PORTFOLIO OF ORIGINAL ELECTROACOUSTIC COMPOSITIONS

A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy in the Faculty of Humanities

2013

Mark I. Pilkington

SCHOOL OF ARTS, LANGUAGES AND CULTURES

Contents

List of Compositions

Audio CD 1

1.	*Sketch on Glass* [recording] (2009)	8'30
2.	*Touch the Stars - Part 2* (2009)	10'48
3.	*Peterloo* [stereo mix] (2011)	11'58
4	*Turing - Morphogenesis* [stereo mix] (2012)	31'16

Data DVD 1: Stereo Works

1.	*Sketch on Glass* [stereo] (2009) [recording] .aif 48kHz 24bit	8’30
2.	*Touch the Stars - Part 2* [stereo] (2009) .aif 48kHz 24bit	10'48

Data DVD 2: Audio-visual Works

1.	*Points and Lines* (2009) .mov 48kHz 16bit	8'00
2.	*Camera Down* (2010) .mov 48kHz 24bit	13'18

Data DVD 3: Audio-visual Works

1.	*Phone Camera* (2010) .mov 48kHz 24bit	6'55
2.	*Birth* (2011) .mov 96kHz 24bit	10'22

Data DVD 4: Multi-channel Works

1.	*Peterloo* [stereo mix] (2011) .aif 96kHz 24bit	11'58
2.	*Peterloo* [surround mix] (2011) .aif 96kHz 24bit	11'58

Data DVD 5: Multi-channel Works

1.	*Turing - Morphogenesis* [stereo mix] (2012) .aif 96kHz 24bit	31'25
2.	*Turing - Morphogenesis* [surround mix] (2012) .wav 96kHz 24bit	31'25

Data DVD 6: Max/MSP Patches

Sketch on Glass

Touch the Stars - Part 1

Turing 5.1

Data DVD 7: *Touch the Stars – Part 1* and Commentary

Touch the Stars Performance Video (2009) .mov 48kHz 16bit	16'33
PhD Commentary.pdf	

List of Diagrams and Figures

Abstract

The University of Manchester

Mark Iain Pilkington

MusD

Folio of Compositions

03/01/13

This thesis accompanies the folio of electroacoustic compositions, describing the reasons behind and methods of realising the compositions.

There are nine original compositions presented in the portfolio, namely, *Points and Lines, Sketch on Glass, Touch the Stars - Part 1, Touch the Stars - Part 2, Camera Down, Phone Camera, Peterloo, Birth* and *Turing - Morphogenesis.* The works exhibit a variety of cross-disciplinary approaches from audio-visual, live electronics, networked performance, narrative and multi-channel. The portfolio consists of four audio-visual works, two 5.1 pieces, one network performance, one stereo work and a work for ensemble and live electronics.

The main concerns spanning the portfolio are the connections navigated through a 'synthesis' of multiple disciplines within the language of electroacoustic music and the finding of challenging areas of research that question and raise new musical possibilities. The commentary presents supplementary information on each work, with a view to providing the reader with insights into the evolution of my compositional vocabulary. More attention will be devoted to the audio-visual and space aspects, with particular reference to theoretical writings in the field.

Technical Information (Surround Works)

To aid the process of listening to the materials, an audio CD is also supplied, with all surround works presented in stereo aiff format at 44.1kHz 16bit resolution. On DATA DVD 4: Multi-channel Works, there are two stereo files and two interleaved surround files (.aif files, 96kHz 24bit) for the original, 5.1 versions of *Peterloo* and *Turing - Morphogenesis.* The surround files correspond to the following loudspeaker arrangement, a common 5.1 formation:

Channel 1 = Left Speaker (L)
Channel 2 = Right Speaker (R)
Channel 3 = Left side (Ls)
Channel 4 = Right side (Rs)
Channel 5 = Centre Speaker (C)
Channel 6 = Low Frequency Effect (LFE)

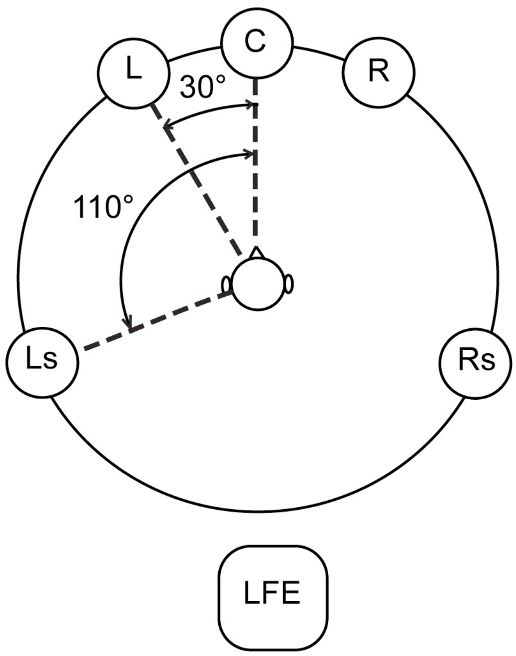

Diagram 1: Loudspeaker Plan for Playback of *Peterloo* and *Turing - Morphogenesis*.

The above diagram shows the relative loudspeaker positions which are labelled as Left, Right, Centre, Left Surround, Right Surround and LFE. The relative positioning shown for the LFE loudspeaker is not obligatory.

Declaration

I hereby declare that no portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or any other institute of learning.

Acknowledgements

This submission presents the results of doctoral research conducted at the University of Manchester between 2009 and 2012.

I am particularly grateful for the support, advice and inspiration of my supervisor, Prof. David Berezan, and Dr. Ricardo Climent. In addition, the Manchester Theatre in Sound (MANTIS) composers have been a constant source of encouragement and motivation.

I would like to dedicate the work to my children Noah Joseph Pilkington, Mitzi Anne Pilkington and Luke Peter Pilkington.

Introduction

The commentary supports a folio of compositions in the submission for my practice-based PhD research in electroacoustic composition. Each chapter identifies methodological, ideological and theoretical aspects through the appliance of cross-disciplinary approaches within audio-visual, algorithmic, narrative and space / multi-channel composition. The intention is to present challenging new approaches that combine a diversity of media in order to create a series of compositions that expand the language of electroacoustic music composition. Each chapter describes the concepts and strategies involved in each composition, supported by examples, illustrations and diagrams.

The first chapter, entitled *Points and Lines*, describes how combining onscreen moving images and electroacoustic sounds opens up new sound-image relationships within an audio-visual composition. The second chapter, entitled *Sketch on Glass*, describes the process of combining electroacoustic and instrumental sounds in collaboration with an instrumental composer. The third chapter discusses the development of two differing compositional approaches; *Touch the Stars - Part 1 is* an algorithmic composition that maps and transforms non-musical astronomical data into a live electroacoustic music performance, and *Touch the Stars - Part 2* is a stereo fixed media version. The fourth chapter describes *Camera Down* and *Phone Camera,* audio-visual compositions that explore ideas of 'visual music', using abstract visuals that apply principles from the language of electroacoustic music. The fifth chapter, *Peterloo,* explores the idea of 'narrative' and multi-channel space in electroacoustic music. *Peterloo* recreates the sound world of Manchester in 1819, using contemporary urban and rural sound objects to formulate an aural acousmatic scene in which a drama ensues. The sixth chapter, *Birth* explores how a kinaesthetic audio-visual experience is created by combining computer generated geometrical forms and electroacoustic sounds. The final chapter, *Turing - Morphogenesis*, is concerned with adapting a scientific theory (A.M.Turing's paper *The Chemical Basis of Morphogenesis* (1952)) into an acousmatic piece to convey the propagation of sound entities perceptually anchored through the continued presence of their energetic characteristics within a multi-channel environment.

The commentary consolidates and expresses many musical ideas within each compositional process, highlighting a diversity of approaches that will continue to inspire and inform. The investigation of new areas of the composition and performance of electroacoustic music will increase and widen the possibilities of creation and reception.

Chapter 1: *Points and Lines* (2009)

Duration: 8'00

Format: Audio-Visual

Points and Lines was the first piece composed for my portfolio. This chapter reveals the practical and theoretical methodologies that emerged during the formation of an audio-visual composition. The work is concerned with the creation of abstract correspondences between onscreen moving images and electroacoustic sounds. Setting alliances between the nodes of visual and electroacoustic procedures has allowed the discovery of new forms of structural expression: a new modality. The appliance of symbolic visual media demonstrates the limitations of our musical understanding and imaginations. The audio-visual domain provides a platform for expanding the limits of electroacoustic music into areas beyond my current practice.

Visualisation within a Spatial Setting

The 'acousmatic' and 'audio-visual' modes both converge on the processes of 'visualisation' within a spatial setting. The term visualisation is used to describe the process that enables us to derive meaning from an audio-visual experience. Spatialisation allows the formation of spatial forms around the localisation of social events coordinated in space. Combining both event types, we realise that the two sensory events run contrary to each other; the spatial anchoring of aural events is much more vague and uncertain than that of visual events. Sound is contained within a spatial setting in which the location of sonic events rarely indicates a precise direction. In comparison, the visual event has a fixed location. Once identified, the object and its interactions are projected clearly from within the spatial setting. Investigation into these perceptual differences has provided a creative stimulus for forming correspondences between audio and visual material.

The Analysis and Representation of Sound

Visual elements in purely electroacoustic music are primarily used as an analytic representation of objects. Visualisation of the time and frequency domain functions as low level analytical abstraction of the physical and perceptual properties of sound over time. While graphically very simple, they are limited in their ability to realise fully the imaginary audio-visual world I intend to create. Composers have always derived much from research into the visual arts and I have a special interest in work concerned with the intersection of the domains. The audio-visual experience is a dynamic interplay of directed intentions, and unlocking these forces enhances and expands our relationship with the work as a whole. Utilisation of the audio-visual field in electroacoustic music reveals an imaginary space that allows the composer to construct art forms that communicate beyond one particular language. According to Emmerson, 'the aim in such an 'envisioning' of synthesis is to allow greater imaginative play.'[1]

The Graphic Score

When working with sound, I often explore elements of visual media to form an evocative notation to represent complex sound structures. Conventional Western music notation, when applied to the composition of sound, is problematic, due to the internal limitations of conventional musical notation. Scoring for sound has found a place in the widespread practice of the graphic score, which allows for a boundless area of musical expression, through the use of visual symbols outside of the realm of traditional music notation.[2] *Points and Lines* can be described as a graphic score *in motion,* containing both symbolic and abstract representations of a time-based design. Technology now enables a seamless convergence over the control of audio-visual elements.

---

[1] Emmerson, Simon, 'Music Imagination Technology', *Proceedings of the International Computer Music Conference 2011*, University of Huddersfield UK, (2011), 365-372 at 367.

[2] See Theresa Sauer, *Notations 21*, New York, 2009, 10. Graphic scores combine innovative audio and visual information to 'improve communication amongst composers, performers, and audiences, to develop wholly different language, to encourage creative improvisation, and to challenge the way we understand music and sound'.

The Concept

The motion of light and the way it physically affects our lives and very existence have always fascinated me. The way light physically reflects from different surfaces and the way it blurs with motion enables a glimpse into another dimension beyond what we would consider the real world: the experience of multiple instances that collapse upon viewing. Albert Einstein's *Relativity: the Special Theory and the General Theory* presented new ways of thinking about space, time and gravity. According to Einstein, the apparent distortion of the physical object is not an optical illusion, but is due to a change in the nature of space itself, caused by motion. Space and time become fluid and cease to exist as separate concepts, both occurring in a new 'continuum' called space-time.

The Typology of Sounds

The sounds used in *Points and Lines* are grouped into four types:

1. Natural: from the excitation of natural substance.
2. Instrumental: from acoustic instruments.
3. Mechanical: from machinery.
4. Synthetic: produced by the mathematical calculations of electronic signals.

The pre-recorded sound-files provided the means to assimilate material behaviour through analysis and transformation (Figure 1).

Typology of Sounds for *Points and Lines*.

Natural:

Metal:
Striking of a tin lid produced harmonic bell-like structure (for example, 0'12 and 0'25).
Steel ball bearings revolving within a metallic dish (0'25).
Wood:
Striking of wood produced a deep thud (1'50).
Striking of wood formed part of a rhythmic sequence (1'51 - 1'55).
Single impacts on wood are grouped to form accumulated masses (5'46).
Wooden coffee grinder is tuned according to a specific tone row (1'10).
Air:
An exploding firework formed part of a series of percussive impacts (1'21).

Mechanical:

A MetroLink tram produced a drone with a fundamental frequency of 453.131Hz that subsquently rose to a frequency of 1174Hz (0'25 until 0'28).
The ratchet on a toy crane formed a percussive rhythmic pattern (0'48, 1'10 and 5'44).

Instrumental:

Percussion:
Single strikes on a tam-tam using wooden and metal sticks (1'21).
Multiple strikes on a tam-tam using wooden and metal sticks (1'29).
The resonance of piano cluster chord (1'21).
Tuned tom-toms (1'59).
Strings:
Single cello bow F#4 - 369.994Hz formed rhythmic pulses (3'12).
Cello bowed fifths F#4 - 369.994Hz formed rhythmic pulses (3'12).
Cello pizzicato octaves Eflat 4 - 307Hz and Eflat 5 - 627Hz - E Flat6 1285Hz (2'04).

Synthetic:

The distribution of short synchronous pulses (C#4 - 280Hz) were transformed to produced a texture (1'21).
Sine waves fixed at fundamental frequencies of D7 - 2346Hz (0'00 and 0'12), C7 - 2090Hz (0'06) and A4 - 440Hz (0'06).
Sine wave glissando from G4 - 400Hz to C7 - 2084Hz, B2 - 120Hz to G#7 - 3312Hz and Eflat2 - 78Hz to C8 - 4186Hz (0'43 - 0'45).
Plate Synthesis (1'34 and 1'38) produced at a Physcial Modeling Workshop, hosted by Dr. Stefan Bilbao, NOVARS, 12/12/08. A method of sound synthesis that takes on the physical descriptions of percussive plates, through simulation, allowing for realistic and complex sound production.

Figure 1: Typology of Sounds for *Points and Lines.*

The Modelling of Sounds

Rather than working with the audio and visual material in parallel, I decided to concentrate firstly on the realisation of the audio part of the composition. This would later project structural correspondences into the visual domain. The initial concept was to approach the piece as an instrumental score for cello and mixed percussion, using extended techniques. This provided a context for the design of a representative sound world based on the sonorities of each instrument. The sounds in the typology were either left in their original state or transformed using real-time and non-real time sound processes such as CDP (Composer Desktop Project), Max/MSP/Jitter and Apple Logic. Each sound transformation process offered its own unique sonic characteristics across a range of different audible time scales. Listening back to the results, I identified intrinsic and extrinsic musical characteristics relating to the concept. [3] This facilitated a framework of gesture and texture mixtures that promoted structural relationships within an instrumental domain.

Prior to the construction of the piece, a pitch and rhythmic framework was conceived to facilitate a structural overview. The intention was to use a traditional *top-down*[4] approach to guide initial structural development; later, as the material transformations developed, they formed their own morphological correspondences.

This approach of applying a preconceived framework is a method I had previously employed in the visual domain. Dividing the visual frame into zones by drawing perspective guide lines directly onto a canvas or screen revealed a visible 'skeletal' form. This underlying form was retained by carefully balancing the spatial arrangement of the visual material. At times, I deliberately disturbed the equilibrium, often through spatial misplacement, to enable the composition to represent an alternative state of reality.

---

[3] Smalley, Denis, 'Spectromorphology: explaining sound-shapes', *Organised Sound*, ii (1997),107-126 at 110. Intrinsic describes the actual sound events within a piece of music. Extrinsic describes extra-musical cultural associations with the piece.

[4] See Leigh Landy, *Understanding The Art Of Sound Organization,* Massachusetts, 2007, 34. As opposed to a *bottom-up* approach of formulating musical structure.

The Pitch Correspondence

The control of pitch was used to articulate musical structure by using intervallic to relative pitch transitions.[5] A pitch hierarchy was designed to align the tonal pitch-centres of the sound material using a horizontal and vertical tone row.[6] Spectral analysis revealed the fundamental frequency of the material. This was then transposed using vari-speed or time stretching to the nearest intervallic pitch value in the row. Initially, it was found important to use a transformation process that maintained the quality of the original recording so as not to add artefacts that could distract intervallic pitch alignment. As the piece progressed, sound transformations caused coincidental pitch occurrences to appear that shifted spectral focus away from the intervallic and more towards relative pitch. Throughout *Points and Lines*, this spectral shift from intervallic to relative pitch gradually increases over the entire duration. What follows is a detailed analysis of a sound-event (1'10 - 1'12) that is typical of pitch transition process. For reference, note value uses scientific pitch notation (i.e. C4 denotes middle C) and frequency is measured in Hertz (Hz). Wood sound-types produced from a squeaking coffee grinder were analysed using the open source FFT software, Spear.[7] The fundamental frequencies were synthetically reinforced with the addition of sine tones (E5 - 659.255Hz and D5 - 600Hz), causing micro-tonal fluctuations (for example, 1'11). A synthesised set of harmonic partials (Middle C - 255Hz, G4 - 389.98Hz, A5 - 440Hz, B4 - 493.56Hz and C♯5 - 552.96Hz) modulated inharmonic spectra (1'10). Eight shorter wood sound-types (ca. 100ms) produced a rhythmic accumulation: type 1 (E♭5 - 622.25Hz), type 2 (B5 - 978Hz), type 3 (no apparent fundamental frequency), type 4 (E♭5 - 622.25Hz), type 5 (E6 - 1318.5104Hz), type 6 (E♭6-1244.5Hz), type 7 (no apparent fundamental pitch) and type 8 (E♭5 - 622.25Hz). Finally, a high-frequency sound was analysed in two halves: Part 1 has prominent frequencies (F7 - 2841.04Hz, F♯7 - 2899.99Hz and C8 - 4664.06Hz) where the perceptual distance forms intervallic pitch mixed with a filtered noise band. Part 2 matched the frequency of the first two tones of Part 1, but then reduced to 2840.31Hz and 2865.32Hz for a duration of 600ms. This gradual linear change caused rhythmic beating to occur through amplitude modulation.[8] Throughout *Points and Lines*, pitch correspondence occurred at various times and for various durations within the poles of the pitch-continuum.

---

5 Smalley 'Spectromorphology: explaining sound-shapes', 119. Smalley defines *intervallic* pitch as were, 'we can hear pitch-intervals'. In *relative* pitch, 'we hear with much less precision the distance between pitches and can no longer hear exact pitches or intervals in spectral space'. Instead we are inclined to follow higher-level gestures and motions - *note collectives'*.

6 Oxford Music Online Dictionary. An ordered succession of elements to be used as basic material in a composition. The term is most frequently applied to an ordering of the 12 pitch classes, but it may also be used of a succession of fewer or more than 12 pitch classes, or of successions of pitches, durations, dynamics, time points, timbres and so on. In my particular case, the tone row consisted of 10 pitches C, C♯ D, E♭, E, F, F♯, G, A♭ and B♭.

7 An application for audio analysis, editing and synthesis developed by Michael Klingbell.

8 See Truax, Barry, ed., *Handbook for Acoustic Ecology*, Burnaby, B.C., 1999 (Accessed 17 September 2012), <http://www.sfu.ca/sonic-studio/handbook/Amplitude_Modulation.html>.

Rhythmic Transitions

Rhythmic transitions were developed within a predefined hierarchical rhythmical framework. At the beginning of the work, rhythmic rigidity is maintained through the application of simple, complex and compound time signatures at a tempo of 75 bpm (for example, 0'48). Relinquishing control of such rhythmic restrictions later allows the sonic transformations to combine, interact and create causality, allowing the appearance of new rhythmic associations (4'09).

Modelling sound through an abstraction of pitch and rhythm may seem contrary to certain aspects of electroacoustic composition. It was only at the outset that I adopted subjective musical terms to regulate sonic development in order to retain a pseudo musical sense: through an exploration of different models. Later the structural focus shifted more to the spectromorphological tendencies contained within material transformation. The contrast of each approach represents a temporal shift from pitch and rhythmic relations to the exploration of spectral space.

The Typology of Visuals

The visual materials used comprised sketches, paintings, time-based camera-sourced video and computer generated graphics. This diversity provided a rich source of content which correspond to sound-types evident in the final film.

Drawing:

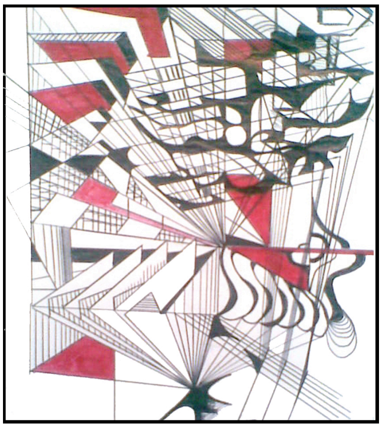

Figure 2: Photograph of *Untitled* (M. Pilkington 2009) Hand drawn graphical sketch using pen and ink. Lines and planes were formed into a perspective landscape (for example, 0'04).

Painting:

Figure 3: Photograph of *Globalization* (M. Pilkington 2007) Oil and photomontage on canvas. The photograph was taken prior to completion, showing the technique of perspective guide lines (for example, 0'13 and 0'26).

Time-based camera-sourced video materials:

These comprise a hand-built scaled model of a city providing an architectural background (for example, 1'24, 2'55 and 7'40), a rotating mirror ball (1'59 – 2'44) and passing street lights (5'52).[9]

Computer Graphics:

Sound to Light 1: the size, position and colour of a 2 dimensional line object mapped to the amplitude of an incoming audio signal (for example, 1'11).

Sound to Light 2: the size, position and colour of 2 dimensional line objects were mapped to the frequency content of an audio signal (1'33).

Single Light Beam: responded to auditory changes and was filmed on a low fidelity phone camera (4'34).

Artificial Landscape: consists of 3D and 2D OpenGL structures transformed by incoming audio content direct from the piece between 5'54 and 8'15.

Complex Organism: resembles micro-organisms set in motion by sound viewed as if under a microscope (3'56).

Both audio and visual materials provided the initial 'building blocks' that were later linked through their patterns of 'motion' within a dynamic system.[10]

Audio-visual Construction

My intentions were to open up new sound-image relationships through and beyond the restraint of the frame and to project a piece of electroacoustic music using visual processes in the pursuit of greater creative potential. Motion became the commonality that allowed the unification of audio and visual media. Visual perception is primarily based on how 'motion allows us to comprehend space through the law of differentiation'.[11] This notion can be equally applied to the spatial aspect of sound.

[9] *Synth City* (2007) installation, *'The World is My Imagination'* Exhibition, Cube Gallery, Manchester UK.

[10] See Rudolph Arnheim *Visual Thinking,* Berkley, New York and London, 1969, 276. Such a system can be considered as a 'dynamic view of the world' that 'corresponds to what is known about the objective state of nature' based on gestalt psychology.

[11] See Rudolph Arnheim, *Art and Visual Perception - A Psychology Of The Creative Eye*. Berkley, New York and London, 1954, 233.

In visual perception, a unifying dynamic system incorporates the following gestalt principles governing differentiation:

Emergence - Complex pattern formation from simpler rules.
Reification - Spatial construction of the perception of 'illusionary contours'.
Multi-stability - Instability between two or more interpretants.
Invariance - Recognition of form regardless of spatial position.

Animation allowed for motion to form correspondences to the auditory elements using traditional and pixel-based transformation procedures. Combining the output of these manipulations provided empirical information that inspired creative direction beyond the internal limitations of a given formal system. The development of these dynamic treatments and processes became central to the compositional structure.

Static Dynamic Systems

The seemingly static images of paintings, sketches and photography abstract movement or action in a timeless image. Crystallizing the nature of a complex event in one arresting pattern allows visual perception not to be isolated within a particular manifestation but to become a shared dynamic. A similar connection can be made to the ineffable way a graphic score encourages sound exploration. At 0'04, a static image is set to the right of the frame creating a sense of perspective and a communal space. Moments of stasis also occur in the form of still frames that act as points of contemplation (for example, 2'21 and 5'49). During the process of stop-motion animation, a point of static reflection occurs during the selection and positioning of visual material within the spatial scene. The original representations of a visual object changes depending on its location and motion within a spatial field.

Transformation of the Audio-Visual Field

To form an overall appearance of continuity, the material from the visual typology was grouped into identifiable audio-visual scenes or cells.[12] Once the audio-visual objects were contained in the single dimension of the audio-visual field, decisions were made on their dynamic interplay. The best way to display their directed intentions was arrived at by observing the material properties to identify perceptual and apparent physical forces. The engagement of various visual transformations actively encouraged this through a balancing of spatial relations both horizontally and vertically in the audio-visual field. As individual elements expanded into whole entities, gestalt form-generating principles emerged, expressing perceptual sensations beyond the material aspects of audio-visual images.

Certain scenes investigate ideas of architectural form through the use of computer graphics and a scaled physical model (for example, between 2'55 – 3'55). The objects and landscape are infused with sound to transform spatial form and meaning. At 5'56, computer generated forms respond to the sonic characteristics of the piece through generative and stop motion animation techniques. The central object and surrounding landscape consist of a surface texture made up of coherent lines that energetically respond to the incoming audio. In a similar way, sound was mapped to alter light intensity. This process was filmed using a low fidelity phone camera which added further artefacts (1'20 and 4'18).

[12] Evans, Brian, 'Foundations of a Visual Music', *Computer Music Journal*, xxix (2005), 11-24 at 19. The Russian film-maker Serge Eisenstein used the term 'cell' to define the unit of an audio-visual montage.

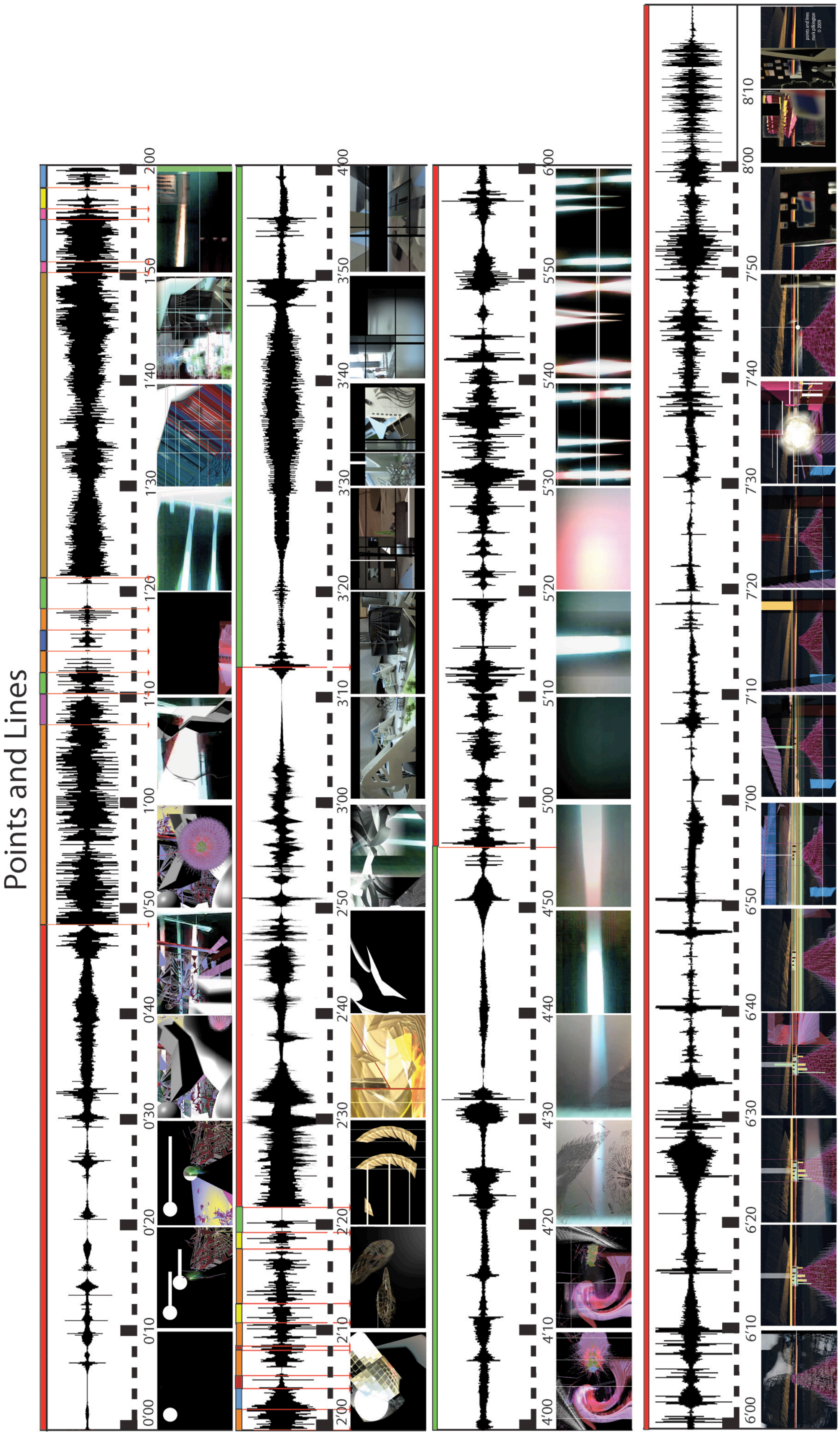

Figure 4: Schematic of *Points and Lines*.

Conclusion

The schematic (Figure 4) displays many audio-visual scenes of thematic spaces that explore the original concepts of light and space-time. Use of a diversity of media has resulted in an innovative crafting of optical and auditory spatial illusions and the audio-visual correspondences that exist in the language of electroacoustic music. The experimental language of *Points and Lines* provides a broad palette of audio-visual methodologies that were later incorporated into successive audio-visual works within the portfolio.

Chapter 2: *Sketch on Glass* (2009)

Mark Pilkington and Daniel Kidane.

Duration: 8'30

For Electronics, Cello, Violin and Amplified Shruti Box.

The challenge of this work was to combine electroacoustic and instrumental sounds in collaboration with an instrumental composer. The contrast in our methodological approaches provided a shared experience of discovery and forged new directions within our compositional praxes. Combining real and virtual musical processes into a musical performance enabled us to develop our ideas into a sound world of live electronics and acoustic instruments. A music algorithm, *Sketch on Glass,* generated a sound file to which the instrumental composer wrote a score for cello, violin and shruti box. The aim was to form a transparent sound world by blurring the identity of the electronic and acoustic instruments through the mimetic interchange of meta-instruments.

Background to the Collaboration

The collaboration was with Daniel Kidane, an instrumental composer based at the Royal Northern College of Music, Manchester UK, with an experience of writing for orchestra, chamber ensembles, chorus and dance. His knowledge of the sound worlds of the violin and cello was a valuable asset in creating musical associations between acoustic and electronic sounds. My previous collaborations with Daniel included *Car Ballet* (2008), a short film for the MOVES Festival (International Festival of Movement on Screen, Manchester), and *Noise of Many Waters* (2011), a sound and light installation at the Victoria Baths, Manchester (RNCM Festival of Music 2011).

The Algorithmic Design

The first stage of the composition was to design and construct a sound algorithm called *Sketch on Glass* (The patch is included on Data DVD 6) to abstract musical information from cognitive and symbolic models. The real-time sound processing environment allowed for one single gestural movement to control several sound parameters at once in order to produce a complex sound treatment. A combination of manual, dynamic and visual event driven input processes was mapped to transform the sound of two short sound files *Glass 1* and *Glass 2*. [13] The recorded output produced a sound-forming structure, *Glass 3,* that inspired the musical direction of the acoustic instruments in live performance (see Diagram 2).

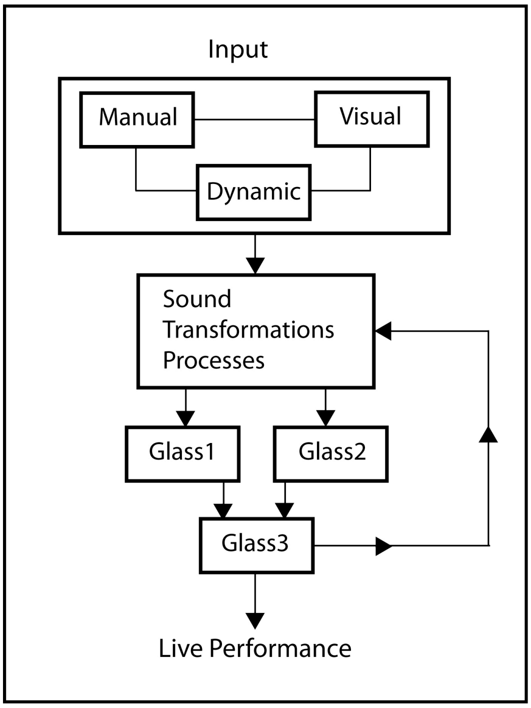

Diagram 2: The Algorithmic Process used in *Sketch on Glass.*

[13] Originally *Glass 1* and *Glass 2* were generated using Csound, an audio programming language for sound, originally written by Barry Vercoe in 1985.

Analysis of *Glass 1* and *Glass 2* Sound Files

Glass 1: The harmonic content consists of ten prominent partials ranging from a fundamental partial 1 (91.741 Hz - F#2) to partial 10 (3745Hz - B♭7), where the frequency is consistent over two seconds. The amplitude envelope rises logarithmically giving a dramatic expression to the sound. The sharp increase in amplitude stops abruptly when the maximum volume at the end of the sample is reached.

Glass 2 : The harmonic content consists of ten prominent partials ranging from a fundamental partial 1 (91.741 Hz - F#2) to partial 10 (3200Hz - G7). Some of the harmonics fluctuate slightly within the decay envelope, causing phase differentiation for eleven seconds.. The overall dynamic envelope consists of a sharp attack with a gradual decay, contrary to the dynamic profile of *Glass1.*

The two sounds, *Glass 1* and *Glass 2*, act as impulse-based morphologies set within an experimental interactive environment that allowed for the organic growth of material.[14] The limited range of sound material meant that I had to focus on extending the sound morphologies of *Glass 1* and *Glass 2* through dynamic signal processing. This required a disciplined approach in order to avoid adding further sound materials to increase the spectral detail. The ability of the algorithm to audition the development of sound material in a constructive and creative way meant that it prevented the generation of surplus amounts of material. Young makes the point that 'computer-assisted electroacoustic compositions allow materials to develop much faster than the time to audition them'[15] meaning that the creative act of listening is compromised.

Three real-time driven event types control algorithmic operation:

Manual: control comes directly from the input of the computer key pad.

Dynamic: a continuous stream of variable data directly linked to the current internal state of the algorithm, achieved by amplitude tracking, the setting of timed sample vector values and extraction of the timing reference from the playback position of sound file *Glass 3*.

Visual: a mnemonic method to project the temporal course of the sound transformation, forging an audio-visual relationship.

[14] Young, John 'Sound morphology and the articulation of structure in Electroacoustic Music', *Organised Sound* ix (2004), 7-14 at 7. Iterative morphology 'has the potential to demonstrate a fluid relationship between rhythm and pitch, as impulses can be micro-edited and mixed (overlapped) in the manner of grains to allow fusion into new textural and timbral constructs'.

[15] Ibid.

The three event types are cross-connected to many of the parameters of the sound transformation processes. The flexibility in control allows predictable and unpredictable occurrences to form a structural role within the final sound file.

Sound Transformation Processes

Vari-speed: control of playback speed and direction allowing for the transposition of pitch.
Amplitude: control of volume level.
Granulation: adjustment of the start and end points of a sound file within a buffer, resulting in variations in rhythmic iterations or pulses.
Filtering: selection of different filter types.
Internal signal recording; internal audio content is captured and replayed.
Time domain frequency shifting: pitch is changed without altering speed.
Panning.
Delay.

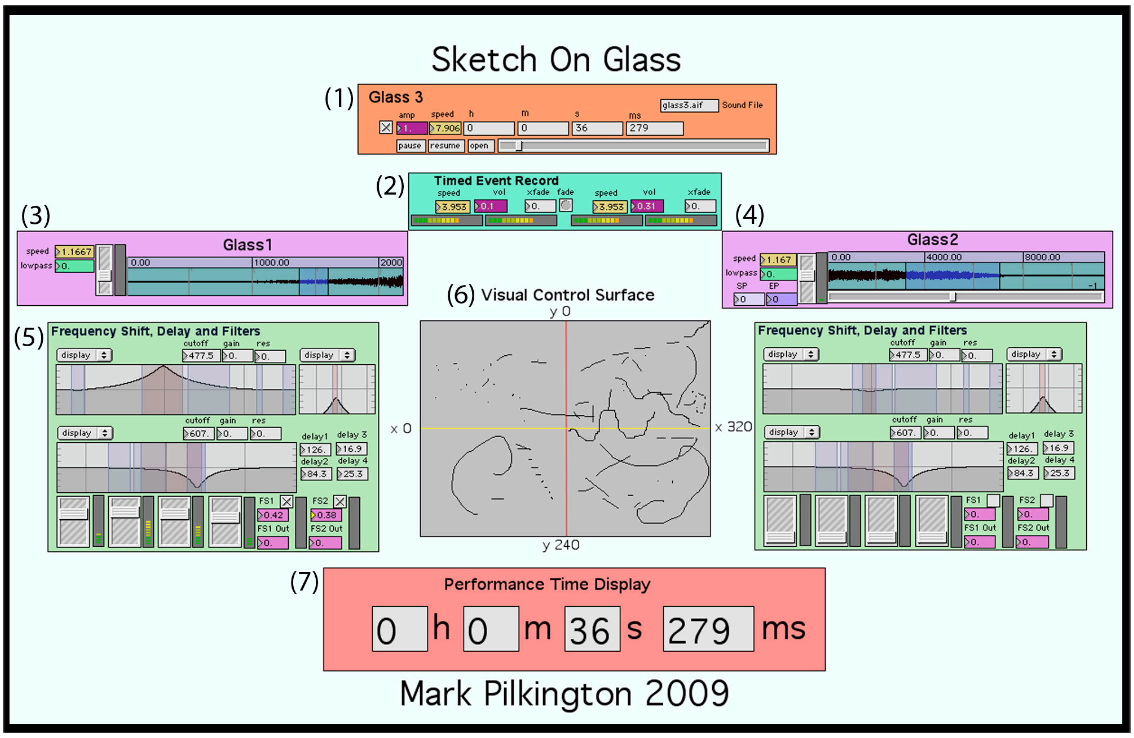

Figure 5: Screenshot of Max/Msp Performance Algorithm *Sketch on Glass*.

Description of the *Sketch on Glass* Modules (Figure 5)

Glass 3 (1)

Manual Control Parameters: *Glass 3* sound file playback, vari-speed, amplitude and lowpass filtering.

Dynamic Control Parameters: during playback some events are automatically triggered by the position of the sound file. An internal clock is used to trigger automatically pre-programmed events. For example, at specific times, the internal audio signal is recorded into a buffer for further processing.

Visual Control Surface: vari-speed.

Timed Event Record (2)

Manual Control Parameters: vari-speed, amplitude, lowpass filter, start and end playback position (ms). The fade control generates a ramp that reduces and increases the amplitude over a duration set proportionally by the speed setting.

Dynamic Control Parameters: these automatically capture the audio from the File Playback module. The playback speed is set proportionally to the size of the record buffer.

Visual Control Surface: playback speed.

Glass 1 (3)

Manual Control Parameters: speed, amplitude, lowpass filter, playback speed and waveform position.

Dynamic Control Parameters: n/a.

Visual Control Surface: this controls playback speed proportionally to the waveform window.

Glass 2 (4)

Manual Control Parameters: speed, amplitude, lowpass filter, start and end position (ms). SP (Start point) and EP (End point) adjust the interval time of the amplitude tracking envelope.

Dynamic Control Parameters: the amplitude tracking automatically adjusts the start and end points of the waveform causing granualisation. 5% of the start value is added to the value of the end position to prevent any overlap across the start position.

Visual Control Surface: the playback speed and the start and end positions of the waveform window.

Frequency Shift, Delay and Filters 1 and 2 (5)

Manual Control Parameters: 5-band filter array, time domain frequency shift and amplitude.

Dynamic Control Parameters: Filter parameters.

Visual Control Surface: Filter, delay and time domain frequency shift.

Visual Control Surface (6)

The visual trajectory is mapped to various sound parameters using the x, y coordinates input using the mouse. The coordinates of the line drawn on the surface can be retraced, stored and recalled.

Performance Time Display (7)

Time display used by performers.

The *Glass 3* Sound File

The development of the *Glass 3* sound file (glass3.aif is included on Data DVD 6) coincided with the construction of the algorithm. As each new process was implemented, the algorithm was tested and the audio output captured as a recording. The resulting sound file was then replayed from within the algorithm, and this process was repeated until the *Glass 3* sound file was fully completed (10'00 duration). The structural development of *Glass 3* was therefore proportionally linked to the behaviour and development of the sound processes. Further structural decisions were made through focused listening that revealed sonic images. Images that pertained to a perceptual experience or *noema*[16] were enhanced purely by the movement of spectromorphological properties. As the structure was in continuous motion, each perceptual moment was directly related to the *rate of change* of the material properties. My aim was to produce kinaesthetic sensations through a process of spatio-temporal evolution.

The transformations of *Glass 3* occurred simultaneously and often overlapped with each other over different time scales.[17] The incorporation and understanding of the time scales became of paramount importance to the successful implementation of structural conclusions.

Proximity was induced by increasing and decreasing the spectral content, adding to the sense of distance within the imaginary landscape (for example at 6'15). Spectral density occurred through the expansion and contraction of material content. For example, density reduces to a single partial (0'08, 3'16 and 3'40) and also expands into a fuller spectral occupancy (1'54 and 2'59). This acts to influence the listener's perceptual focus on a range of sonic details.

The work also features the rapid switching between synchronous and asynchronous rhythmic pulses over differing time scales. Fluctuating the duration of the sound particles causes expansion and compression of the material, forming eidetic images (for example, 6'33). Synchronous harmonic pulses are suddenly transformed through the transition of staccato spectral cuts before finally settling into a chaotic pitch glissando mixed with a compressed noise-based texture (7'33). Using shorter time frames rapidly switches spectral focus propelling the sound’s energy, when set in contrast to periods of limited activity (1'41). Moments of stasis appear as the energy of the material reduces over longer periods of time, serving as points of refrain and reflection. Pointillistic detail was achieved by increasing the volume of short micro-sounds contained within chaotic sound masses.

[16] See Edmund Husserl, *Ideas: General Introduction to Pure Phenomenology* (also known as Ideas I), trans. W. Boyce Gibson, Collier Books, 1913, (1962), 238. *Noema* is a phenomenological condition ascribed to our relationship to an object/material.
[17] See Curtis Roads, *Microsounds,* Massachusetts, 2001, 3. Musical time scales used in mircosound composition. Infinite, Supra, Macro, Meso, Sound Object Micro, Sample, Subsample and infinitesimal.

Prolonged tonal structures were extruded from the harmonic content of *Glass 1* and *Glass 2:* the regular pulsing of spectral strands formed voice-like drones (for example, 8'23). A sound that resembled a larger bell-like structure was observed to have the dynamic profile of *Glass 2,* but over a much more prolonged duration and with a lower spectral range (4'23). A process of pitch restructuring occurs as the sound is temporally transposed from its original tonal pitch centre, resulting in a glissando effect as each partial is transposed into a new harmonic formation (2'34, 7'58 and 5'22).

This selection of procedures were repeated numerous times and played a significant role in forming major structural elements. The overall projection was a pattern of iterative energy of both enlarged and microscopic views of the phenomena derived from real-time gestures. Due to this mode of production, performance errors often appeared. These were accepted as part of the process. Finally, *Glass 3* required further editing using the audio restoration software iZotope RX.

Once completed, *Glass 3* was presented to the instrumental composer to write a complementary instrumental score for violin, cello and shruti box. The spectral characteristics of *Glass 3* provided gestural and structural information to enable a mimetic interchange with the acoustic instruments. Finally, *Glass 3* was reincorporated back into the *Sketch on Glass* algorithm and played alongside the acoustic instruments during the final performance.

Acoustic Instrumentation

Mapping the instruments to *Glass 3* required changing the sonic characteristics of each instrument. This was achieved by applying extended techniques, such as interference using found objects or simple electronic modifications. The shruti box is a small wooden instrument that produces its sound through a series of bellows. It can produce single or multiple pitched drones and is predominantly used in Indian classical music. The reeds of this instrument have a particular nasal quality which was electronically amplified using a hand held megaphone placed at the front of the instrument. The megaphone also acted as a simple diffusion device by simply moving it from side to side. The movement also induced a Doppler effect that slightly raised and lowered the pitch.

The extended techniques applied to the cello and violin included the use of open strings that allowed for micro-tonal pitch fluctuations, sliding string harmonics and glissando across all strings. The cello was also played using a metallic guitar slide to produce a dense non-pitched inharmonic sound i.e. similar to the sound of a distorted electric guitar. The 'sul ponticello' technique was also used. This involves placing the bow on the bridge of the cello to produce an icy sound full of tension.

Within the context of a performance, careful consideration had to be given to the balance between the live electronics and the instrumental sounds.

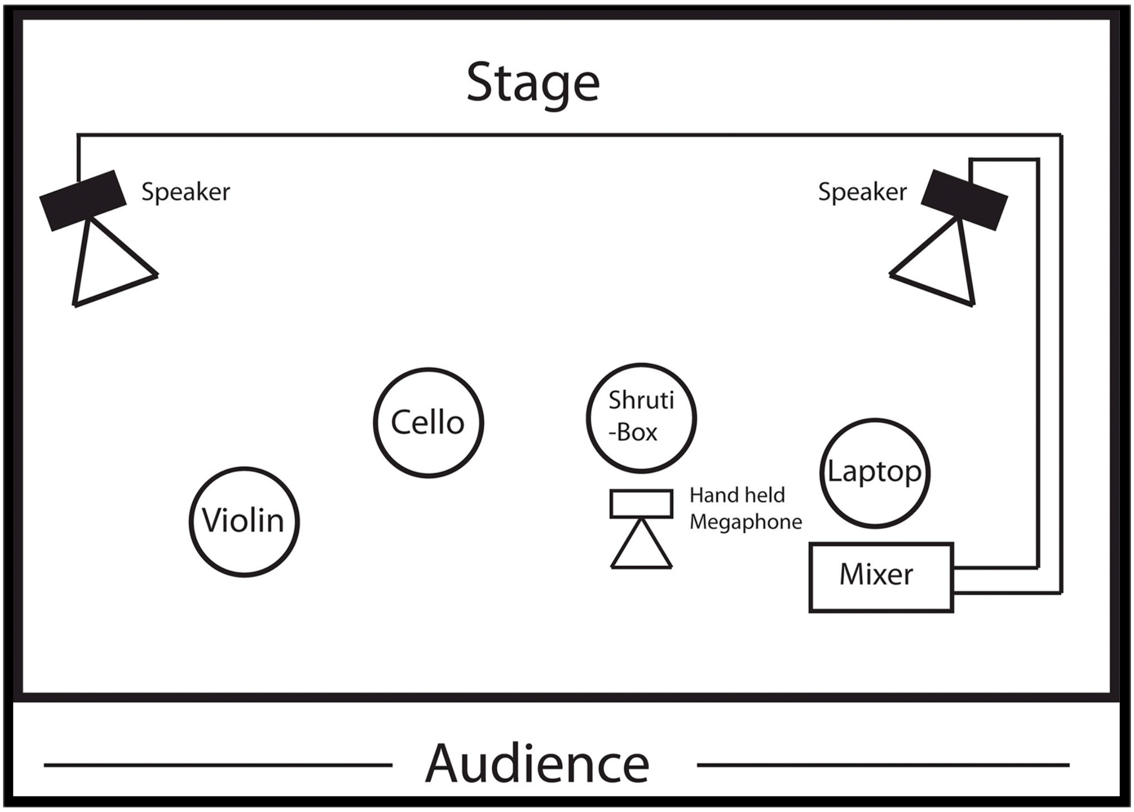

Diagram 3: Layout of Performers and Instruments for *Sketch on Glass*.

Conclusion

The collaboration mapped the transitional process between algorithmic and instrumental composers and formed a transparent sound world between live electronics and acoustic instruments. The difference in our compositional styles enabled us to experience new areas of composition methodologies that provided an enriched result for the listener.

Chapter 3: *Touch the Stars - Parts 1 and 2* (2009)

Touch the Stars - Part 1 is an algorithmic composition that maps and transforms non-musical astronomical data into a live electroacoustic music performance. *Touch the Stars - Part 2* is a stereo fixed media version inspired by the experience of *Touch the Stars - Part 1*.

Touch the Stars: Part 1

Duration: Unspecified - Performance 10'00

Format: Networked Electroacoustic Performance

Touch the Stars - Part 1 is a networked electroacoustic performance that maps live astronomical data in a sound producing algorithmic.

> Music made with distributed music ensembles and controlled lab experiments both yielded paradoxical results that prompt new questions relating to time in performance and ensemble "production".[19]

In March 2009, I was co-commissioned by FutureEverything and the Jodrell Bank Observatory, University of Manchester, to compose a composition to be performed at the opening of the FutureEverything Festival 2009, Manchester UK. This resulted in a networked performance in-collaboration with Dr. Tim O'Brien (Associate Director of the Jodrell Bank Observatory). It became apparent that, in our research, we both used the process of 'sonification' as an auditory enhancement of information data. Sonification is an auditory process that presents a perceptual experience in which meaning is derived from a musical or sonic abstraction of numerical data (arriving in this case from a remote radio telescope).[20] The decision was made to produce a performance that combined electroacoustic and radio astronomy practices to create a live interactive networked performance.

[19] Chafe, Chris, 'Tapping into the Internet as an Acoustical/Musical Medium', *Contemporary Music Review*, xxviii (2009), 413 – 420 at 415. Sonification, 'seeks to translate relationships in data or information into sound(s) that exploit the auditory perceptual abilities of human beings such that the data relationships are comprehensible'.

[20] Walker, Bruce N. and Ness, Micheal A., *Theory of Sonification* in: Thomas Hermann, Andy Hunt and John G. Neuhoff, eds., *The Sonification Handbook* , Berlin, 2011, 9.

Science and Art: Inflation Theory

The composition was inspired by inflation theory, which proposes that a period of extremely rapid exponential expansion of the universe occurred prior to the more gradual Big Bang expansion. During this time, the universe's energy and density were dominated by a cosmological constant type of vacuum energy that later decayed to produce the matter and radiation that fills the universe today. [21] This inspired a compositional praxis through the application of both artistic and technical strategies into a musical event, and the transformation of non-musical numerical data into a credible music composition. The contrast between scientific and artistic theoretical reasoning stimulated the aesthetic direction of the composition.

Aesthetic Considerations of the Musical Structure

The guiding principle of the composition was a music algorithm that communicated the displacement of two differing environments: the concert hall and the radio universe. The task was to produce an auditory system capable of tracking physical changes of an external space into a musical experience projected into the internal space of a concert hall. A resulting 'observing' system allowed the audience to 'hear' changes in the profile of a remote landscape. The algorithm interpreted two data streams continuously transmitted over a local area network from the radio telescope. The data streams consisted of the hydrogen temperature [K] emitted from distant stars and the azimuth (°) of the telescope. The data were mapped to calculate and manage a series of live sound parameters that reflected any changes as an auditory output.

[21] Guth, Alan. H. and Steinhardt, Paul. J., 'The Inflationary Universe', *Scientific America Journal*, ccv, (1984), 90 -102.

Performance Interaction

> Music performance is an interdependent art form. Musicians' real time gestures are constantly influenced by the music they hear, which are reciprocally influenced by their own actions.[22]

The algorithm had the ability to be controlled by both automated generative processes and the gestures of a single performer. Both could directly control a series of dynamic sound processes scaled within an audible range. A dynamic interdependent system was created that could react to a set of external conditions within a recursive loop between outputted sound and musical performer. The final design demonstrated a balancing of interacting sonic parameters between performer and environment.

Single Sound Expansion

The fact that the universe is a vacuum made it impossible to source a sound from this particular environment. Applying the scientific concept of 'inflation theory' (Guth and Steinhardt 1984) provided a reflective metaphorical grounding for a single sound to be the initiator for the expansion of all sonic manipulations. The sound material consisted of a one second sound recording of a rubber balloon burst (1secburst.aif is included in Data DVD 6). Its dynamic profile consisted of a sharp attack and slow decay curve, resembling a non-pitched percussive sound-type. This simple sound contained all the sonic information required for further analytical and elaborating transformations. Musical creation involved moving from the exterior surface towards the interior structure of the sound to derive new morphological perspectives.

[22] Weinberg, Gil, 'Interconnected Musical Networks: Towards a Theoretical Framework', *Computer Music Journal*, xxix (2005), 23-29 at 23.

Performance Algorithm - *Touch the Stars: Part 1*

The networked performance linked three different geographical locations: the Contact Theatre (Manchester, UK), a radio telescope based at Jodrell Bank Observatory (Cheshire, UK) and our own Milky Way galaxy. The telescope received radio signals from the energy of distant stars and converted this into digital data. An operator controlled its movement and remotely managed the data. This was then passed into the *Touch the Stars* algorithm, with which the music performer interacted, and the sound was projected to an audience in the auditorium.

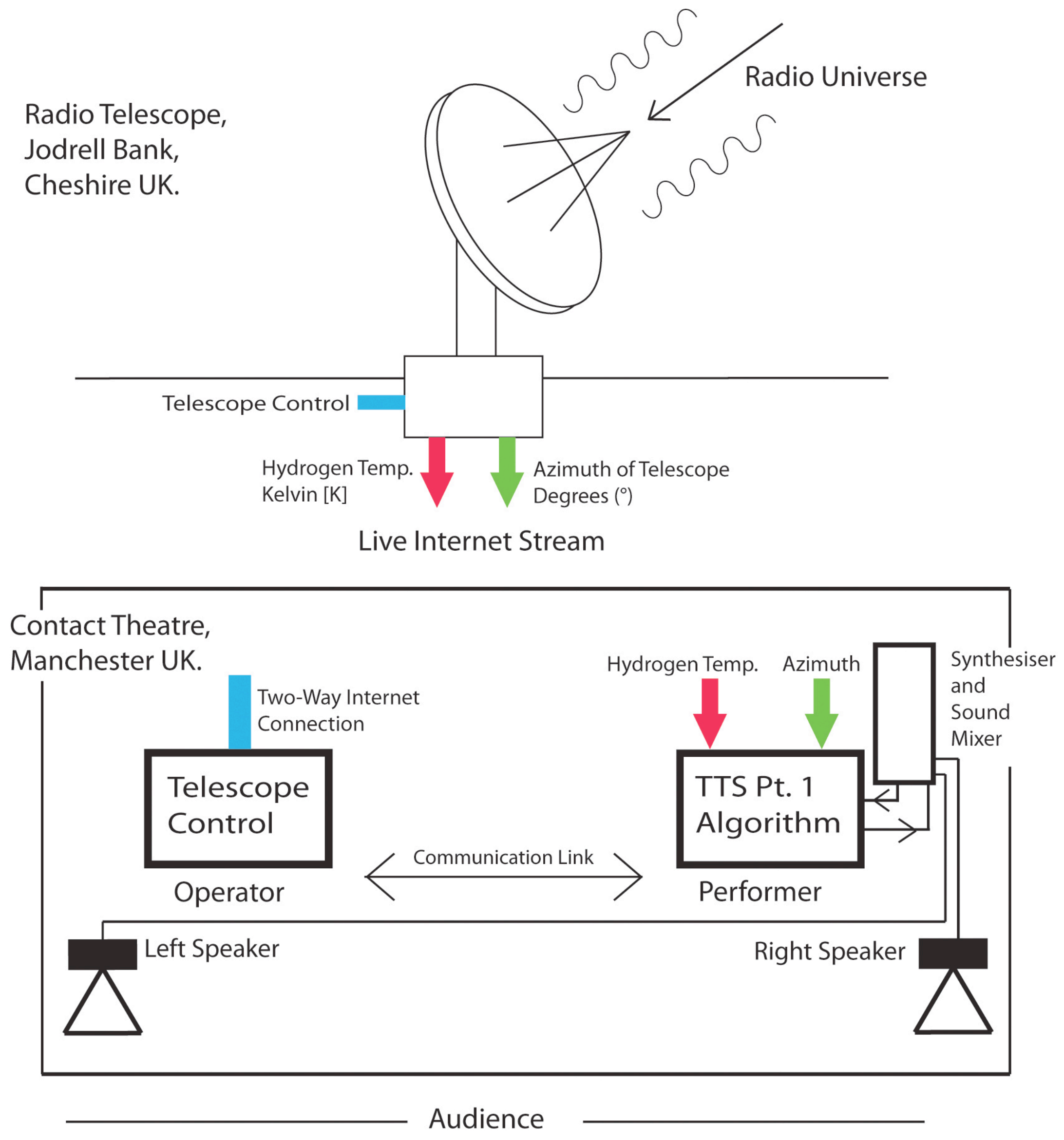

Diagram 4: Schematic of the Networked Performance for *Touch the Stars - Part 1.*

The *Touch the Stars - Part 1* Algorithm (Figure 6)

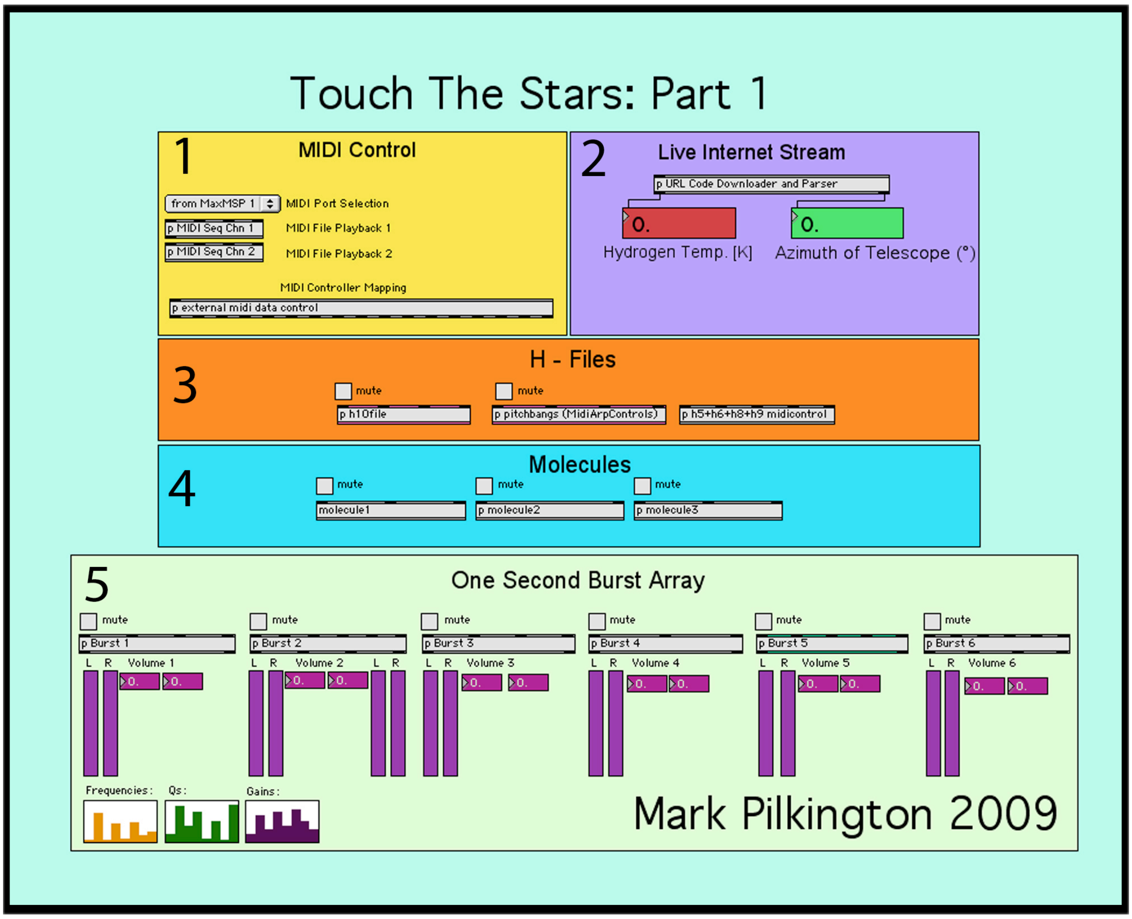

Figure 6: Screenshot of Max/MSP Performance Algorithm *Touch the Stars - Part 1*.

Description of the Modules (The patch is included on Data DVD 6)

MIDI Control (1)

Manages the communication of internal and external MIDI data. Two time-variable MIDI file players transmit a single MIDI file to trigger a Clavia Nord Lead 3 Advanced Subtractive Performance Synthesizer to produce additional electronic sounds. The front panel of the device also acts as a MIDI interface mapped to the internal sound parameters within the algorithm.

Live Internet Stream (2)

Manages the incoming data from the telescope. The astronomical data are uploaded at one-second intervals to a URL address. Once the URL is identified, a text input stream is activated and a text file is translated by the algorithm. The message is transformed into a matrix, which parses the data into a list of coordinates mapped onto internal signal processes.

H - Files (3)

Controls five sound files (ca. 10'00) generated in the studio using pre-existing astronomical data and performer interaction. Off-line editing was carried out using EQ and audio restoration techniques. The sound files comprise dense uniformed noise bands that temporally shift spectrally, intertwined with micro-pulses. The varying distribution of the pulses form signposts of sound that impose a temporal disturbance upon the surrounding sound material. These multiple percussive pulses shift temporally creating a polyrhythm across differing time scales. The harmonic clouds move between chaotic and simple repetitiveness. The performer has direct MIDI control over the playback speed, volume and parametric filtering of the sound files. The sound files are interpolated into the performance to match increases and decreases in the activity of the astronomical data received from the current position of the telescope. These large-scale sound masses become an additional layer that enhances the spatial presence, colour, balance, tension and release of the overall sonic image. The overall effect creates a sonic illusion of sounds emitted from a large industrial mechanical machine.

Molecule (4)

Consists of three modules containing a single sound source (1secburst.aif) transformed by dynamic signal processes that include vari-speed, multi-tap delays and comb filters.

One Second Burst Array (5)

Transforms a single sound source (1secburst.aif) by using several processes contained in the following six sub-modules:

Burst 1 - allows independent manual control of a bank of bandpass filter objects, MIDI controlled filters and volume. The internal dynamic signal adjusts volume and filters and hydrogen data adjust playback speed.

Burst 2 - Azimuth and MIDI data control the playback speed. MIDI and Hydrogen data adjust the buffer size. Internal dynamic signal controls the output signal degradation by sample-rate reduction and word size truncation.

Burst 3 - MIDI adjusts buffer size. Hydrogen data controls the playback speed. The internal signal dynamically adjusts delay times and frequency shift.

Burst 4 - consist of a single buffer controlled by MIDI to adjust buffer size, delay time and signal phase.

Burst 5 - MIDI adjusts the playback speed, buffer size and delay time of an overdriven signal.

Burst 6 - consists of a dual buffer set to play for 500 ms and 250 ms. MIDI adjusts speed control and buffer size.

The overall volume of each sub-module is independently scaled by the incoming hydrogen data.

Final Performance

The performance took place on the 13 May 2009 at the Contact Theatre before an audience of delegates and invited guests (a video of the performance is on Data DVD 7). The network performance balanced improvised and autonomous musical elements. At the same time, the trajectory of the telescope at Jodrell Bank was remotely controlled on stage by Dr. Tim O'Brien. As the telescope crossed the Milky Way, there was an increase in hydrogen temperature due to the abundance of distant stars. After the performance, the reactions of the audience were very positive and stimulated further debate about the project. Finally, I felt we had successfully managed to communicate a sense of the physical universe through the delivery of an aural translation of the radio universe.

Touch the Stars: Part 2 (2009)

Duration: 10'48

Format: Stereo Fixed Media.

After the realisation of *Touch the Stars - Part 1,* I felt the concept warranted further musical investigation and composed a fixed media version *Touch the Stars - Part 2* incorporating the generative processes from *Part 1*. This chapter discusses mapping, *spectral space*[23] and instrumental improvisation as musical processes, starting with the emergent properties of extra-musical events and gradually shifting towards a series of activities based on purely aesthetic musical choice. This transitional process represents a return to the formation of sonic properties based on the subjective state of the listener's perception. It is a move away from a complex or chaotic system to an application of fixed media musical processes.

The Concept

The concept was based on imagining different environments and physical elements, inspired by the signals of the radio universe travelling across space. Elemental forces such as gases, liquids and solids and transforming energy states became my imagined sound world, and the appliance of a scientific approach allowed for a more controlled relationship with the sound material directed by consciousness and intuition. The scientific approach also inspired me to obtain an understanding of the scientific theories, which led to new possibilities in the representation of the nature of things. A deeper understanding of scientific concepts came to inspire my music.

Inspiration also came from the music of spectralist composers, in particular Gérard Grisey *Partiels* (1975) and Tristan Murail *Désintégrations* (1982) and their analytical methods of spectral temporal development to achieve a sonic result. The Greek composer Panayiotis Kokoras's piece *Anechoic Pulse* for tape (2004), made from sounds recorded in an anechoic chamber and simple transformations expressing texture by uncovering their musical relationship to one another, also influenced the work.

[23] Smalley, Denis, 'Space-form and the acousmatic image', *Organised Sound*, xii (2007), 35-58 at 56. Spectral space is defined as an 'impression of space and spaciousness produce by the occupancy of motion within the range of audible frequencies'.

Sound Material

Touch The Stars - Part 2 used a far greater amount of sound material than the two sound fragments used in the generative processes of *Touch The Stars - Part 1*, including synthetic, environmental and instrumental recordings. This sheer diversity provided a rich plethora of sonic material, enabling the exploration of the musical concept. Listening to each sound element in isolation revealed its morphological structure prior to any form of musical transformation.

Musical Processes

The composition is built on a transition of musical processes that dynamically informed its structure. A process can be described as a way of 'reinventing a way of thinking and working between the interstices between the different concepts of the 'project', the 'material', 'science', and the creative act, all this without neglecting the artistic emotion borne of such a procedure.'[24]

Astronomical Scientific Data

The astronomical data gathered from the performance of *Touch the Stars: Part 1* was mapped to the frequency and amplitude of the harmonic series in C. Thirty four harmonic partials of the harmonic series were selected within a frequency range between 65.4Hz and 1569.7534Hz. Using additive synthesis, the frequency of each harmonic partial was allocated a simple sine wave oscillator. As the data was played back, it proportionally altered the frequency and amplitude of all thirty four oscillators producing an incremental layer of harmonic overtones. The temporal evolution of this harmonic mesh tracked the astronomical data collected from the performance for 10 minutes. This process continued by ascending through each step of the C harmonic scale until a number of tonal layers had been produced. The overall result formed a very gradual evolving dynamic sonic profile of varying spectral complexity. This slow evolution created a sense of 'stasis' and a music of slow transitions (for example, 0'43, 1'40 and 4'31).

[24] Ledoux, Claude and Fineberg, Joshua, 'From the Philosophical to the Practical: An Imaginary Proposition Concerning the Music of Tristan Murail', *Contemporary Music Review*, xix (2000), 41-65 at 46.

Spectral Space

Kinetic energy formations of unexpected events and gestural surprises dominate the foreground as they punctuate the underlying serenity in the work: a series of low impacts initiate a spectral transition of perceived pitch rising (for example, 5'38) and later descending (6'34). Percussive impacts are used as dramatic gestures and also mark the transitions of spectral space. At 6'02, the causality of shorter impacts spectrally expands the energy of differing sound materials.

The presence of chaotic masses of complex spectra disturb the stability of the more steady state sounds through consonance and dissonance (for example, 3'34). These types of transformations become more discursive through the distribution of intermittent particles and non-stationary noise bands. The unpredictable stability of this type of sound phenomena reflects the behaviour of certain sounds found in nature (for example, rocks and water).

Variations in the compression and expansion of spectral density create a sense of propulsion. At 1'52, the spectral energy of a chaotic sound mass dissipates in a vertical motion due to a decrease in its low frequency content. The energy also drives the distribution of the mass spatially across the stereo field. At 0'39, vertical short pulses create a sense of distance through a rapidity of movement and a decrease in volume.

The displacement of context or source-bonding of sounds is caused by the *mediation* and *juxtaposition*[25] of sound combinations through source-cause recognition. Rapidly changing the identity of sound material and gestural behaviour acts to add a sense of ambiguity until a point of musical embodiment takes place through a resolve of structural stability either by repetition or acquaintance (for example, 9'39).

---

[25] Young, John, 'The Extended Environment', *Proceedings of the International Computer Music Conference 1994*, (1994), 23-26 at 24. Two methods of articulating the reality-abstraction continuum.

Improvised Instrumental Gestures

Performing and recording instruments presented a potential diversion away from the mathematical process of complexity. This new discourse allowed an instrumental connection to be incorporated within the existing musical context. The instruments were performed by myself in unconventional ways using a method of free improvisation. Any transformations only occurred directly at the point of performance by using extended techniques to uncover the inner resonance of the instruments. An overblown toy kazoo acted as a resonating chamber of non-verbal and guttural expressions (for example, 8'32). Different explorations of the kazoo acted as short percussive stabs followed by a reverberant decay (7'18) and increasing overtones of a guttural cry that dissipated and reappeared as a vocalised drone (9'44). The strings and the body of a Fender precision bass guitar were struck, plucked and strummed at different intensities producing various sound elements (5'09, 7'04 and 7'32).

Various sections of *Touch the Stars - Part 2* were transformed using both analog and digital recording methods. An analog stereo cassette recorder was used to produce tape saturation techniques. During the recording stage, the input signal level was increased to such an extent so as to saturate the magnetic tape to cause tape compression. The overtly compressed signal was then played back through analog equalisation and recorded back into the computer. In contrast, SPEAR[26] (Fast Fourier Transformation) digitally analysed the inherent structure of the various sound files in order to restructure their partials and re-synthesise them into new forms.

Listening became a procedural event in imagining the types of sonic entities to populate certain scenarios. Concentrated listening formed a sensory awareness of eidetic images at particular points of the composition. This cognitive process of perceptual recognition acted as a point of mimetic reference in reaching a creative conclusion.

> ...musical listening allows one to link sensory apprehension to analysis of composition and execution, and by doing so, to justify the modulations of sensibility, from overall apprehension to the details of its moments or registers'[27]

[26] SPEAR is an open source software application for the audio analysis, editing and synthesis developed by Micheal Klingbeil.
[27] See Jean Luc Nancy, *Listening*, New York, 2007, 63.

Conclusion

Many musical processes were used throughout the composition of *Touch the Stars - Part 2*. The extremity of processes revealed new possibilities within my composition praxis. Exploration of spectral space, mapping and instrumental gestures offered an auditory experience grown out of thought and reflection. The musical discourse was to blend the complexity of emergent structures with compositional ideas based on spectral space to communicate dramatic elements that reflected a musical landscape born from the Milky Way galaxy.

Chapter 4: *Camera Down* (2010) and *Phone Camera* (2010)

***Camera Down* (2010)**
Duration: 13'18

***Phone Camera* (2010)**
Duration: 6'55

Format: Audio-Visual

Camera Down and *Phone Camera* are audio-visual compositions that explore ideas of visual music using abstract visuals set within the language of electroacoustic music.

> Visual music can be defined as time-based visual imagery that establishes a temporal architecture in a way similar to absolute music.[28]

The visual music phenomena required a cross-disciplinary approach through the technological and holistic convergence of sound and light. This chapter explains the methodologies linking abstracted visual images and electroacoustic music with reference to various techniques and theories.

Audio-visual Composition

Both compositions were modelled on the mimetic interaction of abstracted audio-visual media captured from the activities of human and natural phenomena within given environments.

> ...mimesis makes it possible to establish an abstract 'spatiality' as a coherent system that is partly artificial and partly real. Nature is imitated, for example, but only *seemingly* reproduced: what are produced are *signs* of nature or of the natural realm.[29]

The mimetic morphological characteristics of the audio-visual media imparted inter-relationships through *consonance* and *dissonance*[30] to create structural unity.

[28] Evans, 'Foundations of a Visual Music', 11.
[29] See Henri Lefebvre, *The Production of Space*, Oxford, 1991, 376.
[30] Alves, Bill, 'Consonance and Dissonance in Visual Music', *Organised Sound,* xvii (2012), 114 - 119 at 118. 'The principles of consonance and dissonance, broadly understood to encompass concepts of stability and instability or tension and resolution, provide a structural model for the art of visual music'.

Phonography and Photography

Phonography and photography are processes that share the same ideology of spatial 'discovery' through the capturing of activities within given environments. Phonography can be described as a constructed continuum in which material properties initiate mimetic discourse. [31] Its artistic development is analogous to that of photography, in that the image can be representational or abstracted. It is 'distinct from recording in general only to the extent that the capture of sound is privileged over its production. This bias reflects an attempt to discover rather than invent'.[32] In *Camera Down*, phonography is used to capture sound events whilst walking along a country valley (for example, 2'02, 2'13, 5'36, 6'04 and 6'14). In *Phone Camera*, shorter sonic events are offered in the form of reverberant impacts and metallic scrapes (for example, 0'33, 0'47, 1'11 and 1'24). Photographic images were used in *Camera Down* and *Phone Camera.* In *Phone Camera,* an aesthetic choice was made to capture all of the photographic and video material on a low fidelity mobile phone camera. Due to a deficiency in the lens, the device added digital artefacts to the images. This textural transformation was retained and became an inherent part of many of the still and moving images. *Camera Down* uses a single photographic image of an air-shaft taken from within the Mersey Tunnel in Liverpool (for example, 0'00 – 2'15). All the raw audio-visual material provided intrinsic and extrinsic characteristics that enabled me to remodel their structural behaviours based on sound-image relationships. [33]

Virtual Landscapes

My interest in combining audio-visual media gathered from unrelated environments into a single compositional entity is demonstrated in both *Camera Down* and *Phone Camera.* Using a camera and sound recording equipment, I captured first-order audio-visual material over various time frames from a number of rural, urban and studio environments. The interaction of these audio-visual events had a direct and profound impact upon the overall structure of the composition. The morphological transformation of the recording stage continued in the studio using various transformation processes. It was at this point that the identifiable behaviour of 'reality' was further abstracted through transformation into 'virtual' audio-visual units. These units provided multi-sensory extrapolations of sound-image relationships mapped to spatial

---

[31] Fischman, Rajmil, 'Mimetic Space: a conceptual framework for the discussion, analysis and creation of mimetic discourse and structure*', EMS: Electroacoustic Music Studies Network*, De Montfort/Leicester, (2007), 1-9 at 3.
[32] Dumiel, Y. aka Sterling, I., 'What is Phonography?', *Phonography*, 2007 (Accessed 13 October, 2012), < http://www.phonography.org/whatis.htm>.
[33] Barreiro, Daniel L., 'Sonic Image and Acousmatic Listening'*, Organised Sound*, xv (2010), 35-42 at 5. 'The intrinsic aspects are related to the inner characteristics of the sound...dependent on the identification of the sources. The extrinsic aspects...are the connotations, meanings and references that lay outside the sounds themselves...human experience...domains other than the sonic'.

transitions within imaginary 'virtual' landscapes.[34] Described in detail are two examples of virtual landscapes within *Camera Down* (6'01 - 8'10) and *Phone Camera* (2'18 – 2'37).

Camera Down

The original visual material was made by pointing a video camera directly into sunlight. The intensity of light caused refracted abnormalities to appear in the lens and also through a piece of broken glass. The light is split into its spectrum by multiple reflective surfaces contained within the glass. This simple optical process of abstracting light patterns through the lens often appears in my work (such as in *Points and Lines*). In Eisenstein's 1929 article, *The Fourth Dimension in Film,* 'he compares the play of overtones and how they change timbre in music and sound with the way different lenses distort space'.[35] The speed of my film was slowed down to comprehend the motion of the transforming light patterns. The audio part of this section was made by re-modelling various sound events recorded from a rural setting at Dunsop Bridge (Lancashire UK). One interesting and surprising sonic event was the occurrence of gunshots within the peaceful serenity of the country valley. The source of the sound at first was made unrecognisable due to the natural sound transformation of the valley walls. The inability to identity the source of a sound in any given environment is a fascinating experience and had a profound affect on constructing audio-visual relationships. This is highlighted by the process of *offscreen sound* produced by visual exclusion of a sound's source, causing the sound to be projected 'out of sight' beyond the periphery of the screen. [36] A similar experience occurs in *acousmatic listening*[37], only in this case the audio-visual contract is upheld.

The use of asynchronous sound also displaces symbolical significance between the audio-visual activities. The viewer is left to construct their own meaning in the identification and significance of cultural objects within a particular scene. The sound 'imposes a meaning on the visual as a consequence of divergence between both dimensions'.[38] An example of asynchronous sound can be found in the work of Austrian experimental film-maker Peter Kubelka's *Unsere Afrikareise* (1966), a documentary that merged rhythmically and thematically images with sounds derived from elsewhere.

---

[34] Kröpfl, Francisco, 'Integrating sound and visual image as artform' in: Françoise Barrière and Christian Clozier,eds., *'Relationships between audition and vision in the creation of electroacoustic music'. Acts IIIV (2004/2005),* iii (2007), 89-90 at 89. The 'virtuality' is imposed as 'sound matter develops in 'real' space' image so far is projected on a bi-dimensional surface; in a 'virtual' space'.

[35] See Robert Peterson, *Eisenstein on the Audiovisual: The Integration of Music, Image and Sound in Cinema,* London, 2001, 157.

[36] See Michel Chion, *Audiovision: Sound on Screen,* New York, 1994, 40.

[37] Ibid. 32. 'a situation wherein one hears a sound without seeing its cause'.

[38] Kröpfl, 'Integrating sound and visual image as Artform', 89.

Phone Camera

A 'virtual' landscape was formed in *Phone Camera* by technological interruption across audio-visual media. The visual material consisted of the light patterns of passing motorway traffic captured on a low-fidelity phone camera. The visual restriction of the device meant that digital artefacts transformed the structural characteristics of the intended image. The capacity for technology to introduce 'noise' into both auditory and visual media was explored to varying degrees throughout *Phone Camera*. These extremities formed a coherent bond through the identity of technological transmission. The process of stop-motion animation forms a superimposition of horizontal and vertical variations of the film footage synchronised to the auditory energy of electronically produced pulses or 'glitches'. The interruption of the 'glitch' can be considered an audio-visual phenomenon as it occurs simultaneously across both screen and speaker technologies. Its instantaneous motion caused a spatial disruption in the source-cause reception of the audio-visual media. The activities contained within this technological landscape give the impression of mediatic space.[39]

Conclusion

In *Camera Down* and *Phone Camera*, the viewer is offered a dynamic 'roller coaster' ride through a series of virtual landscapes of sound and light patterns constructed from 'concrete' and 'abstracted' events. Both of the pieces offer contrasting structural relationships that navigate through the audio-visual domain within 'virtual' landscapes. The examples mentioned are linked through the heterogeneous behaviour and the identity of the technological interruption of audio-visual media.

[39] Smalley, 'Space-form and the acousmatic image’, 39. A term that implies the auditory technological transmission and communication of mass media.

Chapter 5: *Peterloo* (2011)

Duration: 11'58

Format: 5.1 Fixed Media.

The artistic aim of *Peterloo* was to explore the idea of 'narrative' in electroacoustic music, based on the historical events of 'The Peterloo Massacre', which occurred in Manchester, England on 16 August, 1819. A peaceful gathering of 60,000 people arrived to discuss social reform. What transpired was a miscommunication between the attending public and the local authority, in which 15 people lost their lives and 300 people were left injured. This chapter discusses the main compositional strategies applied, outlining the reasons for the choice of particular sounds, the treatments applied, the structural processes and the formal framework. Location recording, sound materials and structural design will be detailed. Their relationship to the nature of the work's construction, the resulting outcomes and existing theories in the electroacoustic tradition will then be discussed.

Peterloo is a sonic construction using opposing sound materials to illustrate differing political opinions of those present on the day of the event. The conceptual idea was a rich source of inspiration, stimulating eidetic sonic images (denoting mental images) that informed the compositional process. The reconstruction of an imaginable landscape is a recurring theme that runs throughout my work. The many dramatic emotional scenarios created consider the listener's position, reception and inclusion as if he/she were an eye-witness on the day of the event.

The musical language of the work offers a rereading of the relationship between sound and its discourses, set within a historical narrative in order to rupture the illusion of representation through the blurring of the boundary that usually separates the listener from the true historical message. The piece attempts to recreate the sound world of Manchester in 1819 using contemporary urban and rural sound objects formulating an aural acousmatic scene in which the drama ensues.

Sound Materials

Before the actual recording and production of the sounds took place I researched the history of the event in order to formulate imaginary sound-types. After reading Henry Hunt's[40] 1822 autobiographical account of Peterloo, an imaginary sound-world and its cultural objects began to form in my mind. This information helped to determine the types of locations and recorded sounds necessary to construct the scene. Setting out a typology of sounds (Figure 7) based on the criteria of specific acoustic properties culminated in 'structured sound' that then informed the overall 'sound structure'. Structure acts as a dialectical object of perception altering the meaning of individual sounding elements through an accumulation of their physical properties reconfigured within a wider setting. Their affinities and the various roles they played within a context or hierarchy formed a major part of the compositional strategy. This imaginary framework implied location, source and function and these in turn required single and multiple sound-types. As the sound material expanded in scope during the construction of the composition, these three aspects continued to have important roles in informing the direction of the larger sections of music.

[40] Hunt (1822) political reformist autobiographic account of Peterloo. <http://www.gutenberg.org/dirs/etext05/8hnt310.txt>

Typology of Sounds for *Peterloo*.

Location: Manchester City Centre 'Student Protest'.

Voices:
Chanting of 'Let Them Go, Let Them Go...' are combined with crowd cheers (4'52).
Spoken words and utterances formed a composite of despondent jeering (6'06).
Spoken words 'Get the horses off the pavement!' (9'44).
Shout 'Get off me, help...!' (7'01).
Singing of the 'Hokey Cokey' (2'03).
Cheering crowd formed a complex mass across entire spectral field (4'04).

Animals:
Horse hooves produced percussive clatter (6'30).

Materials:
Rapid iterations of hi-frequency formed short metallic pulses (8'22 and 8'32).

Location: Macclesfield Forest, Cheshire.

Voices:
Cry (6'49).
Prolonged animalistic yell (9'52).

Animals:
Goose squawk (1'00).
Bird calls (9'49).

Materials:
A swinging metallic gate produced an intervallic pitched motif (1'46).
The decaying resonance of metallic strikes (5'22).
A wooden coffee grinder produced textural pitch fluctuations (1'22, 8'11 and 9'11).
Falling wooden log crashed through undergrowth (9'42).
Footsteps traversed the forest floor (2'12).

Synthetic:

Voices:
Granualted voices (0'09).
Prolonged sustained texture resembled the sound of a large crowd of people (0'46).
Prolonged sustained harmonic texture produced an artificial choral sound (10'06).
An inharmonic texture resembled a large vocal mass (7'15).

Animals:
Hi-frequency imitation bird chirps (3'15).
Distance dog yelp (6'49).
Eerie phantom voices (7'45).

Materials:
Homogenous white noise produced short wave radio static (8'45).
Filtered percussive noise burst (6'45).
Mechanical metallic hi-frequency impulses (0'14).
Thin metallic iterative pulses decelerated due to an increase in duration (1'37).

Figure 7: Typology of Sounds for *Peterloo*.

Location Recording

The recording process took place in three very contrasting settings: student protests (Manchester City Centre), an evening recording session in Macclesfield Forest (Cheshire) and at the site of Peterloo (Manchester). Placing myself in the landscape revealed to me the sonic characteristics within each particular soundscape, a phonographic experience that provided contextual knowledge beyond the limits of the sound material. [41]

> The artist works with the understanding that aesthetic values will emerge from the recorded soundscape or from some of its elements.[42]

The attraction of working with a soundscape is that it provides an acoustic manifestation of a place identified through the causality of all natural and unnatural sounds. The interaction of the sounds creates temporal structural forms consisting of articulations and happenings that are then studied and applied throughout the composition. The soundscape contains many spatial parameters, offering a 'holistic space comprised of an array of zoned spaces.'[43] Our relationship to the sonic environment is a familiar part of our everyday life: the sounds we hear are the reflections of our surroundings.

As well as the passive engagement of recording the soundscape, performing within the sonic environment became an active recording experience through physically transforming found sounds: recording the impacts of logs falling on different surfaces, walking through the thick undergrowth of the forest floor, footsteps stamping on gravel, shouting into a distant valley created echoes that articulate space. This active process conveyed a shared cohesion of engaging with the sonic consciousness of listening, forming an ontological experience.

The SoundField ST 350 microphone and the Edirol R-44 portable recorder allowed Ambisonic recordings to be made at each location. The Ambisonic recording method was used to capture both the spatial and acoustic properties of a recorded sound for playback across a multi-speaker system (5.1). Ambisonics is a technique originally developed by Michael Gerzon in the early 1970's for reproducing three-dimensional sound images. It provides a way to encode recordings into three-dimensional soundfields. These encoded soundfields can then be reproduced over various speaker arrangements.[44]

---

[41] Landy, *Understanding The Art Of Sound Organization*, 106. A 'soundscape' is an environment of sound (or sonic environment) with an emphasis on the way it is perceived and understood by the individual, or by a society'.

[42] Westerkamp, Hildegard, 'Linking Soundscape Composition and Acoustic Ecology', *Organised Sound*, vii (2002), 51-56 at 54.

[43] Smalley, 'Space-form and the acousmatic image', 37. 'The behaviour of the sounding identities of the zones accords with the gestalt grouping principles of similarity, proximity in space and/or time, continuity, organisation, context, belongingness, and common fate'.

[44] In the case of *Peterloo* the original B-format recordings were decoded using the G-Format into 5.1 surround format. The decision to use 5.1 surround reflects the industry standard for 'surround' and set a

In future, re-encoding the 5.1 surround format back into the Ambisonic B-format for soundfield diffusion may improve the listeners experience and therefore their involvement with the music.

The material captured from each location revealed many structural details that became key musical features. An old fashioned wooden coffee grinder provided the source of many pitch-based textures. The grinding friction of metal against wood inspired a historical visualisation of a squeaking wooden wheel attached to a horse and cart (for example, 1'24). Further articulations were combined with other sounds into accumulations prior to a large impact (5'05) and merged within the decay of a synthetic sound (8'10). The sound of voices, consisting of conversations (for example, 5'31), cheering (4'03) and chanting (4'51), provided linguistic ambiguities that punctuated the structural development.

Synthetic Sounds

Sound synthesis techniques were used to generate purely electronic sounds. The interaction of real-time digital synthesisers, such as the Clavia Nord Lead 3 and Max/MSP, created endless possible sound structures designed to imitate the characteristics of naturally occurring sounds. The ability to control many sound parameters at once enabled the formation of countless complex synthetic sound configurations. When combined with naturally recorded sounds, these created ambiguity by altering the source-cause identity. The resulting abstractions contained many imposed and intrinsic morphologies that shifted perceptual awareness. For example, at 7'33, the close proximity of synthetic micro-sound pulses coalesce, imitate and blur the source of a creaking wooden coffee grinder contained within a micromontage.[45] From 4'59 until 5'07 the spatial frame is interrupted by the onset of synthetic micro pulses that are filtered before decaying into an accumulation of varying sound particles. The rapidity of their appearance added a dramatic tension by altering the fabric of reality. The addition of synthetic sounds in *Peterloo* became a prominent means to destabilise material identity which directly affected the signification of meaning.

challenge, as this was my first time working with this particular medium.

[45] Roads, *Microsounds,*183. 'Micromontage extracts particles from sound files and re-arranges them. A composer can position each particle precisely in time'.

Voices

The sounds of the human voice played an important role throughout the piece. Multiple and single voices formed expressions of words and utterances beyond the realm of recognisable language. Textural connotations were formed from familiar expressions: gasps, wails, guttural sounds and cries. These abstracted utterances were aligned and embedded with differing sound-types, forming textures that suggested increases and decreases of human physical exertions, evident at 5'55, 6'46 and 6'56. The student protest recordings contained many types of emotive voices: dramatic, discrete, murmurs, spoken words and chanting. Observing the way the voices interacted within the social fabric of the protest revealed many contradictory factors in how the spoken word responds to actual 'real world' occurrences. This ambiguity of meaning was evident in many of the words spoken by people within the vicinity of the protest. Phrases such as “Get the horses off the pavement!” (for example, 9'44) and “Get off me. Help!” (7'01) lose their original meaning once set within the contextual framework of the composition. Listening to the interaction of passing conversations was inspirational: the way in which the original message was continuously transformed by an interference of mobility affected both transmission and reception. The spoken instructions “Tell you what. You come into here” (5'31), “Everybody keep moving up please” (5'43) and “No worries pal” (5'45) formed literal narratives that contrasted well with the abstract sound-shapes.

To create the sense of a large crowd of people, estimated to number between 60,000 and 80,000, a base layer of pre-edited voice-based material was granulated into short grains. These were set at intervals, just at the point of perceivable recognition (ca. 100ms) to retain the resemblance of human voices. The original meaning of phrases is obscured by the random temporal distribution of each sound particle, but the overall result still contains a resemblance of the human voice. The result appears at 0'35 and 1'10 and consists of layers of a hierarchical variation of the same material over multiple time scales. The variations of the time scales reflect the distribution and behaviour of voices heard within a large crowd of people.

Synthetically created forms of vocal resemblances were used to highlight and support surrounding audio material. At 0'44, a synthetic drone was time stretched and filtered to resemble the roaring cheer of a large crowd. This acted to 'ground' sporadic vocal mutterings and an extended brass-like sound. At 4'52, a prolonged sound, reminiscent of a crowd of children, underlines the chanting of “Let them go!”. Produced by subtractive synthesis of pitched waveforms modulated by white noise (where all frequencies are represented with equal energy), this adds a texture of friction. The overall sound was then filtered to narrow the frequency spectrum so as to create spatial distance. The sustained and reduced dynamic contour produced an unobtrusive pedal-like texture, underpinning the chant without interfering with its dramatic content.

Attraction and Repulsion

Exploring the dynamic tension between the repulsion and attraction of sound combinations was a prime process in the work's structural design. The act of positioning opposing sounds against one another formed unique perceptual units; their oppositional relationship often made connections engendering their own meanings. The superposition of contrasting sound materials metaphorically draws on the dualism of opposing opinions that arose on the day of the event, exemplified from 4'34 onwards in the representation of the 'massacre'.

> When these sound-masses collide the phenomena of penetration or repulsion will seem to occur. Certain transmutations taking place on certain planes will seem to be projected onto other planes, moving at different speeds and at different angles.[46]

The interactions of disparate materials are mapped onto a temporal framework of comprehension, complementation and attainment creating a heuristic listening experience. The redistribution of the many sound fragments produce an alternative physicality, reducing the listener's ability to interpret the origin of the source material. From 5'06 until 5'14 turbulent sound fragments drastically alter the sonic perception of the listener. The short fragments produce a subliminal mimetic recollection in which we only hear the essences of the original sound rapidly dispersed through time. An angry shout of a female voice (5'06) is seemingly swept away under a twisted barrage of materials, simulating the chaos and confusion of an attack. At 6'56, a protester's vocal statement is abruptly interrupted by loud filtered white noise, depriving us of any expected conclusion to his exclamation. From 6'12 until 6'23, vocal instructions are shouted directly at the crowd by police officers in order to disperse them. The instruction, “Fellows get moving!”, is followed by the energetic burst of a descending synthetic sound mass sweeping down through the frequency range before dissipating into a textural cloud of asynchronous sound particles. The high speed dynamic profile and extreme contrast of materials including wood and metal and a brass trumpet extends the sound into a psychological sonic expression beyond the comprehension of reality. As it recedes, we are left with the debris of confusion resounding in the panic of distance voices. Using disparate sound characteristics to directly alter the perceptual translation of the events is intended to provoke a dynamic reaction.

[46] Varèse, Edgard and Wen-chung, Chou, 'The Liberation of Sound', *Perspectives of New Music*, v (1966),11-19 at 11.

Space

> Space is not the setting (real or logical) in which things are arranged, but the means whereby the position of things becomes possible.[47]

Spatial concepts in *Peterloo* utilise the sound and directional phenomenon of a 5.1 multi-loudspeaker system to convey a coherent spatial experience, physically and metaphorically relating to a given environment. Many of the composed spaces are formed by changing sound materials to produce transitions of spatial awareness maintained upon the landscape. Sound carries information about space, place and location; these parameters form a sound-image elucidating the relation between subject and object. When one of the parameters is displaced, we are acquainted with the experience of space. *Peterloo* continuously moves between many spatial planes informed by the way changes occur in the sonic content within a particular imaginary landscape. These spontaneous spatial transitions are described by Smalley as 'transmodal linking'[48] and are applied in *Peterloo* to form part of its narrative structure.

A prolonged transition takes place between 2'52 - 3'50, linking a scene of intense activity to a calmer inner space of contemplation and reflection. This is achieved by the introduction of new sound material formed into a series of mechanical iterations that spatially reposition themselves over time. Wooden sound-types and hi-frequency electronic tones combine to form a mesh of pulsing synchronous sound grains in a *proximate*[49] spatial plane. The mesh is distributed within the 5.1 spatial image. A brass timbre creates a series of overtly sustained, soft and undulating pitched notes in the key of B-flat major, set at a distance from the listener's vantage point (a *distal plane*).[50] The re-introduction at 3'10 of a previously heard vocal chant is also set at a distance within the spatial frame and invokes a reflection of a passing memory. At the end of the passage, another spatial transition occurs, initiated by the extended duration of a low frequency bass pulse (for example, 3'07) revealing its source as a car engine (3'45). This then rises in pitch before cross-fading into a short abstract synthetic drone that resembles the cheering of a large crowd before finally moving into the space of a constructed concert hall (3'51).

[47] See Maurice Merleau-Ponty, *The Phenomenology of Perception,* London, 1994, 284.
[48] Smalley, 'Space-form and the acousmatic image', 39. 'Transmodal linking' occurs when we are aware of a sensory spatial transition.
[49] Ibid. 56. The area of perspectival closes to the listener's vantage point in a particular listening context.
[50] Ibid. 55. An area of perspectival space farthest away from the listener's vantage point.

Structural Design

1. Narrative

Peterloo forms a critical account of social reformation set between the changing ideals of historical and modern political protests. The composition is based on the formation of opposites in diverse sounding media to achieve a recreation of the event. The piece is divided into two main chronological sections: St. Peters Field and the Massacre. Set within these are smaller sub-sections assigned to highlight the narrative drama.

St. Peters Field (0'00 - 4'35) - represents the gathering of people set within a joyful celebration. They are laughing, talking and singing. The sound of a marching brass band leads the procession of people towards St. Peters Field. The description of the event was mentioned in Henry Hunt's historical account at the time, prior and during the massacre.

St. Peters Field sub-section (2'03 - 2'52) - a recording made of people singing the traditional song, the *hokey cokey,* at the student protest is marked by optimistic conversations and joyful laughter.

The Massacre (4'35 - 11'45) - represents the point at which the attack takes place, a melee of confusion. It consists of people shouting, screaming and crying and is set within a dramatic chaotic sound world.

The Massacre sub-section (9'52 - 11'45) - the drama abates to form a point of contemplation, evident in the contrasting stasis of materials.

These imagined zones of activity act in a similar way to screenplays in the construction of mixed media within cinematography. The acoustic design of each soundscape contains many sonic narratives which acted as starting points for the construction of sonic transformations. The interaction of the mapped sound combinations form the dramaturgy within a narrative framework combining movement, expression and dialogue within the acousmatic frame.

2. Material Development

The ability to manipulate the nature of a given sound using a variety of sonic transformations was a core element in the work's construction. The choice of a particular transformation process was often dependent on the suitability of material type to perceptual and imagined space. Real-time software-based transformations allowed me to improvise directly to change the behaviour of the sound. The attraction of working in such away is that it instantaneously stimulates an imaginative response through the interaction of specific parameters. A particular example of this was the use of a custom built interactive Max/MSP patch programmed to control multiple functions of both vari-speed to tune the sound and filtering to shape the frequency content. At the same time, during this particular process, a contrasting sound was simultaneously played back from a DAW creating a perceptual correspondence that influenced the direction of the transformation process. The resulting sound often had no reference to its original source, but shared a spectral bond to that of the playback sound. Further editing was carried out to position the new sound in relation to existing audio content. This method of a *bottom-up*[51] compositional approach is based on developing an accumulation of materials to form the foundations of a larger musical structure. Sound materials containing the presence of the human voice were often used to provide an interjection of emotional content. At 5'38 dramatic voices recorded from a football match were edited into short utterances. Their dynamic profiles provided sonic information in order to shape the content of more prolonged abstract materials. This contrast was intended to form a maelstrom of confusion for the listener. These emotional exclamations were chosen to represent the types of verbal reactions between the soldiers and the crowd during the massacre.

3. Spatial Contrasts

The employment of the 5.1-channel format allowed for the composed movement of sound within a spatial field. The control of spatial dimensions introduced new behavioural tendencies in the sound material. The ability to move sounds across space created an illusion of the reality of enhancing the physicality of the space into which the sounds were projected. Various methods of spatial contrast were employed throughout *Peterloo* to create spatially dramatic effects. A mirroring of reflections recreates the physical sensation of sound reflecting from different surfaces within a particular environment (achieved by delay, pitch shifting and spatial repositioning of the event). This occurs at 5'36 as the replication of a sounding event is transformed as well as spatially moving around the centralised vocal instruction of "...guys keep moving". The active grouping of materials allows the listener to comprehend certain activities fixed at one specific location. This was achieved by setting a sound event at a spatial distance and projecting the result from only one loudspeaker in the array. At 4'40, the sounds of mumbling voices are localised spatially in a similar way. The apparent motion of moving into the distance is achieved by simultaneously reducing the spectral content through filtering and volume control.

[51] See Landy, *Understanding The Art Of Sound Organization*, 34. As opposed to the traditional *top-down* approach of formulating a musical structure.

Conclusion

Peterloo amalgamated dramatic intrinsic and disparate sonic elements gathered from differing geographical locations to represent the historical events that took place at the time of the *Peterloo Massacre* in Manchester. The work also investigated ideas of narrative discourse and space-form within a 5.1 multi-channel electroacoustic composition.

Chapter 6: *Birth* (2011)

Duration: 10'22

Format: Audio-visual.

Birth was the final audio-visual work created for my portfolio. The piece expanded my theoretical and practice-led research into audio-visual compositional procedures previously developed in *Points and Lines*, *Camera Down* and *Phone Camera*. The concept of *Birth* was to produce a purely kinaesthetic[52] audio-visual experience combining computer generated geometrical forms and electroacoustic music in a multi-sensory experience that investigated abstract morphologies through an integration of audio-visual media. This chapter outlines the shared similarities of movement, identity and space of audio and visual media. These were used as the basis for the creation of visual music by applying interdisciplinary methodologies to establish morphological behaviours across audio-visual events.

Birth was inspired by the work of the early avant-garde kinectic film makers that linked music and pictorial harmony (for example, Oskar Fischinger's *Motion Painting* (1947), Viking Eggeling's *Diagonal Symphony* (1925) and Hans Richter's *Rhythmus 21* (1921)). I was also influenced by the unique animation style of Yoshinira Kanada in *Birth* (1984) and *Nausicaä of the Valley of the Wind* (1984). These films featured inventive perspectives, variation of key-frame rate, impressive fire and lighting techniques.

The Transitional Identity of Sound Materials

The first part of the composition to be completed was the electroacoustic music. This was realized by first making recordings of the activities of diverse objects and inhabitants within different geographical locations. Using a portable field recording device (Zoom H4) gave me the ability to record in remote locations and also impart movement around static sound sources. The field recordings provided sounds with identifiable source-cause relationships. Examples of these *first-order surrogacies*[53] occur throughout the piece: rocks falling down into a dry river bed 'barranco' in Tenerife, Spain (for example, 2'14, 2'36 and 2'40), vocal exclamations and shouts (2'04, 2'17) and handclaps in a reverberant underground car park (5'36, 6'28 and 6'37), verbal mutterings and unidentifiable conversations (2'22, 3'57 and 6'23), caged parrots and exotic birds calls in Tenerife, Spain (2'12, 2'19, 4'36 and 8'15) and inner-city traffic noise within the city of Manchester (9'32).

[52] See Gene Youngblood, *Expanded Cinema,* New York, 1970, 97. In an audio-visual sense, 'the manner of experiencing a thing through the forces and energies associated with its motion'.

[53] Smalley, 'Spectromorphology: explaining sound-shapes', 112. The primal level of source-cause relationships of a recorded sound, in which gesture is identifiable and human intervention is evident.

Musical direction was informed by the perceptual distance of spectral content of recorded sound from its original trace through a discourse of timbre evolution, between what Smalley describes as *transformational* and *typological* discourses based on the perceptual difference of a sound's identity through transformation.[54] Throughout the composition, it was important to maintain careful cohesion between the stability and variability of sound identities. In contrast, the non-identity of purely synthetic sounds was exploited spectrally to bind and extend morphological characteristics. The manipulability of the material meant it could be sculpted to imitate the behaviours characteristic of other sounds.[55]

A variety of transformation processes further interpolated the sonic identities of the two contrasting material types (recorded and synthetic) into larger scale abstracted structural elements. Finally, the completed audio part provided a platform to activate further points of signification through the application of visual media.

Visual Typologies

An aesthetic decision was made to use a restrictive palette of visual media based on the abstraction of geometrical form. To envisage a virtual world devoid of any visual cultural reference would stand in stark contrast to the identifiable source-cause relationships of the audio. Removal of the visual narrative allowed me to focus attention on the possibilities of perception of motion within space, motion that was achieved by generative and traditional stop-motion animation processes. The computer enabled me to work directly at the geometrical level of generative graphics, a way of converging the worlds of science and the arts.

Two visual programs *Planes and Lines* and *Ico* were coded using Processing.[56] *Planes and Lines* produced simple 3-dimensional geometric shapes such as cubes, planes and triangles that rotated around a fixed axis (Figure 8). They first appear at 0'08 and continue to play a prominent role throughout the piece.

[54] Smalley, Denis, 'Defining timbre - Refining timbre', *Contemporary Music Review*, x (1994), 35-48 at 43-44. '*Transformational* 'were the original source-cause of a sound is still identifiable after transformation and '*Typological'* were sounds share similar identities but are not regarded as being direct descendants of the same identity'.

[55] See Andrew Birtwhistle, *Cinesonica,* Manchester and New York, 2010, 150. 'The very-newness and non-identity of synthetic sound - sourceless, playerless, timeless, placeless, unrecorded - present a problem of categorization and conceptualization in relation to existing cultural codes and structures, and it is this that brings strange sounds within the field of noise'.

[56] Processing is an open source software programming language and environment. Available at <http://processing.org/>.

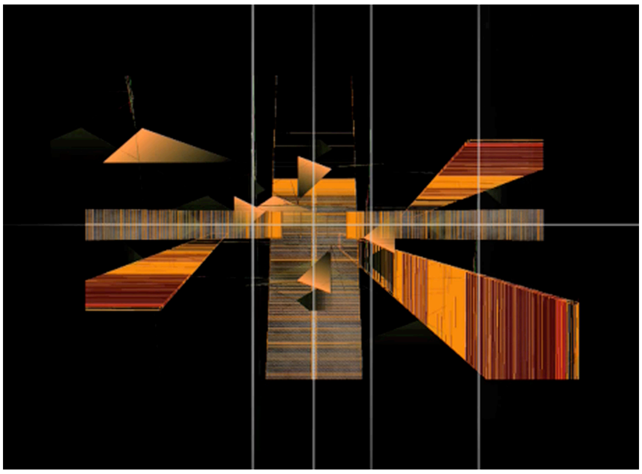

Figure 8: Snapshot of *Planes and Lines*.

The *Ico* program visually plotted the rotating trajectory of an icosahedron (Figure 9), a regular polyhedron composed of twenty equilateral triangles. It is one of the five platonic solids found in natural organisms and the architecture of geodesic domes. Its resourceful structure can be repeatedly used in a modular way to form larger visual morphological structures. Its naturalistic shape contrasts with the rigidity of the simple geometric structures of *Planes and Lines*. At 3'18, it can be clearly seen in the background as a spiralling and dissolving spherical form and, at 3'36, it gives the impression of a solid oval object floating above the perspectival shapes of *Planes and Lines*. As the properties of the visual forms merge they create a perceptual sense of tension and release.

Figure 9: Snapshot of *Ico*.

Generative Motion

The design of the visual algorithms, *Planes and Lines* and *Ico*, allowed me to create emerging generative visual forms with the ability to have meticulous control over pixel positioning of the graphical data. Similar processes were originally carried out by the early computer and synthesis pioneer, John Whitney, who interconnected visuals and music using computer algorithms. Whitney described a process of 'differential dynamics' in which motion is created through algorithmic design exploiting the harmonic distribution of light.[57] It is interesting to point out that there has since been no change in the actual geometry of such processes. The only significant difference involves improvements in computational speed and screen resolution. Understanding the symbolic syntax of the computer code allowed me to exploit the geometry of three-dimensional light forms. The formation of these complex entities involved a process of finding a balance between theoretical and empirical experimentation. The program required a simple text instruction that initiated a complex visual form in motion. The process had affinities with certain algorithmic processes used in electroacoustic music. *Ico* and *Planes and Lines* were rendered into short video clips in preparation for the final process of stop-motion editing in the video editing software.

Stop-motion Animation

Stop-motion animation allowed me to re-examine and modify the computer graphics at frame level. Each individual frame was edited and animated into linear sequences of coherent moving images contained within the audio-visual field. This process was repeated until all of the visual material formed a shared correspondence with the properties of the sound material.

[57] Whitney, John, 'To Paint on Water: The Audiovisual Duet of Complementarity', *Computer Music Journal*, xviii (1994), 45-52 at 47. The process of 'differential dynamics' is described as a 'family of algorithms that activated each point of a cluster differentially. The plasma-like liquidity of such motions permits aggregate architectonic structures to match musical actions'.

Audio-Visual Assemblage

The audio-visual assemblage in the work is based on the formulation of sound-image relationships using dyadic construction of binary sub-sets. The cross-modality of each sub-set exposed the interrelationships of structural form through a symbiotic counterpoint contained within an audio-visual contract.[58] Once both mediums existed in the same environment as a single dimension, new audio-visual structural relationships could be explored. The video editing software Final Cut Pro enabled me to select, view and animate the visual materials alongside the audio. Rather than mapping each visual parameter to follow a specific musical parameter, the overall audio-visual form became a 'complimentary'[59] structure designed through intuition and feeling. Finally, I aimed to express ideas of harmony and concord as a 'concealed construction'[60] within the overall structural framework.

Transmodal Correspondence

The linking of audio and visual material in *Birth* revealed a series of transmodal perceptual correspondences. This became apparent through 'motion' within the spatio-temporal and gestural evolution of the audio-visual material.

Spatial localisation was used to position the audio-visual sources in space. Pairing visual entities with particular sounds enabled the source to be localised within and beyond the boundaries of the frame. This also led to a re-embodiment of gesture contained across cross-modal spatial properties of the audio-visual object (for example, 1'57, 2'13 and 2'29).

Interaction and synchrony assisted in balancing the structural design of *Birth*. The use of synchronism created moments of convergence or 'hit points', described by Chion as *synchresis*[61] (for example, 1'06, 1'17 and 7'06). In contrast, moments of asynchronous correspondence promoted a sense of heterogeneity when the sound was not tied to the image (for example, 1'25, 5'00 and 6'45).

---

58 Chion, *Audiovision: Sound on Screen,* 222. 'The audiovisual relationship is not natural but rather a sort of symbolic pact to which the audio-spectator agrees when he or she considers the elements of sound and image to be participating in one and the same entity or world'.
59 Whitney, 'To Paint on Water: The Audiovisual Duet of Complementarity', 46. A process described by Whitney, of encouraging harmony through associated relationships of the audio-visual.
60 See Wassily Kandinsky, *Concerning the Spiritual in Art,* New York, 1977, 52. A term used by Kandinsky to describe the internal harmony of haphazard forms on canvas.
61 Chion, *Audiovision: Sound on Screen,* 224. The psychological phenomenon that enables 'the forging of an immediate and necessary relationship between something one sees and something one hears at the same time (from *synchronism* and *synthesis)'*.

Throughout *Birth,* identifiable 'scenes' marked by changes in apparent movement of accumulations of audio-visual materials. These were made possible by morphological transformations in both horizontal and vertical dimensions. Identifying the onset and termination of these audio-visual 'scenes' enabled me to populate the frame by establishing congruence between structural similarities of abstracted audio-visual material. For example, at 1'12, a scene is marked by a sudden 'cut' that introduces a new audio-visual entity. This synchronised movement combines both the audio and visual material into a new spatial position before being transformed once again by the onset of another audio impact at 1'18. At 2'28, another scene is introduced that refocuses the audio-visual material to draw attention to a suspension of movement and spatial distance. The identification of scenes made it possible to develop spatial transitions from one scene to the next. Spatial transitions can be described as an experience of physical 'movement' combined with perceptual 'motion' across space (in other words, through the interaction of 'switching' between perceptual modalities and conscious thought). It is through the interpretation of spatial transitions that the overall structure (for example, 1'17, 3'34 and 5'55) is formed. Spatial grouping also occurs through the shared cohesion of movement between audio-visual materials (3'50, 4'37 and 9'44). Spatial blurring removed the edges of geometric formations, adding a sense of depth and weightlessness (2'24 and 8'29).

Synaesthetic Relationships

An understanding of synaesthetic relationships can assist in forming audio-visual language. [62] The dimensions and motions contained in the spectromorphologies of sound often have an associated equivalent in the visual domain. Sounds with short attacks and durations often present themselves as narrowing the visual image. In *Birth,* this was visually represented in the form of lines. The dimensions of lines were used in a variety of ways: to divide the volume of space within the frame, encourage isomorphic relationships and mark audio cues. At 4'34, they are presented as a single one-dimensional entity or grouped into a coherent surface (for example, 0'50). At 7'47, a horizontal line spatially exemplifies a perspective plane until 8'15. At 7'13, lines mark the outline of an object that then flickers to complement the audio. In contrast, more amorphous sounds require a deeper sense of visual space (at 0'03 and 9'06). *Ico* creates a transparent sheen in conjunction with the appearance of complex sound masses (for example, 0'02). It was through my own personal insight that I identified synaesthetic relationships between audio-visual entities.

---

[62] Parise, Cesare and Spence, Charles, 'When birds of a feather flock together': Synesthetic correspondences modulate audiovisual integration in non-synesthetes', *PLoS ONE* , iv (2009) 1. 'Synesthetic crossmodal correspondences...appear to play a crucial (if unacknowledged) role in the multisensory integration of auditory and visual information'.

Perspective

Linear perspective measured the volume and spatial relationships within and beyond the frame (for example, 1'24 and 2'30). Adding a visible horizon line between the fixed points of the viewer and the screen encouraged a sense of spatial depth. Once the line was removed, the sense of a perspective space was replaced with a sense void or floating (9'10). In acousmatic terms, perspectival space can be considered 'as the relations of position, movement and scale among spectromorphologies, viewed from the listener's vantage point'.[63]

Movement along a perspective trajectory was achieved by pairing the spatial proximity of single or multiple audio-visual entities. At 6'16, a replicated moving image is paired with the morphological shape of a single sound that rises and falls in pitch until a different replicating audio-visual object dissolves into the distance. The *Ico* formation was replicated along a perspectival trajectory, and movement was induced by a reduction in scale that left a visual trace of its existence (for example, 6'36 and 9'01).

Conclusion

Birth allowed me to convey the visceral sensations created through a collision of audio-visual materials disconnected from any sense of narrative, purely focusing on the release of kinaesthetic sensations formed through the illusion of motion. The result was a panorama of abstracted audio-visual forms in motion, spatially and arranged into an architectural form.

[63] Smalley, 'Space-form and the acousmatic image', 48.

Chapter 7: *Turing - Morphogenesis* (2012)

Duration: 31'25

Format: 5.1 Fixed Media.

Turing - Morphogenesis is an acousmatic piece that conveys the propagation of sound entities perceptually anchored through the continued presence of their energetic characteristics within a multi-channel environment. It was scientifically inspired by A.M.Turing's paper *The Chemical Basis of Morphogenesis* (1952), which investigates mathematically the onset of instability within morphogens. In my opinion, Turing's theory shares theoretical and practical aspects with the composition of acousmatic music, especially with regards to the structural patterning of spatial parameters through the distribution of differing sound materials within a listening space. It was fascinating to imagine the processes of morphogenesis as a sound world existing within an electroacoustic composition.

Associations of Morphogenesis and Electroacoustic Composition

Comparative 'structural associations' were formed between the process of morphogenesis and the language of electroacoustic composition. In biology, morphogens influence the anatomical form of an organism through the rate of catalytic reactions through a mass of tissue. Movement occurs from regions of greater to regions of less concentration, at a rate proportional to the gradient of the concentration and also to the 'diffusibility' of the substance. I realised that significant conceptual variables such as these could be applied through the use of electroacoustic sound. Both processes are primarily concerned with the productive abstraction of motion and growth. A conceptual connection exists within spectromorphology, as this is also 'concerned with the motion and growth process, which are not exclusively or even primarily sonic phenomena'.[64] Mapping the interplay of these characteristics became a stimulating area of symbolic representation. In a metaphorical sense, morphogens can be represented as transformation processes that directly influence the substance of sound. The movement and 'diffusibility' of this substance can be seen as spatialisation within a multi-channel environment. Making this theoretical connection between a scientific theory and compositional practice allowed me to uncover new musical possibilities. Overall, the scientific concept objectified my compositional approach while still allowing my intuition to be applied freely to the compositional process. Its extrinsic factors became the thread[65] used to form intrinsic and extrinsic musical meanings.

[64] Smalley, 'Spectromorphology: explaining sound-shapes', 110.
[65] Ibid. 110. The term 'thread' is used as the interactive link between the 'intrinsic' and 'extrinsic' processes in music analyses.

Turing 5.1 Algorithm (The patch is included on Data DVD 6)

Forming a study of 'informatics' based on the interaction of natural and artificial auditory systems, the computer became a component of a complex system which generated a polyphony of processes. Designing and constructing my own 5.1 multi-channel software system provided a rich source of inspiration and discovery. The design was inspired by the 8-channel processing software BEASTtools.[66]

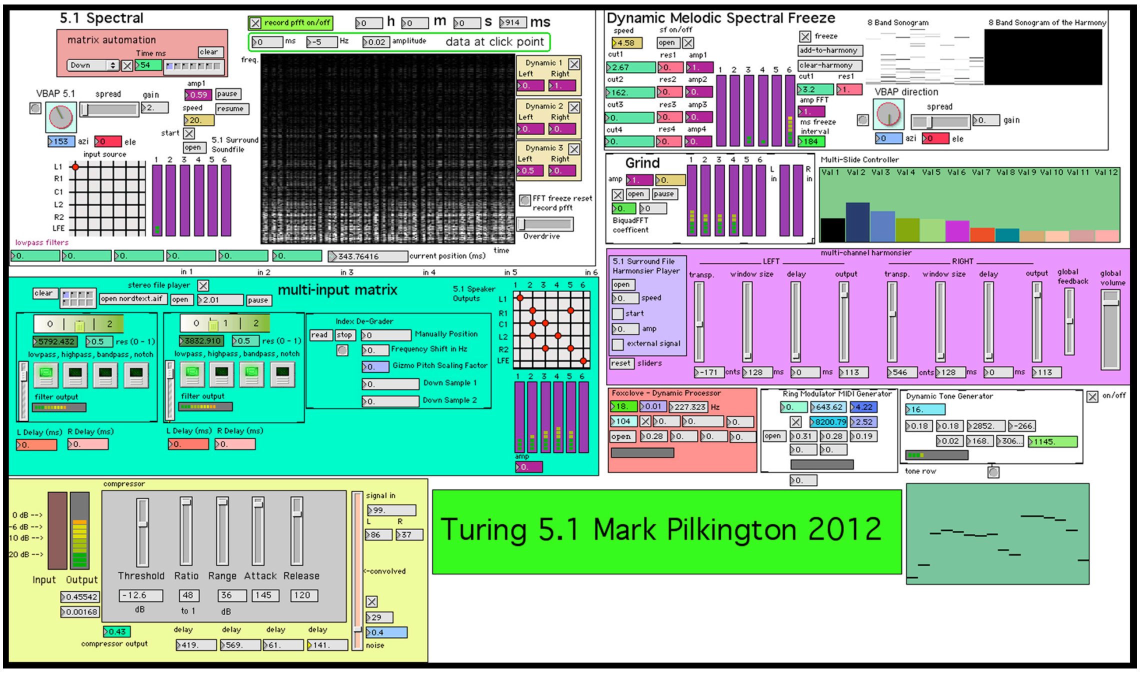

Figure 10: Screenshot of Max/MSP Algorithm *Turing 5.1*

The *Turing 5.1* algorithm (Figure 10) was designed using Max/MSP/Jitter and contained a number real-time compositional tools: FFT spectral freeze,[67] convolution, FM synthesis, filtering, vector based amplitude panning (VBAP) and delay lines within a 5.1 multi-channel environment. Constructing the algorithm became a 'composition of sound treatments',[68] allowing for the simultaneous sculpting of texture and spatial attributes within a multi-channel environment. In conjunction with the algorithm, Apple Logic 9 provided a means of finite editing of spatial attributes across a combination of mono and surround audio channels.

[66] BEASTtools is a fully modular cross-platform environment for exploring and processing sound in 2 and 8-channel formats. Available at <http://www.birmingham.ac.uk/facilities/BEAST/research/BEASTtools.aspx>

[67] Charles, Jean-François, 'A Tutorial on Spectral Sound Processing Using Max/MSP and Jitter', *Computer Music Journal*, xxxv (2008), 87-102.

[68] Nez, Ketty, 'An Interview with Hans Tutschku', *Computer Music Journal*, xxvii (2003), 14–26 at 21. A term used by Hans Tutschku to describe part of his compositional process.

Sound Material

The algorithm produced synthetic sounds derived from electronic audio signals as opposed to the abstraction of recorded real/concrete sounds. The synthesised material allowed me to build a sound world that continuously evolved perceptual contrasts suggesting technological and organic sensations. Its non-identity also became a way to refer to an interior world of the listener's mind, thus affording him/her a personal space. The electronic sounds were also be made to represent intimations of the voices of nature constructed purely around the energy of their gestures and spatial forms. On the other hand, it was also my intention to present a technological sound world built from digital artefacts. Switching between the intrinsic and extrinsic properties of sonic morphologies provided an exciting and simulating prospect of discovery.

The Concerns of Multi-channel Space

In chemical morphogenesis, spatial movement occurs across a gradient that is proportional to a substance's 'diffusibility', which is revealed at points of concentration. In acousmatic terms, this can be equated to the diffusion of the sound material (substance) across a spatial setting (environment).

> 'Acousmatic music is the only sonic medium that concentrates on space and spatial as aesthetically central'.[69]

The units of sound generated from the algorithm evoked space through the deployment of their energy in relation to 'points' across a time frame contained within a spatial setting. A spatial setting can be any conceivable real or virtual social environment in which an acousmatic performance can take place.

> 'Space is a social morphology: it is to be lived experience what form itself is to living organism, and just a intimately bound up with function and structure'.[70]

In the case of *Turing - Morphogenesis,* the spatial setting was contained in a 5.1 multi-channel environment that heightened the reception, sonic distribution and movement in the service of musical expression. Another reason for using the 5.1 format was its accessibility as a commercial format and the fact that it is currently an industry standard for ‘surround sound’. Combinations of mono and surround sound files were used to form spatial trajectories. The

---

[69] Smalley, 'Space-form and the acousmatic image’, 35.
[70] Lefebvre, *The Production of Space*, 93.

mono sound files allowed for precise spatial location whereas the surround files encompass the listener through diffusion. Smalley also suggests that the reception of spatial awareness is enhanced through the notions of prospective and circumspace space.[71] It was my intention to suggest these notions throughout the formation and reception of the composition.

Associated Repertoire

The sonic fabric of *Ash* (1989 - 91) and *Pointes Critiques* (2011) by Horacio Vaggione offers a mesh of morphological inventiveness exposing, revealing and symbolising meteoric or mineral events in sound. His impeccable attention to sonic detail across a series of time scales was inspirational for the composition of *Turing*. The mechanical-like tendencies of *Objet menacé* (2010) by Christian Bouchard implies a material breakdown set within a medium that crosses soundscape composition, glitch, and acousmatic art. The sound world of each composer captures notions of fluidity through to frenetic agitation. With *Turing* I wanted to explore similar techniques to capture *physicality* and *spatial depth* across the continuum of microstructure and macrostructure.

Structural Description

Chemical morphogenesis is primarily concerned with an investigation into an 'onset of instability'[72] by sculpting a breakdown of spatial symmetry. Incorporating these traits into the compositional process was achieved by the sonic evocation of structure and expectation. As the material expanded, it became challenging to add asymmetrical spatial outcomes. One particular section between 10'48 and 14'12 consists of twisted contortions made up of extraneous gesture and spatial morphologies that resisted any form of expectation. The distance at which these interruptions occurred formed moments of relaxation and tension.

---

[71] Smalley, 'Space-form and the acousmatic image', 55-56. Perspectival space encompasses circumspace, 'the extension of prospective and panoramic space so that sound can move around the listener and through egocentric space' and prospective space, 'the frontal image, which extends literally to create panoramic space'.

[72] Turing, Alan M., 'The Chemical Basis of Morphogenesis', *Philosophical Transactions of the Royal Society of London*, ccxxxvii (1952), 37-72 at 37. Instability is a natural condition caused by the random disturbances of the homogeneous equilibrium.

The extended duration of this composition meant that I had to find some way of maintaining musical coherence. This was achieved by structuring familiar sound-types into identifiable 'waves'[73]. The waves contained many familiar spatial and gestural attributes that conveyed a sense of patterning beyond the conceptual framework. The repetition, limitation and gradual evolution of morphological forms assisted in reduced listening and encouraged a mode of inner contemplation. At 11'00, a low distance boom gradually recesses into the distance over reverberant repetitive tapping tones and vocal-like moans.

As individual sounds multiplied into larger sound masses, their properties coalesced to form waves that often emulated the complex behaviour of organic and mechanistic structures. The section between 0'00 – 6'30 sets up a contrast between the syncopation of single short pulses and a multitude of arhythmic textural accumulations with no perceivable pattern. The single short pulses accentuate their spatial position and, at their onset, activate a wider diffusion of complex textural accumulations across the 5.1 loudspeaker array. This occurs due to the inherent spatial properties contained within the sound material, including its 'diffusibility', and has a direct affect on spatial distribution between architectonic and organic structures.[74] In a morphological sense, alteration of the inherent energetic distribution of certain sounds often results in them imitating the characteristics of natural and mechanical sonic phenomena. This also led to the identification of certain eidetic images, such as grains of sand being crushed underfoot, the activity of micro-organisms and technological malfunctions. In counterpoint to the frenetic activity of the shorter microsounds, the mass of larger sounds often appear as deep rumbles recessing into the distance. Their appearance offered points of stabilization, releasing tension and allowing for moments of contemplation. The sound material of the larger sound masses was produced through overt compression, filtering, equalisation and digital reverberation. During the equalisation stage, transparency was maintained by tuning the equalisation curve to harmonic frequencies that avoided additional superfluous overtones (for example, 0'33, 2'13 and 3'25). Other types of large-scale inharmonic chaotic forms were created by applying various types of distortion techniques (2'10, 3'26 and 4'51). Finally, sine waves were included either as single entities (0'41, 4'06 and 4'28) or mixed to reinforce the spectral content of the surrounding sound material (0'41 and 1'55).

[73] Ibid. 66. A term used to describe the emerging 'pattern of morphogen concentrations...'

[74] Harrison, Jonty, 'Sound, space, sculpture: some thoughts on the 'what', 'how' and 'why' of sound diffusion', *Organised Sound*, iii (1998), 117-127 at 127. 'Architectonic is built on quantifiable distances between musical events', observed as clear articulations of space, 'whereas organic space explores the qualitative spatial evolution' as a continuous spectromorphological development.

Performance

The performance of my work often takes place in differing acoustic environments where architectural space has a profound influence on spatial duplication. In order to compensate for this, I often use a mixture of live sound diffusion and electronic transformation techniques to 'adapt' spatial reception. This also encourages a performance dynamic between audience and performer through the visual reception of sound transformations. During the premiere of *Turing - Morphogenesis,* a real-time effects unit and synthesiser added an additional layer of live electronics. Six channels of the fixed media part were sent from an auxiliary send on the mixing desk into a real-time effects unit. The signal was then processed using delay, reverb or pitch-shifting effects and replayed back over the six channels of the fixed media part. This procedure introduced an additional dynamic layer in order to articulate the timbre and gesture of the existing fixed media part. A synthesiser was used in a similar way to form timbral connections to the fixed media part. At the premiere of *Turing - Morphogenesis*, the audience was encouraged to move freely around the space, allowing them to receive a different spatial arrangement relative to their position.

Figure 11: Premiere of *Turing - Morphogenesis*, Manchester Town Hall, 2012.

Final Conclusions

The commentary identifies the pertinent methodological, ideological and theoretical aspects through the appliance of a cross-disciplinary approach within the fields of audio-visual, algorithmic, narrative and space / multi-channel composition.

The intention of each composition is to find shared conceptual commonalities from the disciplines of science and the visual arts in order to inform new electroacoustic music practices. The identification and definition of conceptual frameworks beyond my current research practice is an important aspect of my work, but is never undertaken at the expense of artistic interpretation. Maintaining an artistic balance is paramount, and it is on these terms that I find much satisfaction in being a composer of electroacoustic music.

The variety of compositional approaches has enabled me to perform my work to new audiences within academia and the public domain. Throughout the research, I have established a vocabulary of techniques set within the field of electroacoustic composition that provides a platform for continuous research.

My research will continue to focus on the audio-visual domain, creating compositions that contain both electroacoustic sound and visual media. By using fixed and generative processes, I aim to present works within the context of live performance, film and site-specific installation. Exploring immersive environments, using both screen and multi-channel sound technologies to challenge existing theories of image and sound.

Performance will continue to play an important part in the dissemination of my work, either as a solo artist or part of a music ensemble. I intend to search for artistic commissions, funding and residencies opportunities in the UK and abroad. The performance setting also encourages the design of instruments that have a tactile engagement with sonic phenomena using live processing, synthesis and human-computer interaction.

Alongside my creative endeavors, I aim to maintain and develop a pedagogy based on my PhD research in audio-visual and multi-channel electroacoustic composition. My current undergraduate teaching already involves the theoretical and practical investigation of audio-visual composition and installation, approaches which provide a highly rewarding experience for both myself and my students. Teaching and engaging in compositional critical debate directly influence and contextualise my own compositional practice. Through these practices, my work will continue to evolve as new experiences and approaches are embraced.

Bibliography

Abbado, Adriano , ‘Perceptual Correspondences of Abstract Animation and Synthetic Sound’*,* M. S. Thesis, Massachusetts Institute of Technology, 1988.

Alves, Bill, ‘Consonance and Dissonance in Visual Music’, *Organised Sound,* xvii (2012), 114 - 119.

Arnheim, Rudolph, *Art and Visual Perception: A Psychology of the Creative Eye*. Berkley, New York and London, 1954.

Arnheim, Rudolph, *Visual Thinking,* Berkley, New York and London, 1969.

Barreiro, Daniel L., ‘Sonic Image and Acousmatic Listening’*, Organised Sound*, xv (2010), 35-42.

Bergson, Henri, *The Creative Mind: Introduction to Metaphysics*, New York, 1998.

Birtwhistle, Andrew, *Cinesonica,* Manchester and New York, 2010.

Boulanger, Richard, ed. *The Csound Book: Perspectives in Software Synthesis, Sound Design, Signal Processing and Programming*, Massachusetts, 2000.

Chafe, Chris, 'Tapping into the Internet as an Acoustical/Musical Medium', *Contemporary Music Review*, xxviii (2009), 413-420.

Charles, Jean-François, 'A Tutorial on Spectral Sound Processing Using Max/MSP and Jitter'*, Computer Music Journal*, xxxv (2008), 87-102.

Chion, Michel, *Audiovision: Sound on Screen,* New York, 1994.

Davis, Thomas, 'Complexity as Process: Complexity-inspired approaches to composition'. *Organised Sound,* xv (2010), 137-146.

Dumiel, Y. aka Sterling, I., ‘What is Phonography?’, *Phonography*, 2007 (Accessed 13 October, 2012), < http://www.phonography.org/whatis.htm>.

Einstein, Albert, *Relativity: The Special and General Theory,* New York, 1920.

Emmerson, Simon 'Music Imagination Technology', *Proceedings of the International Computer Music Conference 2011*, (2011), 365-372.

d'Escriván, Julio, *Cambridge Introductions to Music: Music Technology,* Cambridge, 2012.

Evans, Brian, 'Foundations of a Visual Music'**,** *Computer Music Journal***,** xxix (2005), 11-24.

Foucault, Michel, *The Order of Things,* London, 1989.

Fischman, Rajmil, 'Mimetic Space: a conceptual framework for the discussion, analysis and creation of mimetic discourse and structure*', EMS: Electroacoustic Music Studies Network*, De Montfort/Leicester, (2007), 1-9.

Fry, Ben, *Visualizing Data: Exploring and Explaining Data with the Processing Environment*, Sebastopol: CA., 2008.

Greenberg, Ira, *Processing: Creative Coding and Computational Art (Foundation)*, New York, 2007.

Guth, Alan. H. and Steinhardt, Paul. J., 'The Inflationary Universe', *Scientific America Journal*, ccv, (1984), 90 -102.

Harrison, Jonty, ‘Sound, space, sculpture: some thoughts on the ‘what’, ‘how’ and ‘why’ of sound diffusion’, *Organised Sound*, iii (1998), 117-127.

Husserl, Edmund, *Ideas: General Introduction to Pure Phenomenology* (also known as Ideas I), New York, 1962.

Kandinsky, Wassily, *Concerning the Spiritual in Art,* New York, 1977.

Kennedy, Michael and Kennedy, Joyce, *The Concise Oxford Dictionary of Music,* Oxford, 2007.

Kröpfl, Francisco, 'Integrating sound and visual image as Artform' in: Françoise Barrière and Christian Clozier,eds., *'Relationships between audition and vision in the creation of electroacoustic music'. Acts IIIV (2004/2005),* iii (2007), 89-90.

Landy, Leigh, *Understanding The Art Of Sound Organization,* Massachusetts : MIT Press, 2007.

Ledoux, Claude and Fineberg, Joshua, 'From the Philosophical to the Practical: An Imaginary Proposition Concerning the Music of Tristan Murail', *Contemporary Music Review*, xix (2000), 41-65.

Lefebvre, Henri, *The Production of Space*, Oxford, 1991.

Merleau-Ponty, Maurice, *The Phenomenology of Perception,* London, 1994.

Nez, Ketty, 'An Interview with Hans Tutschku', *Computer Music Journal*, xxvii (2003), 14–26.

Nancy, Jean Luc, *Listening*, New York, 2007.

Parise, Cesare and Spence, Charles, ‘When birds of a feather flock together: synesthetic correspondences modulate audiovisual integration in non-synesthetes’, *PLoS ONE* , iv (2009).

Peterson, Robert, *Eisenstein on the Audiovisual: The Integration of Music, Image and Sound in Cinema,* London, 2001.

Walker, Bruce N. and Ness, Michael A., 'Theory of Sonification', in: Thomas Hermann, Andrew Hunt and John G. Neuhoff, eds., *The Sonification Handbook,* Berlin, 2011, 9-39.

Weinberg, Gil, 'Interconnected Musical Networks: Towards a Theoretical Framework', *Computer Music Journal*, xxix (2005), 23-29.

Westerkamp, Hildegard, 'Linking Soundscape Composition and Acoustic Ecology', *Organised Sound*, vii (2002), 51-56.

Whitney, John, 'To Paint on Water: The Audiovisual Duet of Complementarity', *Computer Music Journal*, xviii (1994), 45-52.

Roads, Curtis, *Microsounds,* Massachusetts, 2001.

Roads, Curtis, *The Computer Music Tutorial,* Massachusetts, 1995.

Risset, Jean-Claude 'Horacio Vaggione: Towards a Syntax of Sound', *Contemporary Music Review*, xxiv (2005), 287-293.

Varèse, Edgard and Wen-chung, Chou, 'The Liberation of Sound', *Perspectives of New Music*, v (1966),11-19.

Sauer, Theresa *Notations 21*, New York, 2009.

Smalley, Denis, 'Defining timbre - Refining timbre', *Contemporary Music Review*, x (1994), 35-48.

Smalley, Denis, 'Spectromorphology: explaining sound-shapes', *Organised Sound*, ii (1997), 107-126.

Smalley, Denis, 'Space-form and the acousmatic image', *Organised Sound*, xii (2007), 35-58.

Truax, Barry, ed., *Handbook for Acoustic Ecology*, Online Edition, Burnaby, B.C., 1999, (Accessed 17 September 2012), <http://www.sfu.ca/sonic-studio/handbook/index.html>.

Turing, Alan M., 'The Chemical Basis of Morphogenesis', *Philosophical Transactions of the Royal Society of London*, ccxxxvii (1952), 37-72.

Vaggione, Horacio, 'Some Ontological Remarks about Music Composition Processes', *Computer Music Journal*, xxv (2001), 41-55.

Young, John, 'The Extended Environment', *Proceedings of the International Computer Music Conference 1994*, (1994), 23-26.

Young, John, 'Sound morphology and the articulation of structure in Electroacoustic Music', *Organised Sound*, ix (2004), 7-14.

Young, John, 'Reflections on Sound Image Design in Electroacoustic Music'*, Organised Sound*, xii (2007) 25-33.

Youngblood, Gene, *Expanded Cinema,* New York, 1970.

Discography

Barrett, Nastasha (2001), ‘Industrial Revelations’, *Isostaise*. Empreintes DIGITALes, IMED 0262 (2002).

Bayle, François (1979), ‘Toupie dans le Ciel’, Volume 16 Magison, MGCB e102 (2002).

Berezan, David (2003), ‘Cyclo’, La face cachée. Empreintes DIGITALes, IMED 0896 (2008).

Bouchard, Christian (2010), 'Objet Menacé', *Automacité*. Empreintes DIGITALes, IMED 11108 (2011).

Drese, Ingrid, *Interstices.* Empreintes DIGITALes, IMED 10103 (2010).

Gobeil, Gilles (1995), ‘Nuit Cendre’*, ...dans le silence de la nuit…* Empreintes DIGITALes, IMED 0155 (2001).

Gobeil, Gilles (1997), ‘Point de passage’, *…dans le silence de la nuit…* Empreintes DIGITALes, IMED 0155 (2001).

Grisey, Gérard (1975), 'Partiels', *Les espaces acoustiques*. Accord, AC456 386-2 (2007).

Harrison, Jonty (1999 - 2006), ‘ReCycle’ (5.1 version), *Environs*. Empreintes DIGITALes, IMED 0788 (1999 - 2006).

Kokoras, Panayiotis, 'Anechoic Pulse' for tape, *Electronic Music Vol.III, Música Viva Competition Prize Winners 2004 - 2005 – 2006*, Miso Records, MCD 016-07 (2007).

Murail, Tristan, 'Désintégrations', *Tristan Murail Serendib - L'Esprit des dunes – Désintégrations.* Accord, AC4653052 (1996).

Parmegiani, Bernard, *De Nature Sonorum*, INA/GRM; INA C 3001 (1990).

Parmegiani, Bernard, *La mémoire des sons,* INA/GRM; INA C 2019 (2002).

Parmegiani, Bernard, *Sonare,* INA/GRM; INA E 5203 (2002).

Stolley, Pete, Un son peut en cacher un autre, Empreintes DIGITALes, IMED 0678 (2006).

Vaggione, Horacio, 'Ash' and 'Pointes critiques'*, Point critiques,* Ina-GRM Ina_G 6032 (2011).

Young, John, La limite du bruit - The Edge of Noise, Empreintes DIGITALes, IMED 0261 (2002).

Appendix A: Additional Information on the Portfolio Works

Points and Lines (2009)

Programme Notes

The work is concerned with the correspondences, through abstraction, of onscreen moving images and electroacoustic produced sounds. Setting alliances between the nodes of visual and electroacoustic procedures allowed the discovery of a new modality of structural expression. The concept is based on my fascination of how the 'motion' of sound and light physically affects our lives. Albert Einstein's *Relativity the Special Theory and the General Theory* presented new ways of thinking about space, time and gravity. According to Einstein, the apparent distortion of the physical object is not through optical illusion, but due to a change in the nature of space itself, caused by motion. His text inspired me to produce a series of sound and light experiments to convey this idea as an audio-visual experience. The audio consists of found, instrumental and synthetic sounds manipulated into different scenes fused together into an acousmatic work. The visual images have been gathered from mobile phone clips, a film of a model city, paintings and computer graphics. Together they present a graphic score in *motion* containing both symbolic and abstract representations of a time-based design.

Performances

- Premiered at the MANTIS festival, The University of Manchester, UK, March 7th, 2009.
- Exit Festival, IDKA, Sweden, September 20th, 2009.
- 'A Tribute to Nam June Paik Exhibition', FACT and TATE, Liverpool, UK, December 18th, 2010.

Sketch on Glass (2009)

Programme Notes

The piece combines electroacoustic and instrumental sounds produced in collaboration with an instrumental composer, Daniel Kidane. The contrast in our methodological approaches provided a shared experience of discovery and forged new directions within our compositional praxes. A music algorithm, *Sketch on Glass,* generated a sound file for which the instrumental composer Daniel Kidane wrote a score for cello, violin and shruti box. The aim was to form a transparent sound world by blurring the identity of the electronic and acoustic instruments through the mimetic interchange of meta-instruments.

Performers: Pei-Jee Ng (cello), Urara Otake (violin), Daniel Kidane (shruti box) and Mark Pilkington (electronics).

Performance

- Premiered at the RNCM Composers Concert, The Royal Northern College of Music, UK, March 2nd, 2009.

Touch the Stars: Part 1 (2009)

Programme Notes

Musician, Mark Pilkington, and astrophysicist, Tim O'Brien, reinterpreted the sounds of the cosmos in a celebration of the International Year of Astronomy and the 40th Anniversary of the Apollo 11 moon landings.

A co-commission by Futuresonic and the University of Manchester's world leading Jodrell Bank Observatory, co-curated by Drew Hemment and Teresa Anderson.

Performance

- Premiered at the opening of the FutureEverything Festival The Contact Theatre, Manchester, 13 May 2009.

Touch the Stars: Part 2 (2009)

Programme Notes

After the realization of the *Touch the Stars - Part 1* I felt the concept warranted further musical investigation and so I composed a fixed media version (*Part 2)*, combining generative, mapping, spectral space and instrumental improvisation musical processes. The concept is based on imagining different environments and physical elements inspired by the signals of the radio universe travelling across space. Envisioning elemental forces such as gases, liquids and solids and transforming energy states created an imagined sound world realised through a myriad of acoustic and synthetic sound material. Some examples of such sound material include a one second impulse recording of a bursting rubber balloon (a metaphor for the 'big bang' theory), the extend techniques of an electric bass guitar and an overblown kazoo.

Performances

- Premiered at the MANTIS festival, The University of Manchester, UK, October 30th, 2009.
- PRS for New Music Plus Concert, 'The Planetarium', World Museum, Liverpool, UK, December 12th 2010.
- Projection Exhibition, Manchester, UK, 2012, July 13th 2012.

Camera Down (2010)

Programme Notes

Cameradown is an audio-visual piece realized at NOVARS, the University of Manchester, UK in 2010. The piece has a symbiotic connection to the auditory and visual senses through a metaphysical convergence: an interplay between the two perceptual organisms of the eye and the ear. The sound world of the piece is an exploration of the relationship between naturalistic and synthetic sonic content. The audio-visual material is constructed into a series of spectral and textural complexities, simulating an imaginative perceptual and conceptual experience.

A roller coaster ride through a landscape of sound and light energy patterns reveals a series of 'concrete' and 'abstracted' constructed events. An abstracted dialogue arises from the action and reaction arising from the temporality of different perceptual events. Impossible physical scenarios arise from a maelstrom of evocations placed between desire and experience. Hopefully, the piece has the ability to generate overwhelming emotional impact exclusively from cinematic and electroacoustic methodologies and not through thematic content.

The sound material comprises of original recordings from a diverse selection of sources, such as field recordings of falling rocks, farm machinery, birds, metallic impacts and various types of synthesized sounds. The visual material comprises original images derived from computer generated graphics, oil paintings and film footage from the composer's personal archive.

Performances

- Premiered at the MANTIS festival, The University of Manchester, UK, October 30th, 2010.
- 'A Tribute to Nam June Paik', FACT and TATE: Liverpool, UK, December 16th, 2010.
- CEC 2011, 6th Carnival of e-Creativity, Sattal Estate, Bhimtal, India, February 18-20, 2011.
- CMMAS, Mexico, July 22nd, 2011.
- ICMC, Huddersfield, UK, August 5th, 2011.
- Espacioenter, Bilboa, Spain, November 26th, 2011.

Phone Camera (2010)

Programme Notes

Phone Camera is an audio visual piece realised at NOVARS, the University of Manchester, UK in 2010. The visual material was captured primarily using a low-fidelity mobile phone camera. The inherent quality of digital compression reveals many artefacts on the intended image. These were further transformed to alter the content of the intended message. The capacity for technological transmission to introduce 'noise' into both auditory and visual media was explored to varying degrees throughout *Phone Camera.* The sound material comprises recordings captured from a diverse selection of sources, with location recordings of snow, rocks, vocal utterances and metallic impacts and various types of synthesized sounds. The visual material acts to form narratives comprising mobile phone images meticulously edited alongside an acousmatic piece of music. Other images include computer generated graphics, oil paintings and found film footage.

Performance

- ‘A Tribute to Nam June Paik’, FACT and TATE: Liverpool, UK, December 16th, 2010.

Peterloo (2011)

Programme Notes

A 5.1 acousmatic piece based on the Peterloo massacre that happened in 1819, Manchester UK. The piece offers a sonic reflection that uses opposing sound materials to illustrate the differing political opinions of people present on the day of the event. The conceptual idea was a rich source of inspiration, stimulating eidetic sonic images (denoting mental images) that informed the compositional process. Investigating the reconstruction of an imaginable landscape is a recurring theme that runs throughout my work. The many dramatic emotional scenarios created consider the listener's position, reception and inclusion, as if he/she were an eye-witness on the day of the event. With the help of Dr. Robert Poole, University of Cumbria, the People's History Museum, Manchester and the North West Sound Archive, Clitheroe, I managed to acquire historical information in order to accurately convey the sound events as they happened on the day. The sonic materials are transformations of recordings made at the student protests that happened in Manchester in 2011.

Performances

- Premiered at the MANTIS festival, the University of Manchester, UK, March 5th, 2011.
- PUSH Festival, IDKA, Sweden, April 8th, 2011.
- Immersive Audio-game Showcase, Manchester Sonic Meta-Ontology Projects in collaboration with NoTours, Escoitar and Cities@manchester, the University of Manchester, UK, June 29th, 2012.

Birth (2011)

Programme Notes

A kinetic film of graphical light forms converges with naturalistic sound transformations that link sound with pictorial harmony. A restrictive palette of the graphic based visual material is animated into parallel and asymmetric dimensions projected into space beyond the surface of the screen. The film is an extension of musical expression in which the images and sound transform our perceptions, breathing life into apparently living organisms made of both mechanical and organic materials. This piece is inspired by the early avant-garde film makers Oskar Fischinger, Viking Eggeling and Hans Richter and the Japanese animation style of Yoshinira Kanada.

Sound materials:
- Rock fall into a 'barranco', Tenerife, Spain.
- Shouts in a deserted underground car park.
- Caged Parrots.
- Synthetic sounds.

The piece explores the physical properties of inanimate objects contained within natural and urban spaces. The visual material consists of computer graphics created in Processing (http://processing.org/), an open source software programming language and environment that allows for meticulous control over the pixel positioning of the graphical data.

The film has been constructed by mapping the visual elements onto the audio content, producing a visual score in motion.

Performances

- Premiered at the MANTIS festival, the University of Manchester, UK, October 30th, 2011.
- 'A Concert of Electronic Works by MANTIS', Kingston University, UK, March 22nd, 2012.

Turing - Morphogenesis (2012)

Programme Notes

Turing - Morphogenesis is an acousmatic piece that conveys the propagation of unrelated sound entities anchored perceptually through the continued presence of their energetic characteristics.

The strategies of the composition were inspired by A.M. Turing's *The Chemical Basis of Morphogenesis* (1952), where he mathematically investigates the onset of instability within 'morphogens'. The chemical agents that cause morphogenesis are replaced by sound particles diffused into a 5.1 listening space. The sound material is derived purely from synthetic sounds calculated through a distribution of electronic audio signals.

The piece gradually creates an ontogenetic sound-world using an abundance of abstract computer generated sounds. As the sounds multiply, they begin to coalesce, emulating the complex behaviour of organic structures. Morphological inventiveness is formed through rapid gestures temporally articulated across a multiplicity of time scales. The creative catalyst for the composition was the interaction between computer and composer. The computer acted as the component in a complex system which intervened in a genuine polyphony of processes. Spatial awareness was promoted using a 5.1 loudspeaker array.

Composed at the NOVARS Research Centre for Electroacoustic Composition, Performance and Sound Art at the University of Manchester, 2012.

Performances

- Premiered at the Turing 100 Centenary Conference, Manchester Town Hall June 24th, 2012.
- MANTIS festival, the University of Manchester, UK, October 28th, 2012.