the decisions, but the decisions it makes are fairly um… Let me ask you actually —if you use fuzzy logic...

P.S. Yes?

J.G. Or neural networks...

P.S. Yes?

J.G. The decision coming out of the machine would not always be completely predictable. I mean I don't know if you have any element of that: I mean the sound never repeats itself because the input never repeats itself?

P.S. Yes that element would be the input.

J.G. I don't know whether you ever worked out the number of permutations for say 4 or 5 inputs, if you work out the combinations they may be infinite or close to infinite. But never the less if you repeated every single input at a given time the output would always be the same – is that correct?

P.S. Yes … well there is some small random things for instance the melody it plays is generated randomly. The environment decides which scale is going to be used other data decides what the tempo is going to be, other data how many notes it's going to create but the actual sequence, the actual melody is created randomly.

J.G. I'm sorry I'm asking questions but you can turn them round. The kind of things that occurred to me because of this brain thing. Does the memory… If you recorded the past inputs and those past inputs influenced the future, so you have like the current information right, but if you're driving a car how you feel depends on the past.

P.S. Well it does actually do that, I mean there is an element… all of it is memory in a sense: I used the term 'wake' in that discussion — I'm really interested in that idea in terms of the music that RM creates because as you noticed I'm sure, there is only a very small part of the data that is actually immediately interpreted.

J.G. Yes.

P.S. A lot of it is on a bigger time scale.

J.G. Ah I see.

P.S. So basically everything that you hear is influenced by what come before it, in the sense that a lot of the decisions that are being made, are being made on the basis of statistics: moving frame averages, so it's all updating all the time and it's also dependent on what is in the machine; what it's been through before that point.

J.G. I think that's the crucial point; for me that's a really important point, because … maybe why it sounds the way it sounds to the human mind is that it does have multiple time scales, you know what happened in the past. I think that's really important. And in a way; I don't know if this has some kind of predictive quality of the future in a sense, because when it plays the music…

P.S. It is projecting towards the future in a sense, because that's what music does…

J.G. Yes based on the past, that's a really key thing that you have those different memories like in the Atkinson model —very loosely— you have sensory memory— what comes in at the moment and then you have short term memory and you have long term memory. So you have it in a way those elements and if the sound coming out has some temporal, you know some memory characteristics that are similar to the human brain then I think it makes a strong connection, in and unconscious way, to the person.

P.S. Yes I think there is something like that happening, I mean I hope; that's what I'm attempting to do anyway. Maybe the thing which is lacking ; I mean not there —although one doesn't want to go too far with the anthropomorphism thing— is that it doesn't keep a memory when you switch it off basically.

J.G. Yes ok — but you know it's a car so — well there are some cars which when you switch them off remember how many miles they went but when you leave them for half an hour or so it erases it right— but in the sense that it's a car that you start it fresh is probably ok. The one thing I did want to ask, if you think that adding some kind of activity by the human being in the car, would that be better? So you're in a traffic jam right? So if you stop at traffic lights it kind of decides to change things right? The bass or something… But if you were to incorporate a sensor in the seat to record the persons agitation – (ah yes) Have you thought about that? Or do you think it should be totally sensory without the human subjectivity in the car?

P.S. To be honest I hadn't thought about the idea of incorporating involuntary movement; involuntary behaviour of the human which might be interesting. I had thought about, but rejected the idea of it having a button which you can press to tell it you like it, so that it kind of takes that into account and makes some kind of neural network thing.

J.G. Yes like punishment reward.

P.S. Yes or maybe it would have some stochastic selections, which are maybe influenced by the preferences of the driver. But in a sense I like the idea that it's not in the drivers control but that it's more a discussion between the… That it's kind of a parallel perception.

J.G. Yes, well it is perceiving the drivers behavior as well right?

P.S. Yes it's connected to the driver in the sense, because you feel that in a sense the car is an extension of your own body.

J.G. Yes LA is the ultimate for that.

P.S. Yes and people talk about their cars like — I'm not cornering very well or I've changed my tires, they don't say my car is not holding the road very well they say I'm not holding the road very well. So there is this thing of it being an extension of you phenomenology or your body in a sense and so *RoadMusic* does have this role, which is similar, or it completes that thing possibly.

J.G. The modern car has got plenty of micro processors in it and it's got an unbelievable amount of sensor information.

P.S. Well I have actually started to tap into that now. I mean I have a thing by which I can access it: there is this port on the car which mechanics use so I'm starting to look at that but in a sense —I mean I think there will be some interesting stuff to get out of it, but in a sense the actual movement of the car is maybe more interesting.

J.G. No no I think the movement of the car is enough in many ways… Actually I got this galaxy —I got rid of it because it was too complicated— smartphone and because I'm a scientist and because I'm interested I downloaded this program, and what it does is it reads every sensor on the galaxy and shows you what is going on right? There is a magnetic flux sensor, there is an ambient light sensor, there is all the accelerometers, then there is temperature —the galaxy has got a bunch of sensors. Anyway…

P.S. Did and if so how did RM affect your perception of the road.

J.G. I think it made me —you've got to realize that we did you know, we were driving around trying to find a parking space and stuff— but if I actually drove the car with it, say I drove in LA and I used it for a week I could tell you a lot more.

P.S. Yes absolutely

J.G. But because of the circuit; the way we were doing it, it made me more aware of the outside; of what was going on. It gave me a sense of awareness, because you'd informed me that what it produces is related to all the inputs and —because I'm a scientist

probably— I was listening to it and I was thinking its interesting but it also made me curious to make connections between the sounds and what's going on, follow me? It got me interested in a way, you know I could see that when we got to one part where the sun was shining I listened to the music changing and I enjoyed that experience -not relating it in a reductionist kind of way but making the connection- so I was actually more aware of what was happening when we were driving than I would normally be, because normally I would be totally unaware ok?

Now if I was driving the car I would probably also totally unaware in that sense, because what I would be aware in is an automatic mode of driving, you know I drive in a week — lets see— 20 hours a week I'm in the car, about. So I'm in automatic mode; it took me away from the automatic mode and I found that was interesting, it kind of got my mind working. That's why sometime, when maybe you get it in some kind of app form, it would be really interesting and I think it could be— it could be something that keeps you amused; that keeps you aware of what's going on around you. Because what I usually do; I have the satellite radio, I listen to the BBC ok BBC radio and you know whenever the car stops — I mean I shouldn't do it but I'm looking at the blackberry— I'm always trying to find things to do right?

P.S. Instead of being involved in what is actually going on?

J.G. Yes so it's really nice, it's a kind of zen experience that you're listening to these sounds and I can imagine you know it could be made into —Lets say it was really bad traffic, you could sort of almost generate a feedback system, maybe your driving might even change you know in relationship to the sound for instance, it could have a very calming effect. It could be very good that way. You know bio feedback?

P.S. Yes.

J.G. There is an element of bio feedback in it because I guess if you were to drive really aggressively you'd get completely different music to if you were driving in a more conscious mindful way.

P.S. Basically that's all down to the programming, but yes the way I've programmed it, it doesn't necessarily get more exciting when you start throwing the car around, but of course depends on how you hook up the sensors to the sounds.

P.S. Did you feel it was factual like sonification or more of a narration or fictional.

J.G. I just thought it was kind of a little surrealistic in the sense that it was interpreting my environment; providing an interpretation of a dynamic — spatial, temporal, bearing, dynamic that I was experiencing and it was giving a kind of interpretation and so kind of surrealistic — I mean I don't know if surreal is the right word … but it's not factual or anything like that, and it's not obvious but it's —I know the word— it's sublime that's the word. You know what I mean it's not like, oh beautiful -like in Mozart.

P.S. It's sublime like in Kant?

J.G. Exactly, like sublime has a kind of sense of awe and a kind of sense that makes me little bit scary in a strange way because this music is talking to me and what I'm visualizing and experiencing in terms of acceleration and all these different things; it's giving it an auditory interpretation which is —I'm going to use the word subliminal in a different sense from sublime but subliminally being interpreted by my brain. And so it's like a new layer of awareness, that's how I would describe it, but a very integrated sense of awareness. Integrated with the environment as it changes — it's actually the change because there's two ways in which we can look at something you can say ok there's the road but what we are — the human brain doesn't really care about a static picture of the road, it's the change right?

P.S. Uh huh.

J.G. Change in forces change in —you know suddenly a traffic light turns green or somebody pulls out in front of you, it's change and so the music is actually an interpretation of the change it's not an interpretation of the static hyper thing you would take with a camera.

P.S. Absolutely.

Composers

The following three testimonials are written by or are from interviews conducted by composers collaborating on *RoadMusic*.

Atau Tanaka has experienced several versions of *RoadMusic* on several different occasions and in different cars (including Newcastle Universities electric car), the most recent was during the first GMEM workshop in February 2012. Tanaka has also driven a car with *RoadMusic*. Interview via Skype18-07-12.

P.S. Can you describe your experience of riding with RM.

A.T. … I suppose I went into it as a kind of knowledgeable user. In the sense that I do music systems, I work with sensor interfaces; I'm involved with you obviously on sonification. And what struck me immediately about *RoadMusic* was the directness of the experience and the things which I value in an interactive music system which is the physicality of it, the kind of viscerality of the experience and this in some ways was more than I expected —that the dynamics of the car the translation of the road conditions and the light could at once give an immediate sonic result but could also work at this other level to shape something which we could actually consider as a piece of music. That was a pleasant surprise.

P.S. Does the fact that it is sonification change the status of the music?

A.T. Yes in that it makes it a direct experience. On the first question of is it music? First we have to temper that question because if it's the general question of is it music we get to this very dangerous question of is it art or not and this can be a subjective question where everyone would have a different answer and because it's subjective it wouldn't be based on anything. Now since I'm an experimental musician who has worked with a wide range of sound sources as music, I'm someone who is very ready to think about the sonification of road conditions and car dynamics as a form of music and in that way I'm open to that possibility. But beyond that, I think that the question of is it music, has to do with what the design objectives of the system are. And even from the title of the project "*RoadMusic*" music is in the title so there is an intention; one of the objectives, the goals is to make music. So the question is does it do it successfully or not? And I think it does.

So in this way of approaching the problem we get away from is it music or not, is it good music or not, is it music that we like or not but rather is it intended to produce music and was it successful in its original intent. And in this I think it was. This intent I think drove the design of this system, to produce output, even if it was sonified, to produce output in musical terms that is to say that there are different layers in the resulting sound that can be considered as musical voices; the kinds of sounds that were chosen, were very musical instrument kinds of sounds, even if they may be very abstract. Today there is considerable history and appetite of people listening to electronic music, so that they fit within a palette of sounds we are accustomed to in electronic music and so then the data sonification part functioned as a way to shape the musical output and in this way it is a musical sonification and not a data sonification; in the sense that we are not turning data directly into sound and listening to it to glean information or to look for musicality in raw data. The data is used to modulate or shape the musical voices and the musical sounds that are synthesized by the system.

P.S. Does the data make it fact or fiction.

A.T. The fact or fiction question is one which is very important to me. The fact that it is fact helps the system to be successful as an experience as a physical experience.

The fact that it's fact makes it effective and it helps the real physicality of the system and I think that that is one of the first things that you notice. But then in many ways it's a hook to pull the listener in, to get the listener more interested in the less evident parts of the interaction, the longer-term interaction and so forth. But if for example by going over a bump, there is a bump in the music, you sense it, you get it, it's funny and by then believing, it gets you engaged in believing the less physical stuff and having that second level, longer term reaction and so fourth, is none the less extremely important because if it was only bumps that go bang then the system would be a bit trivial and it would very quickly become tiring.

P.S. I wanted to ask you about authorship in relationship to this project: does it shift the paradigm of composer performer audience.

A.T. This is a preoccupation for me and for many of us in the area of interactive systems now that the traditional boundaries between composer, performer and audience are becoming blurred. Or even between instrument builder, composer, performer and audience. So that in many interactive systems people may have double roles the composer

may build his own instrument or an instrument builder may compose a first piece or with participatory systems the audience becomes engaged in the creative process. So all these things change our notion of authorship of a piece of music of an instrument or a system and *RoadMusic* is a perfect example of this in that it takes music into a new setting, the setting itself is an integral part of the music that is created, so in some ways one can even say that the environment becomes one of the authors in the resulting music. Or that the car can be thought of as an instrument, or a performer or that the other cars that are on the road that we need to drive with become performers. And so in this way the system that has been created the interactive system —it's interesting to think about where the boundaries are of what constitutes the instrument. Is the instrument the computer with the sensors that's in the car or once it's armed with these sensors does the car become an instrument? Or that Pd patch that has been created, it's a pretty specific patch; it creates music in a certain way, in a very musical way, is that an instrument or is it part of the composition? Has the system designer taken a certain authorship over the resulting music or by creating the system in that way do we have a body of work, that's similar, that's self consistent so that a composer coming in, being asked to make works for this system may be making variations or may be making entirely new works? Certainly the notion of authorship has changed, the notion of instrument has changed from a self-contained thing to a system that includes the environment.

P.S. Do you feel that the mobile aspect has a specific importance in that condition – in that shift in role.

A.T. Does the mobile setting lead to new forms of music? I would say that it can, that it doesn't have to, but why we think about it that way is because there is an interesting situation to address. It's not the mobile situation in that it's taking place on mobile technology but I think it is this sort of itinerant context: the moving vehicle, the change in location, the listener no longer being in a fixed place. Now certainly we can and do listen to traditional music in these settings moving around with our Walkman driving a car while listening to a symphony and they are perfectly good experiences but I think there is something very compelling abut making a new music that integrates the dynamics from the mobile experience itself.

P.S. Do you feel that *RoadMusic* changed your driving?

A.T. Yes, I had to resist it changing my driving (laugh). The early satisfaction is to understand that it is real, so on the fact and fiction spectrum that was on the fact side so

that gives immediate satisfaction and then the immediate reaction to the satisfaction of immediacy is to want to do it again or to want to provoke something in the system so then, maybe this is me being a musician, so then I start to drive the car like an instrument wanting to play it. Now of course this can create an unsafe situation in the car and this is where I think the reality of the driving experience makes itself clear —driving is a serious business, we're taught how to do it, we need to do it safely, we need to respect others on the road, we need to make sure we don't get in an accident, so it's not a light matter and this interplay between the potential playfulness of driving and making the music do what we want and actually being serious about the driving is an interesting tension.

Andrea Cerra Experienced different *RoadMusic* trips during a workshop in Marseille, 11/14 April 2012. These are written responses to a questionnaire I sent him; received via email ton June 22, 2012.

P.S. Do you consider that listening to *RoadMusic* differed from normal musical listening? If so in what way?

A.C. At the beginning of the first trip (train station to GMEM) I didn't know I was listening to RM, the traffic was very slow, and my first impression was to be listening to a very cool radio program about electronic music. After a while, when I realized that the nature of the sounds, the mixing, the musical form was quite weird (it had a raw "live" quality, non refined, living...) so I asked to Peter (who was driving) if it was RM. On the other trip I was informed, so I just analyzed the behaviour of the computer.

P.S. You were informed that *RoadMusic* generates its sounds from data about the drive, to what extent and in what way(s) was this apparent to you as a passenger or driver?

A.C. Once you know how the computer works, it's a mixture of noticing a very transparent (if never monotonous) collection of first level interactions and being surprised by a more intelligent emerging behaviour.

P.S. Did *RoadMusic* effect your perception of the road?

A.C. I had the feeling that RM spoke to me more about the car, made me conscient of the forces (gravity, road irregularity...) that the car has to deal with, and in some way showed the soul of the car. I had the impression to be riding a live animal, not a machine. Perhaps we didn't experiment enough different landscapes.

P.S. Do you consider the sound environment of *RoadMusic* as fact or as fiction?

A.C. A bit of both, knowing that a matrix, or a list of numbers used as a rythmic structure, or a quantization grid, are cultural facts. On the other side, the first level interactions are quite self-evident, and convey a strong "here and now" feeling.

P.S. Do you consider that the presence of *RoadMusic* in the car effected the drivers behavior in any way; if so how?

A.C. I think the driver (Charles) was very used to the system and almost played the car like an instrument. At the same time, the traffic flow in Marseille is quite nervous and crazy, and some of the driver's moves could have been related to other cars, scooters...

P.S. Could you provide a brief personal appraisal of your experience?

A.C. Since I was young, I loved driving on the countryside, at night. Music has a very important part for me in this kind of experience: it defines the visual landscape and gives an strong identity to the whole experience. *RoadMusic* is a step forward, and it can really provide a heightened way of enjoying these solitary moments.

Charles Bascou was one the first people to experience *RoadMusic*, he has driven with it himself and he has an in-depth understanding of the programs (translated from French). Interview via Skype June 27, 2012 (translated from French).

P.S. Can you give me your first impressions of *RoadMusic*?

C.B. What hit me was the state that it induces -the present of driving- it created a state (of mind) music a sort of higher level if you like. You are not in how can I put it: dramatic music a narration you're in a thing that transports the present and turns it into something else. Well it puts you in a different state.

P.S. Does it work in the same way as other types of music?

C.B. As certain types of music yes. For me it has something to do with a sort of tranquil trance.

P.S. So the fact that the audio is generated by data doesn't change it's status?

C.B. Yes yes that's just it, it works off something else, and it's offers a slightly augmented state, which means that the music carries you to a higher state like you might be in in a trance; like flux or trance music. The result is close to such types of music but the means (of getting there) are not the same… It's a kind of state that you can reach through some types of music and which does not necessarily depend on an interactive system. What I mean to say is that that you cease to listen with your head and you listen with your body. In trance music the repetition of a rhythm means that your brain gets accustomed to it. It will no longer individually analyse each event that happens but rather what is expected in what comes and goes and comes back and so you get into another type of listening. In *RoadMusic* the same thing happens but through other means, which is related to something that is of the order of the feeling in the car. Your whole body feels that it is braking or cornering or ... and you have something that carries this in the sound. That's what makes it interesting because you realize that when you start to attach sound to other sensations, you go to a level –I want to say higher, but it's not higher in a hierarchical sense, but you move to a raised level in terms of listening. There is no beginning or end. You are the one who decides where to stop this thing. There is also the notion of being in something which is constantly advancing – it's like driving, it's the same it's a flux. At the

beginning (if I remember rightly) I hadn't really felt a direct relationship between the music the driving and the movement. Even if I was very aware of how it functioned. What I remember was a sort of memory or impression -an impression like a printed or photographic impression of these movements in a (musical) form. There are places where the form is closely tied (bumps and things) where you felt that something else was at work. But overall in the relationship it creates what is almost more marking (well if we are analysing) is the 'impression' side of it: something just happened and you feel that the music is going to take that trajectory; that it's going to pick something up here, it's through little things that take place or through something more global. I remember a high-pitched sound that follows the accelerometers but which is slightly in the background. I had the impression that it was printing something, it was also because it lagged slightly which gave the impression that it was reproducing.

P.S. Can you describe how *RoadMusic* has evolved since the first time you experienced it?

C.B. The interior structures and former are more spread out - there was more of a zapping a side to it before- a flux which shifts but which still remains stable over time.

P.S. Can you develop more on what you said about real and narrative?

C.B. In general, listening to music in the car tends to transport me elsewhere but precisely makes me forget the car.

P.S. Does *RoadMusic* do that?

C.B. No that's just it, because you are a bit in reality, you are much more attentive to your environment, in fact you are really in your environment. And it augments your perception and even your diligence, whereas in general music in cars really transports you elsewhere, at least it does me. It rarely does that thing where it fits with the road, or sometimes it does but it’s an intoxicating effect or the driving has an intoxicating effect. I think everybody has done it at some time; on something (a musical piece) where you're somehow transported where you hair stands up on end a little ... well you hit the accelerator, you create other sensations for yourself, ultimately you accompany the music, you try to translate the feelings the music gives into driving: guys who turn the music up full blast and drive like maniacs just for pure pleasure.

P.S. So how does it effect your driving

C.B. The point of driving is no longer solely situated in going from point a to point b and to drive as fluidly as possible - it also becomes listening (because the link is perceptible all the same). What influence does that have (on driving) I'm not able to say exactly, someone else would have to judge, I wasn't analysing my driving... I get the impression that you seek things out. At one point you tickle the system -inevitably. You try accelerating, braking; well it's a basic thing, to see how the thing reacts.

I know that the way (of driving) is different because, we drive differently according to the attention we pay to the road and I think that with *RoadMusic* attention is really increased. It implies your presence at the wheel of the car in a way, and legitimizes it. Let's say that you're more respectful towards the exterior.

P.S. Does one play it like an instrument?

C.B. The driver has some kind of responsibility, but we are all in the same car (in the same boat) and it's not spectacular so to speak.