Theo Burt: Composition Folio

Theodore Burt

PhD

The University of York
Music Research Centre

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Abstract

A folio is presented consisting of seven computer-generated compositions. Many of the works create and explore relationships between sound and video, reflecting a concern with the multi-modal nature of perception. In most of these compositions, material is structured by simple algorithmic processes. These processes are used to explore relationships between perception and cognition: how the changing form of a work over time reveals the nature of a process to us, and how our understanding of that process affects our expectation and anticipation of future form. One work in the folio takes the approach of transforming existing sound and image. This process is used in an attempt to disrupt 'musical meaning' and other symbolic content encoded in the source material.

These compositions were completed between 2009 and 2012 and are presented chronologically, demonstrating the progression of my ideas throughout this period. An accompanying text discusses ideas relevant to the folio in general and gives a critical commentary on each work. Compositions included: *Four*, *Colour Projections*, *Control Processes*, *Summer Mix*, *Colour Projections / set 2*, *Bastard Structures 2*, *Tiling Sessions*.

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Declaration

All compositions within this folio are entirely my own work, with the exception of *Bastard Structures 2* which is a collaboration with artist Tim Wright. All accompanying text is my own work and has not been presented before.

1 Introductory notes

This folio contains eight compositions. This document will present relevant background information and a brief commentary on each piece.

In section 2 I present a summary of the works within the folio. Please read this before listening or watching any of them, as it contains important information about their presentation. With some of the works it is appropriate to read the commentary first, and in other cases it is beneficial to experience the work before reading about it.

In section 3 I discuss issues that are relevant to the work in the folio. This includes brief discussions of multi-sensory perception, simultaneous sound and video, aesthetic implications of contemporary sound and video technology and process in art and music.

In section 4 I present a methodological overview of the process by which I arrived at this folio of compositions, in terms of theory, experimental practise, self-reflection, expert opinion and performance.

In sections 5 to 11 I present commentaries for each piece in the folio. These are presented in chronological order with respect to the completion of each work. In each commentary I discuss my ideas and thoughts prior to completing the piece, describe the practical creation of the work, and discuss relevant aesthetic issues. The exact structure I use varies with each composition.

In section 12 I present a conclusion, in the form of a brief summary of the folio and the relationships between the works presented. I also detail some current and future projects and their relationship to the work presented here.

Throughout the commentaries I discuss the algorithms at work, but I have chosen not to elaborate on their software implementation. Nevertheless, much of the time spent developing the compositions was necessarily spent writing the software.

The word 'composition' is often ambiguous. To avoid ambiguities as much as possible I have arbitrarily chosen to use it in the remainder of the text only in relation to temporal structure. Hence, as a verb, *to compose*, I use it to mean the act of determining the structure of material over time. As a noun, *composition,* I use it to refer to some existing structure, with respect to time.

Throughout the text I use the word 'music' only to refer to features of sound that might culturally or traditionally be considered 'musical'.

2 Summary of works

This sections provides a summary of works submitted in the folio, with references to the relevant files included on the accompanying DVD-R. It also provides some information on listening to and viewing the work.

Notes on listening to and viewing the works

There are some works in this folio, where it may be more interesting to see the work before reading its associated commentary, and in some cases the reverse is true. If this is the situation I note it below, in the summary for each work.

Because of the simple synthesis methods used in many of the pieces, none of them suit playback over headphones or earphones. Most contain low-frequencies which may be completely inaudible played back over smaller speakers, such as laptop speakers. Please use good quality monitor speakers that have a full and balanced frequency range.

The video files included fall into two categories. The majority are direct recordings from the computer. This is the type of video material that is fed directly to a projector in a performance or installation situation. All the video works are intended for playback on large projected surfaces, and have been composed in this situation. If this is not a possibility during the viewing process, then please try to use as large a screen as possible. The two video files which do not fall into this category are in the form of video documentation of an installation and performance. These are relatively low-quality (limited by lighting conditions etc.), but as documentation are more robust to viewing and listening conditions than the direct recordings.

Finally in *Summer Mix* there are some images included, which are best viewed digitally, rather than printed.

All audio-only data is provided in 16-bit, 44 100Hz, stereo WAV format, and can be played back on any standard media-player or editor. Video files are all in *.mov* and *.mp4* formats. They have been tested for playback with *VLC Media Player 2.0.3* and *Apple QuickTime 10.2*[1] [2]. However, they should work on any recent versions of these players. *QuickTime* is much preferred, as it represents colours more consistently between formats, and will not distort sound. *VLC* has a tendency to show videos with a reduced dynamic

1 *VLC Media Player.*

2 *QuickTime.*

range, and badly decodes some audio formats.

Please copy data files from the DVD-R to disc before listening or viewing. As well as being quieter from a hard drive, some of the data-rates in the larger video files may be too high to stream directly from disc, which will result in jittering.

Four

2009. Installation work. 4 channel digital-audio, digital-video projected on to 4 Foamex boards.

DVD-R Files:

1.Four/Four.mov (14:55s)

Four. Main documentation. Direct sound and video recording of the entire work.

1.Four/Four_Dean_Clough_(excerpts).mp4 (12:18s)

Four. Live footage from installation at Room Mode exhibition (excerpts). Viaduct Theatre, Dean Clough, Halifax, February 2010. Curator: Vic Allen
These excerpts are provided to give an impression of the installed work.

1.Four/Four_Dean_Clough_1.tif, ..._2.tif, …_3.tif

Four. Three photographs of installation at Room Mode exhibition. Viaduct Theatre, Dean Clough, Halifax, UK. February 2010. Curator: Vic Allen

Colour Projections

2009 – . Performance / Installation / Screening work. 2 channel digital-audio, projected digital-video.
Listen/view before reading commentary.

DVD-R Files:

2.Colour_Projections/Colour_Projections.mov (29:47s)

Colour Projections. Main documentation. Direct sound and video recording of a performance of the work.

Control Processes

2010. Screening work. 2 channel digital-audio, projected digital-video.

Listen/view before reading commentary.

DVD-R Files:

3.Control_Processes/Control_Processes.mov (17:19s)

Control Processes. Main documentation. Screening copy of the work.

Summer Mix

2010 – . Stereo audio tracks and images.

Read commentary before listening / viewing.

DVD-R Files:

4.Summer_Mix/1.Summer_Mix_track_1.wav (14:29s)

Summer Mix. Mix of transformed audio including Swedish House Mafia, PJ feat. Velvet, Roll Deep, Paul Van Dyk, Deepest Blue, Supermode.

4.Summer_Mix/2.Summer_Mix_track_2.wav (21:56s)

Summer Mix. Mix of transformed audio including Deadmau5, Mason vs Princess Superstar, Riva Starr, Sash!, Motorcycle, 4 Strings, PPK, D.H.T., Tiësto.

4.Summer_Mix/3.Summer_Mix_track_3.wav (07:14s)

Summer Mix. Mix of transformed audio including Sonique, Grace, Gouryella. Some audio is looped.

4.Summer_Mix/4.Summer_Mix_track_4.wav (04:00s)

Summer Mix. Mix of transformed audio including Roger Sanchez, Eric Prydz.

4.Summer_Mix/5.Clubbers_Guide_Summer09.tif

Ministry of Sound, Clubbers Guide Summer '09. Transformed album artwork.

4.Summer_Mix/6.Deepest_Blue_Deepest_Blue.tif

Deepest Blue, Deepest Blue. Transformed album artwork.

4.Summer_Mix/7.Cream_Future_Dance_(detail).tif

Cream, Future Dance (detail). Transformed album artwork.

4.Summer_Mix/8.Tiësto_Maximal_Crazy_(detail).tif

Tiësto, Maximal Crazy (detail). Transformed album artwork.

4.Summer_Mix/example_source_images/

Two examples of pre-transform images are included here. These do not constitute part of *Summer Mix* and are included for interest only. These are low-resolution images, and inclusion of them is considered *fair-use.* All rights remain with Ministry of Sound and Tiësto/Musical Freedom.

Colour Projections / set 2

2011. Performance / Installation / Screening work. 2 channel digital-audio, projected digital-video.

Listen/view before reading commentary.

DVD-R Files:

5.Colour_Projections_set2/Colour_Projections_set2.mov (16:32s)

Colour Projections / set 2. Main documentation. Direct sound and video recording of a performance of the work.

Bastard Structures 2

2011 – . Collaborative performance work with Tim Wright. 2 channel digital-audio, digital-video projected on to corner of room with 2 projectors.

DVD-R Files:

6.Bastard_Structures_2/Bastard_Structures_2_Millers_Yard.mp4 (20:20s)

Bastard Structures 2. Live footage from a performance at Music to Hear and See, Club Integral Northern Branch. Millers Yard, York, UK. April 2012. Curator: Val Persona.

This footage it relatively low-quality, but actually conveys the event very well. One particular quirk of the videoing is that on fast strobing sections, the sound may appear desynchronised from the audio. This was not the case at the actual event and is the result of temporal aliasing caused by the video camera used.

Tiling Sessions

2012 – . Performance work. 2 channel digital-audio, projected digital-video.

Listen/view before reading commentary.

DVD-R Files:

7.Tiling_Sessions/Tiling_Sessions.mp4 (36:49s)

Colour Projections. Main documentation. Direct sound and video recording of a performance of the work.

3 Background

The discussions presented here briefly outline relevant ideas and existing works. They are intended to provide some context to the presented work and are by no means exhaustive.

3.1 Multi-Modal Perception

There has been a tendency over much of the twentieth century for psychologists studying human perception to consider individual modes of sense independently. For example, experimental studies have often been limited to either the effects of sonic stimuli, or the effects of visual stimuli.[3] However, in the late nineteenth and early twentieth centuries the gestalt psychology movement, originating in Berlin were advocating a move towards a holistic understanding of the mind that considered conscious experience as a totality. This led to a particular focus on the nature of perception, and interest in related phenomena such as optical illusions.

More recently there has been a resurgence of interest in cognitive, behavioural and neurological studies of 'multi-modal' or 'cross-modal' perception. Bertelson and Gelder summarise the scope of the majority of these studies:

> Sensory modalities are classically distinguished on the basis of the type of physical stimulation that they are most sensitive to – light for vision, sound for hearing, skin pressure for touch, molecules in air for smell, etc. Research on perception has generally considered each sensory modality in isolation, but most things that happen in the normal environment produce stimulation to several modalities simultaneously. The phenomena considered ... have their origin in the fact that some multimodal inputs yield related information about the same event or object.[4]

Synaesthesia is a relatively well known neurological condition where stimuli from one sensory mode triggers responses in another. Hence someone may literally 'see a sound'.

> The word *anesthesia*, meaning “no sensation,” shares the same root with *synesthesia*, meaning “joined sensation.” It comes from the Greek *syn*, union + *aesthesis*, sensation. It denotes the rare capacity

3 Bertelson and Gelder, 'The Psychology of Multimodal Perception'.

4 Ibid.

> to hear colors, taste shapes, or experience other equally strange sensory fusions whose quality seems difficult for the rest of us to imagine.[5]

The term 'synaesthetic' has often been used less formally to describe effects where material presented to multiple sensory modalities somehow appears related, or is perceived as a single structure.[6] While this could of course describe much everyday experience, or traditional narrative film, it is usually used to describe the effect when it occurs within more abstract material such as abstract art or film.

For me, one of the most interesting descriptions of perception is that given by Maurice Merleau-Ponty in *Phenomenology of Perception.*[7] Merleau-Ponty's thinking was influenced by the gestalt psychologists: 'The central figures of the movement—Max Wertheimer,. Kurt Koffka, and Wolfgang Köhler—rejected the atomistic and mechanistic assumptions that had dominated philosophy and psychology for centuries...'.[8] He emphasises a 'primacy of perception', warning against an analytical reduction of phenomenally received experience. The scope of his theory was wide, and is often considered a critique of the traditional Cartesian division of mind and body.[9] In much of *Phenomenology of Perception* he emphasises the experience of being in the world *bodily.* He describes how experienced sensations belong to a perceptual *field*, implying that all senses are inherently spatial, and the objects of those senses must exist in space. This is not, however, a conception of space as an externalised, physical system, but space as a formal experience. Here he discusses the unity of the senses:

> 'It [the unity of the senses] cannot be understood in terms of their subsumption under a primary consciousness, but of their never-ending integration into one knowing organism. The intersensory object is to the visual object what the visual object is to the monocular images of double vision. The sight of sounds or the hearing of colours come about in the same way as the unity of the gaze through the two eyes: in so far as my body is, not a collection of adjacent organs, but a synergic system, all the functions of which

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5 Cytowic, *Synesthesia*.

6 Berman, 'Synesthesia and the Arts'.

7 Merleau-Ponty, *Phenomenology of Perception.*

8 Carman, *Merleau-Ponty*.

9 Ibid., 85.

> are exercised and linked together in the general action of being in the world, in so far as it is the congealed face of existence.'[10]

3.2 Simultaneous sound and video

The majority of the works in this folio use simultaneous sound and video and seek to establish some kind of consistent relationship between the two. Some of the earliest examples of abstract films establishing relationships between sound and image are those made in the early to mid twentieth-century and referred to under the umbrella term 'visual music'. This includes artists such as Oskar Fischinger who produced a large number of animations synchronised to music recordings, such as *Kreise* (Circles), in 1933.[11] The term 'visual music' is used to describe a number of different concepts with relation to film, but in the case of artists such as Fischinger, Mary Ellen Bute and later John Whitney, it tends to refer to the idea of transposing the traditional structures of music (for example rhythms and pitch relationships) to a visual form.

This approach is often noticeable when watching these works – for example, in *Kreise* the animations always appear to follow the 'musical' structure of the piece, rather than the sound itself. It is possible that the motivation for this approach comes from an idealised view of music – a belief that the familiar elements of Western art music (time-signatures, notes that are linked to a single pitch, rhythm notations, musical keys) actually represent some fundamental basis, rather than having arisen as a series of cultural conventions.

Around 1930, several people including Mikhail Tsekhanovsky in Soviet Russia, and Rudolf Pfenninger in Germany were independently exploring the potential for direct sound synthesis using new optical soundtrack systems that were developed for film.[12] [13] Visual forms could be drawn or printed directly onto the optical soundtrack of film, and replayed through a projector. This process was taken further by Canadian animator Norman McLaren. In works such as *Scherzo* (1939) he would draw or paint in the visual region and optical soundtrack of a piece of film, creating entirely abstract but related sound and animation.[14]

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10 Merleau-Ponty, *Phenomenology of Perception.*

11 Fischinger, *Kreise*.

12 Iankovski, 'Акустический Синтез Музыкальных Красок'.

13 Levin, 'Tones from Out of Nowhere'.

14 McLaren, *Scherzo*.

A particularly interesting abuse of a film's optical soundtrack is Guy Sherwin's 1977 film *Railings*.[15] In it, Sherwin films various sequences of metal railings with the camera rotated 90 degrees. On printing the film, he allows the image of these railings to spill over onto the part of the film normally reserved for the sound track. This creates dense horizontal lines over the area, which get replayed by the projector as buzzing tones. Many factors such as the spacing of the railings and their angle with respect to the camera all constantly effect the timbre and pitch of this tone. It is not necessarily the primary aim of the work to produce a 'synaesthetic' relationship between sound and image, but the consistency and unity between the structures of the two mean that this effect is at times inevitable.

In the twenty-first century there appears to be a bias in computer-based sound and video art towards work that gives primacy to sound, in that video is created to complement existing audio. An impressive example of a work created this way is the video for Autechre's *Ganz Graf* by Alex Rutterford.[16] His precisely synchronised visuals are based on a manual analysis of the soundtrack.

In 2007, Richard Chartier curated a programme of artist's films titled *Colorfield Variations* (a reference to the Colour Field movement of painting).[17] It is notable that the majority of works consist either of largely independent music and image (for example, Stephen Mathieu, *Orange was the color of her dress*) or visuals precisely post-synchronised to music (for example, Frank Bretschneider, *Looping i-vi (excerpt)*).[18] One exception to this is *Broadway One (excerpt)* by Ernest Edmonds and Mark Fell.[19] [20] In this, and other compositions in their series, the visual area is divided into several vertical columns of pure, solid colour, and sounds of varying tone are triggered when these columns are replaced with new colours. Edmonds states of his collaborative sound and video works:

> The underlying concepts for all of these works is that a single structural form generates both audio and visual representations. These audio and visual representations are not necessarily equivalent, that is to say they need not have a one-to-one mapping,

15 Sherwin, *Railings*.

16 Rutterford, *Video for Ganz Graf by Autechre*.

17 *Colorfield Variations*.

18 Mathieu, *Orange Was the Color of Her Dress*.

19 Edmonds and Fell, *Broadway One*.

20 Bretschneider, *Looping I - VI*.

> but they are part of the same underlying generative structure.[21]

This idea of a single structural form underlying both the sound and video seems crucial to any genuinely cross-media work, and is an approach I have taken in each of the audio-video compositions within this folio.

3.3 Aesthetic implications of contemporary computer sound and video technology

The technologies of sound and video production are highly specialised and their mechanisms distinct. It is useful to remind ourselves of an obvious point here: that our sound and video technologies were originally designed to record and replay events in the world as we might perceive them. It could be said that being technologically incapable of simulating the world itself, we have been forced to recreate particular forms of stimuli and apply them individually to particular sensory organs. In a situation where we are attempting to create an illusionary world, the range of useful relationships between sound and video materials is relatively clear – their role is predefined in relation to this notional world. But if we decide to use these technologies for another purpose – perhaps to create non-representational sound and video compositions, this defined relationship is removed, and we are left with two quite separate technologies and mediums.

It may appear that within the limits of its computation power, a computer could generate any desired video, audio, or any combination of the two. However, this view makes the assumption that someone might create an artwork by first perfectly conceiving it in their mind, and then using technology 'transparently' to directly translate their initial conception of it into a material form. Even if such an idealised situation could exist, any works produced would be entirely limited to what we could initially conceive. If we instead imagine a situation where a work is created through a process of experimentation with technology, then we can immediately see that our aesthetic outcome is linked with the means by which we may interact with that technology.

Hardware interfaces to audio and video in a computer are very specific, and generally directed towards either replaying recordings of the world or attempting to simulate it. A typical computer configured for real-time audio and video generation will consist of structurally very different sound and graphics systems. For example, a graphics card might operate by converting lists of polygons or two-dimensional arrays of pixels into a video signal, 60 times a second, while a sound card might operate by converting lists of

21 Edmonds, Martin, and Pauletto, 'Audio-Visual Interfaces in Digital Art'.

numbers into voltages, requiring thousands of numbers per second. Many of the software technologies commonly used for audio and video composition, such as *Max / MSP* or *Pure Data* provide only a thin layer of abstraction over this hardware, a choice intended to minimise processing overheads in the software itself.[22] [23] The resulting system is general in terms of its absolute potential: with the right combination of pixels or audio samples we could produce a huge range of material, but highly specific in terms of how we can interact with it.

So, working directly with real-time audio and video this way, is effectively working with two separate media. Perhaps the only inherently common element linking them is time – we are constantly accessing and updating the state of each from the present moment. It is not surprising then, that the most prevalent relationship between the sound and video in contemporary compositions is temporal, a visual change occurring at the same time as a sonic change. There is also an aesthetic issue with this divided medium: in a work produced this way, the 'sound' of the audio and the 'look' of the video are defined entirely independently from the relationship between the two. To put it another way, the relationship between the audio and video informs little of the aesthetics of either. It is unsurprising given this aesthetic schism, that so often in sound and video compositions, elements of music are brought into the audio and references from the visual arts into the video.

Of course there is nothing inherently wrong with this approach – no matter how the sound and video are created, we are bound to experience them simultaneously, as some form of totality. But surely it is possible that by considering different relationships between sound and image we may produce effects and raise ideas that otherwise would not have been. Edmonds clarifies his and Fell's approach to relationships between sound and image that may occur in their work: 'The implicit correspondences between audio and visual information are not intended to correspond to any particular physical or psychological theory. Rather, they constitute the specific aesthetic of the given work.'[24] So in each of Edmonds and Fell's pieces, the specific relationships we may begin to perceive between space, timbre, colour, the timing of sounds and the timing of colour-changes constitute the aesthetic form of the work itself.

My own approach to dealing with these two independent media is to attempt to bridge the two by addressing neither directly. Instead, each work begins with the definition

22 Cycling '74, *Max / MSP / Jitter 6.0*.

23 Puckette, *Pure Data*.

24 Edmonds, Martin, and Pauletto, 'Audio-Visual Interfaces in Digital Art'.

of an abstract structure, and a consistent mapping of that structure to both sound and video. Having created a software system to implement this definition, the process of composition becomes a manipulation of the structure over time. The structure is effectively acting as a medium, obviating the need to consider the sound and video independently.

3.4 Process in art and music

In his *Variations* series John Cage defines indeterminate processes that take place during each performance.[25] To Cage, indeterminate pieces are experimental by nature – each performance of a genuinely indeterminate work is unique, and therefore becomes a singular object in time.[26] The privileged position of the 'composer' is removed as the composer can be no more aware of the outcome than an audience.

Where Cage focusses on the event at which these indeterminate processes take place, other approaches (especially in early conceptual art) focus on a presentation of the material artefacts of process. For example, John Baldessari's early photographic works, such as *Trying to Photograph a Ball so that it is in the Center of the Picture* present a number of photographs showing attempts at the goal specified in the title (with varying success).[27] A viewer of the work might have their attention drawn in several directions – to the formal aspects of the photos themselves, to the historical existence of the event at which these photographs were taken (as described in the title), to an evaluation of success (with respect to the specified goal) in each individual photograph and the overall political and aesthetic implications of the work's existence (including Baldessari's attempt to escape from traditional rules of photographic composition).

Sol LeWitt's work reflects his famous description of conceptual art that 'The idea becomes a machine that makes the art.'[28] Many of his two-dimensional works are exhibited as the material manifestation of a precisely-defined mathematical set. For example, in his 1980 silkscreen work '*All One, Two, Three, Four, Five & Six Part Combinations of Six Geometric Figures*', LeWitt presents each of these defined combinations (192 figures in total) together. Like Baldessari, his use of the title disambiguates the concept behind the work. But where Baldessari's title refers to a historical event, LeWitt's draws attention to an entirely abstract mathematical structure, notionally independent of time and space.

25 Cage, *Variations I - VIII*.

26 Cage, 'Composition As Process: Indeterminacy'.

27 Baldessari, *Trying to Photograph a Ball so That It Is in the Center of the Picture.*

28 LeWitt, 'Paragraphs on Conceptual Art'.

An important drive of Cage, Baldessari, LeWitt and many other artists seems to have been to remove their own control over the fabrication process, and therefore eliminate the influence of traditional rules of formal composition and the possibility of self-expression. In Baldessari's case this is by defining and executing a process which is only tangental to the final formal outcome, and in LeWitt's case, by defining the work conceptually and giving it to others to actually fabricate. For other artists seeking these ends, early computers must have held a significant appeal. The writing of a software program is itself the specification of a process, and once in execution, the artist relinquishes control (in non-interactive situations). Further to this, the computing power available opens up the possibility of solving significantly more complex problems, or generating more complex structures.

Ernest Edmonds describes how he determined a layout for his work *Nineteen* in 1970 using a FORTRAN program.[29] Twenty unique, approximately square pieces were to be arranged in a 4×5 grid, subject to a particular set of logical conditions. A process was run by computer to search for a layout that satisfied all these conditions. Because the logical conditions yielding the piece's layout are not available to the viewer and they are not intelligible from the work alone, the work must be understood from a formal point view.

Presenting multiple images produced from related algorithms is often likely to reveal more about the process used. For example Manfred Mohr's combinatorial exploration of cube transformations present all combinations of a particular set of transformations using simple line representations of three dimensional cubes.[30] Rather like some of LeWitt's sets, this abundance of information somehow points to the process at work.

Edward Zajec wrote somewhat pessimistically of his early computer works:

> 'When the output of these programs was exhibited as stills in the form of computer graphics, I realized that the structure of the underlying process was of little or no relevance to the viewing public. This opened up a whole set of new problems which could be summed up by saying that no relevant contribution can be made by using the computer in the arts unless the public can be coinvolved as an active participant.
>
> Computer graphics in this context merely represents a transition stage. They stand as stills in a process in motion and fall short of

29 Edmonds, 'Constructive Computation'.

30 Mohr, *P-155-R*.

> realizing the full potential of the medium.'[31]

Zajec believes (at this time) that as his still works do not reveal their processes, they are not of interest to the viewer.[32] Only by interacting with the computer can a viewer become participant and begin to appreciate the processes at work. This frustration perhaps explains why Zajec adopted computer video as soon as realistically possible. If emphasising process itself is a concern, time-based compositions afford many extra possibilities.

In his 1965 piece for magnetic tape *It's gonna rain*, Steve Reich takes a single recorded phrase and loops it independently on two tape players, at first in synchronisation, but then allowing each to gradually desynchronise, or change in phase.[33] As this process occurs, new rhythms and patterns are observable as the temporal relationship between the two phrases changes. In his 1968 essay 'Music as a Gradual Process' Reich writes:

> The distinctive thing about musical processes is that they determine all the note-to-note (sound-to-sound) details and the over all form simultaneously. (Think of a round or infinite canon.)
>
> I am interested in perceptible processes. I want to be able to hear the process happening throughout the sounding music.
>
> To facilitate closely detailed listening a musical process should happen extremely gradually.[34]

3.5 My use of process

In all the works in this folio, I use automatic processes or algorithms. When constructing the work, this is for experimental reasons – I find it much more interesting to be uncertain of the aesthetic outcome of a particular algorithm until it is run. There is no iterative structuring or layering of material – I perceive a potential piece of material for the first time, in its entirety. Forms appear that I would not have composed myself. When I use processes that seem relatively predictable, and something unforeseen occurs, the event is more surprising. When I present these results to an audience, they experience them in much the same way. I find particularly interesting the perceptual and cognitive interaction between time-based processes and the forms they generate: the changing of form over time

31 Zajec, *Artist and Computer*.

32 This also carries the slightly odd implication that there is nothing of formal interest within the images.

33 Reich, *It's Gonna Rain*, (1965).

34 Reich, 'Music as a Gradual Process'.

reveals (partially) the nature of the process to us, and our understanding of this process affects our expectation and anticipation of future form.

I prefer to perform most works. This is not because I enjoy improvising – most of my live performances are thoroughly prepared beforehand, or sometimes even entirely automatic. It is more the knowledge that the processes (even if entirely deterministic), are occurring simultaneously to the material they generate. A screening or recording of a work becomes an artefact or documentation of a past event (or past process). As I am often presenting discovered material that had an unexpected effect on me, I am also interested in how other people interpret or are affected by this material. When I am structuring work, I often consider how the structure I am creating will exacerbate or reduce these effects on the people experiencing it. Often this will result in me organising material in the same order as I created it – a series of experiments, with each guided by the results of the one before it.

4 Methodology

In this section I will give an overview of the process by which I arrived at this folio of compositions, in terms of theory, experimental practise, self-reflection, expert opinion and performance. In the individual commentaries which follow this, I describe in more detail the motivation for the work in terms of the preceding work, and my thinking at that point.

My approach to these issues stayed consistent over the course of creating the folio. Here I describe the typical approach I might take to create a new composition. I begin with a concern, or set of concerns that I wish to explore. Whilst I may consider these theoretically, these issues will concern the aesthetic result of a composition, and its reception perceptually and cognitively. Usually they address issues which were raised after reflecting on preceding works, but may also integrate issues that have been raised from an external source, for example the practise of another artist.

I am then looking for an idea for a process, a practical series of steps I can take to explore these concerns. This is not an instant decision, and is often something I consider sporadically over a significant period of time. This is a critical stage in the composition, as it is the choice of this process which will largely direct the aesthetic outcome of the work. The idea I arrive at usually takes the form of a specific system (usually a computer program) that has the capability of producing a limited aesthetic range of sound and/or video material in response to further input of some kind. Although I may have some idea of the kind of material I will be able to produce with a system, the results are largely unknown until I have created it. I will usually have multiple ideas and reject all but one. This selection of a system relies largely on an intuitive evaluation of the potential of the system to produce interesting results – I would find it difficult to justify my decision rationally, even when I feel quite certain I have made a good choice.

There is now a period of work, prior to any material being created, where I must carry out this initial process, for example by building a computer program that implements the system I have conceived. An important element is designing the interface by which I will interact with the system to produce material. This is not necessarily a typical computer GUI, but could consist of a programming API in a particular language, or a set of objects in Pure Data which can be reconfigured and manipulated.

After this system is complete, I begin to create work by exploring the system I have built, with my initial concerns in mind. This is the first time I get to experience any material generated by the system, and I will often go back and modify the system as a result of this. Experiments, followed by an evaluation of their outcome typically direct further experiments. To me, the most interesting outcomes are those with results that I did not anticipate. It is these unexpected results that tend to direct and develop the aesthetic of the work, and often may go on to motivate concerns for future work.

As I become more familiar with the system I begin to consider the broader aesthetic form of the composition, and begin to make choices as to what material I will use, and how I might structure it. It is at this point that I often feel it useful to consult other art and music practitioners, and ask for feedback on this initial material. I am generally looking for qualitative criticism that may help me clarify my own feelings towards the material. Particularly useful in this process have been Solomon Burt, Roc Jiménez de Cisneros, Mark Fell, Tony Myatt, Peter Worth and Tim Wright.

There is rarely a feeling that a project is complete, but a time comes when I feel I have enough interesting material to present. It is usually an upcoming performance, or a record release that I have agreed to provide work for that motivates me to bring the material together into a unified structure. Performing a work to an audience is an important part of the development of a work for me. It not only takes it out of a context that is familiar to me, encouraging me to reflect on it in new ways, but provides informal feedback from audiences. Both verbal feedback after the event, and visually gauging the audience's reaction during the work feed into my development of the work. A result of this is that a particular composition continues to develop over a long period of time, as I reflect on the work and perform it.

COMMENTARIES

5 Four

2009. Installation work. 4 channel digital-audio, digital-video projected on to 4 Foamex boards.

Four consists of four speakers and four panels of projected video, replaying computer generated material. It is the only work in the folio to be presented exclusively as an installation. The material generated is noisy and loud, both sonically and visually. Over shorter time-spans its structure appears chaotic and unpredictable, but taking any one of its three sections as a whole, a relatively conventional, linear structure becomes apparent. It has been installed twice, at the group installations *Room Mode* and *Actuate My Void* in Halifax and Brighton respectively.[35] [36]

The system for generating sound and video material was conceived and built before any composition started. I will demonstrate that this system effectively acted as a new, digital medium, eradicating the need to consider the sonic and visual components separately for the majority of the composition process. I will also show how the characteristics of this digital medium directed the composition as a whole.

5.1 Medium

My primary goal when planning *Four* was to produce an abstract work in which sound and light would be related, but without either being given primacy. This can be seen as an early attempt to interrogate some of the issues discussed in section 3.3. At this stage in my research I was concerned with building direct, temporal correspondences between sound and light, producing '*synaesthetic'* effects. The most obvious method for achieving this is to enforce a relatively consistent relationship between sound and image at every instant (or short period) in time.

The first step was to conceive of such a relationship and implement a software system that would be guaranteed to maintain it. The idea for this system was inspired by a data sonification technique known as Audio Frequency-Shift Keying (AFSK), employed in the past by fax machines, modems and home computers storing data on cassettes. Some home-computers when retrieving this data would provide a simple visualisation for the data as it was being loaded. The first time I saw this process (as a child, on a Sinclair ZX

35 'Room Mode'.

36 'Actuate My Void'.

Spectrum), the combination of the sound and video was quite unlike anything I had seen and heard before. More recently, after analysing the AFSK techniques by which this was achieved, I realised that this area was a potentially rich medium to explore.

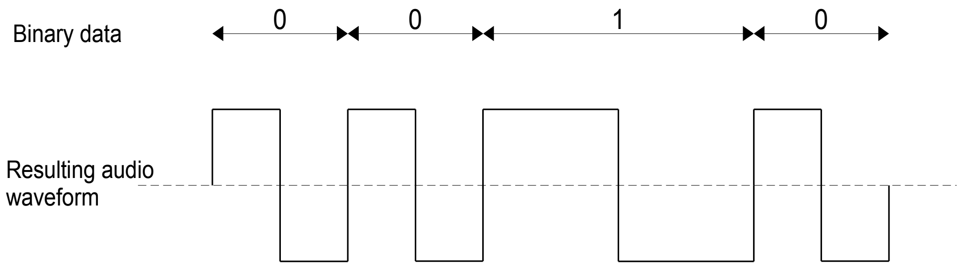


Figure 1: Example of binary Audio Frequency-Shift Key (AFSK) pattern

Received Number	Duration of Waveform Added (samples)	Equivalent Tone Frequency at Sample Rate of 96kHz (Hz)
0	8	12000
1	16	6000
2	32	3000
3	64	1500
4	128	750
5	256	375
6	512	187.5
7	1024	93.75
8	2048	46.875

Table 1: Mapping of list numbers to duration of waveform oscillation in Four.

An example audio waveform from an AFSK system is shown in Figure 1 alongside the binary data it is intended to represent. It is fairly clear from this that a '0' in the system is represented with a single cycle of a square waveform, and a '1' with a single cycle of a square waveform but twice the period (or half the frequency) of the '0'. On the ZX Spectrum this data was also visualised by setting the border of the computer monitor (or television) to one colour to represent the '0' and another to represent the '1'. As the border colour would be changed faster than the computer monitor could refresh the screen (images were formed on CRT screens with a downwards scanning motion), this produced noisy horizontal striped patterns of colour.

There is no conceptual statement intended in the choice of such a historical system. I chose it purely for its aesthetic potential. I extended the AFSK basic system to produce a wider range of material. Rather than working with binary data, allowing for just '0's and '1's, I decided to integrate all integer numbers between 0 and 8 into the system. Each *number* would be mapped to a single cycle of a waveform, with a period corresponding to a fixed number of audio samples. These are specified in column 2 of Table 1. To allow for extended dynamic ranges in the material, I also associated each *number* with an *intensity* value, a real number from 0 to 1, that controls the amplitude of the waveform for that cycle, and the brightness of the colour associated with it (an *intensity* of zero would produce silence and black). One of nine preselected colours would be associated with each *number*.

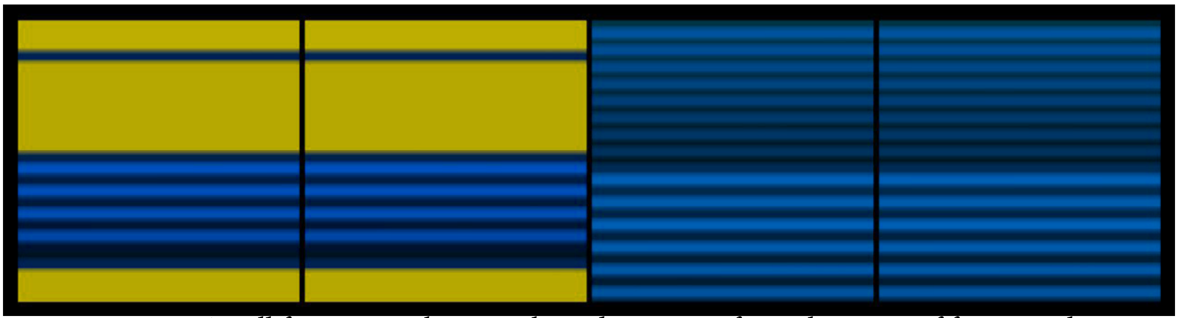


Figure 2: A still from Four showing the video output from the array of four panels.

The final sound/video system works as follows: the system receives a list of *numbers* and *intensities* generated by a process (as yet undefined). Each *number* is used to add a fragment of audio to a single output audio stream and display an area of colour in the video, with amplitude and brightness adjusted by its associated *intensity*. The audio stream produced is continuous and uninterrupted. For example, were the system to receive the list '0 4 2' it would splice together three full oscillations of length 8, 128 and 32 samples in that order, creating a total length of 168 samples. Video is displayed each frame by looking at the last *numbers* played, and for each, drawing a horizontal stripe in a colour mapped to the *number,* with a brightness related to the associated *intensity*. The width of the stripe drawn is proportional to the length of the audio fragment associated with the *number*. A still from video generated with the system is shown in Figure 2. When the system has converted all received *numbers* into sound and light, it sends a message to the process generating lists of *numbers,* requesting more.

The system was implemented within the audio/video data-flow environment *Pure Data*, through a combination of native *Pure Data* 'patches' and external code objects, written in the language C.[37] Experimentation made it clear that several instances of the sound and image running simultaneously (with potentially related material) produced a pleasingly dense sound with a more complex timbre. Multiple instances also raised the possibility of producing interesting structural relationships between each instance. I chose a static configuration of four instances of this sound and video generator, receiving four (potentially) independent streams of *numbers* and *intensities*. Each generator outputs one mono audio stream and one square of video.

37 Puckette, *Pure Data.*

This system, bridging and 'hiding' the existing audio and video technologies within the computer, effectively functions as a single digital medium. By manipulating sequences of numbers, related sound and video is produced. Whilst working with it, there is no need to consider these two elements individually, the resulting whole is experienced as a future viewer of the work might.

5.2 Structure

Characteristics of the medium

The specific choice and design of this system had by this point already constrained, or rather defined, many aesthetic aspects of the material it could generate. For example, anything generated using the system will necessarily have consistently related audio and video at any one moment in time.

Any sound produced by the system is guaranteed to include frequencies up to the Nyquist limit and have a 'hard' sounding timbre. As it is only possible to produce single oscillations corresponding to 9 different frequencies, slow subtle changes of timbre are not possible. Instead, steady tones can be produced by sending repeating patterns of *numbers*, or chaotic, textural sounds by sending rapidly changing or unpredictable *numbers.* Due to the process of joining whole audio waveform cycles, these rapidly changing *numbers* also introduce extra high-frequency components that are perceived as noise. Desirably, many of these effects have a visual analogue. For example, rapidly changing data produces rapidly changing and fragmented areas of colour that are also perceived as 'noisy' in a visual sense.

Sending a continuous stream of the same *number* will produce a series of oscillations of identical period. Hence this will produce a steady tone with a fundamental frequency of that shown in the third column of Table 1. From this it can be seen that 9 possible *numbers* were chosen because they can produce fundamental frequencies that cover the majority of the audible frequency range (approximately 20 Hz to 20 000 Hz). It is important to note that the fundamental of each tone is half the frequency (or one octave down) from the previous. Any exactly repeating pattern of *numbers* will act as an oscillator in its own right and produce a continuous tone with a fundamental frequency related to the period of one iteration of the pattern. For example sending the *numbers '3 4 3 4 3 4 3 4...'* will produce a tone with a fundamental period of 32 + 64 = 96 samples, or 1000 Hz (at a 96000 kHz sample rate). Tones made out of longer patterns will inherently carry more high frequencies as they are made up of more sub-waveform-cycles. Such repetitions are seen visually as a regular repeating pattern of coloured stripes. The longer the repeating pattern of *numbers*, the more complex the repeating pattern of stripes, and the more high frequencies are present in the sound.

Testing the system in various situations, it became clear that the full frequency-range sounds and bright colours produce material with a brash and brutal nature. It is the result of an explicitly digital process – the sound and video is quantised and acoustically and visually unprocessed, or 'dry'. The piece seems to work more interestingly when its visceral, material form is emphasised with loud sound and large-scale video. The first presentation of the work was under an old viaduct arch in Dean Clough, Halifax. To my initial surprise, the dry, digital sounds combined extremely well with the reverberant space, and the bright, noisy squares cast ambient light that illuminated the surrounding arches. This contrasting space, rather than distracting from the work actually seemed to exaggerate its hard-lined, digital character. Footage from this installation is included with the folio.

Each of the four sound and video generation systems consists of a single speaker, and a roughly one metre square suspended screen on which the video is projected. Projecting flush with the edge of each suspended screen produces a very high contrast between the black, lightless background behind the screen and the bright square of video on the screen. Four of these speaker and screen systems are aligned horizontally.

Producing Structure

Having established this medium, various exploratory algorithmic processes were implemented in *Pure Data* using multiple methods to generate the four streams of *numbers* and *intensities* necessary to produce material.[38] *Pure Data* most naturally represents static systems. Its event-based data-flow paradigm does not afford the easy creation of algorithmic, or even linear temporal structures. Most of the algorithms in *Four* use a form of 'shaped' random numbers, or unpredictable feedback systems to produce short-term structural elements. Employing similar techniques to control longer temporal structures in the work proved unsuccessful, so manually controlled parameters were added to allow a manipulation of the material over time.

Of the sixteen algorithmic processes created, only three were retained in the final work. Rather than attempt to compose one long temporal structure for each algorithm, I decided to divide the material from each algorithm into several subsections, separated by passages of silence and blackness. These provide a temporary respite and interesting

38 Ibid.

contrast to the often aggressive, loud and bright material. Each of the three algorithms used produce characteristically different material. The first uses gradually changing patterns of numbers to produce chaotic textures, interspersed by patterns of sustained tones. The second uses a feedback process where statistically generated numbers are fed back into their own generator. This produces very unpredictable behaviour, that shifts autonomously between several observably different states. The third system uses a photo (of a flamingo – not visible within the piece), and selects pixels from in it in a circular motion which are translated to *numbers* and *intensities* to create repeating patterns.

5.3 Discussion

Temporal Structure

Taking a single frame of video, and associated fragment of audio, there is likely to be little perceived relationship relationship between the two. The strongly perceived unified relationship between the sound and video emerges from the related patterns of change within the independent content of the sound and video. The relationship is of a synchronous nature, isolated to a moment in time. There is a perceptible short-term interaction between the two, but the medium has no further temporal characteristics, and importantly, suggests nothing of how we might temporally structure a composition within it. This left me with no option but to compose an unrelated temporal structure for the piece. Consequently there is a, perhaps inelegant, independence between the shorter, textural, stochastic structures and the longer, composed structures within the material.

This also seems to directly impact how we receive the material. There is no noticeable interaction between the current video and any previous or imminent audio. This lack of 'view' of the past or future seems to encourage a relatively passive form of engagement with the work. As there is little possibility of predicting or understanding what will come next, we resign ourselves to the experience simply happening.[39] If there were no discernible structures present at all, we might be able to define the whole as simply 'noise' – a structure in itself. But it is the unpredictable movement and changes between incomprehensible noise, and moments of structure that prevent this. This seems to be a common thread in the work of many musicians dealing with noise. In discussing Japanese noise artists such as Merzbow, Paul Hegarty writes:

> The disruptiveness of this 'form' or formless, as Bataille would have

39 I do not use the term 'passive' to imply a *weaker* engagement here, but qualitatively different.

> it, through volume, unpredictability and relentless change, makes a settling or dwelling difficult. This ecstatic non-music continually structures and destructures both the listening subject and the music, or, in another theoretical register, it deterritorializes and reterritorializes them. It is the movement and alternation between that makes it noise. Pure deterritorialization is an end to noise, a new locatedness, but as de- and re-territorialization play out as listener and performer alike find and lose structures, and lose repetitions and recurrence, *this* is the noise of the territory of undoing.[40]

This can be contrasted to work with elements of predictability throughout – for example consistently repeating rhythms and larger structural patterns, constructs often thought of as 'musical'. In this circumstance, our understanding of the completion of these rhythms or patterns seems to lead to an anticipatory, even analytical engagement with a work – we may feel like we are one step ahead of it at any time. An example from Western music theory would be the anticipation of a cadence towards the end of a phrase of music.

Consistency

Four could be described as noisy, both sonically and visually. Despite this, the material has a consistency of character – the aesthetic range of material is constrained by the synthesis system itself. This consistency of character can often be seen in the work of musicians producing noisy sound materials through an engagement with specific physical devices. A particularly good example of this is Yasunao Tone's *Solo for Wounded CD.*[41] In *Solo...* Tone repurposes a CD player as a sound generation and creation technology (by triggering its error-correction mechanisms). The original sound or music on the CD may vary, but the CD's 'skipping', structured by the players error-detection mechanisms produces material with a highly characteristic sound. A recording of *Solo for Wounded CD* is unlikely to contain much material that seems to belong 'outside' this sonic domain, as it is a real recording of a particular physical and electronic process.

This can be contrasted to composers constructing sound by arranging and layering multiple pieces of audio material in an editor or digital audio workstation, with time represented horizontally across the screen. A composer working this way has the freedom

40 Hegarty, *Noise Music.*

41 Tone, *Solo For Wounded CD*, CD (1997).

to introduce virtually any audio material at any point on this time-line. This places little constraint on the sonic character of the work – if it is a requirement that the composed sound works in some kind of sonically consistent manner, this will have to be imposed explicitly by the composer, through his choice of materials and processing.

The aesthetic consistency of material presented by *Four* gives the installation as a whole, a sense of unity. What is presented as four speakers and four panels (with no attempt to hide the structure of the hardware) appears as a single system, framed by the character of the material it presents.

6 Colour Projections

2009 – . Performance / Installation / Screening work. 2 channel digital-audio, projected digital-video.

Please view/listen to work before reading commentary.

Colour Projections is an audio-video work exploring a contrived relationship between geometry and sound. It is quite different from *Four* aesthetically, and many aspects of it are a response to problems raised in the making of *Four. Colour Projections'* temporal structures appear considerably simpler than those in *Four*, and as a result the work is generally experienced in quite a different way. As most of the processes used to structure the geometry over time are intelligible from viewing the work, I will not describe these in detail, but will discuss some of their general effects. I have presented this work more widely than any other, in the form of live performances (for example at Museu d'Art Contemporani de Barcelona), installations, film screenings and a video release on the record label *Entr'acte*.[42] [43]

As with *Four* I was initially concerned with producing a strong 'synaesthetic' link between sound and image. However, I was unhappy with various aspects of *Four*'s audio and video system, its effective medium. Although it defined a strong, immediate (almost instantaneous) relationship between sound and video, it suggested little of how a work within it might be structured temporally. As a result, to produce interesting structure, unrelated algorithms had to be designed to control the output of the medium at every moment – a conceptual schism between the instantaneous form of the work, and its development over time.

Colour Projections started with a simple initial concept – that geometry be deeply related to both a visual and sonic representation. A single instance of geometry should be mapped to a single discernible sound. Two instances of geometry to two sounds. There is an important difference between this system, and that used in *Four*. Where the structures in *Four* were effectively built from lists of numbers, *Colour Projections* uses geometry. It is relatively natural to consider geometric shapes as representing physical objects, and we understand physical objects to exist in time. Hence, geometry as a spatial metaphor already carries with it the possibility of temporal structure. As an existing language it also carries

42 'Audiopantalla MACBA - Monochromes'.

43 Burt, *Colour Projections [E80]*, CD-ROM (2009).

with it a rich array of well known techniques, processes and transformations (for example, the geometric union of two polygons). Due to geometry's relationship with space, many people are able to understand these processes in an intuitive manner, independently of any mathematical processes used to derive them.

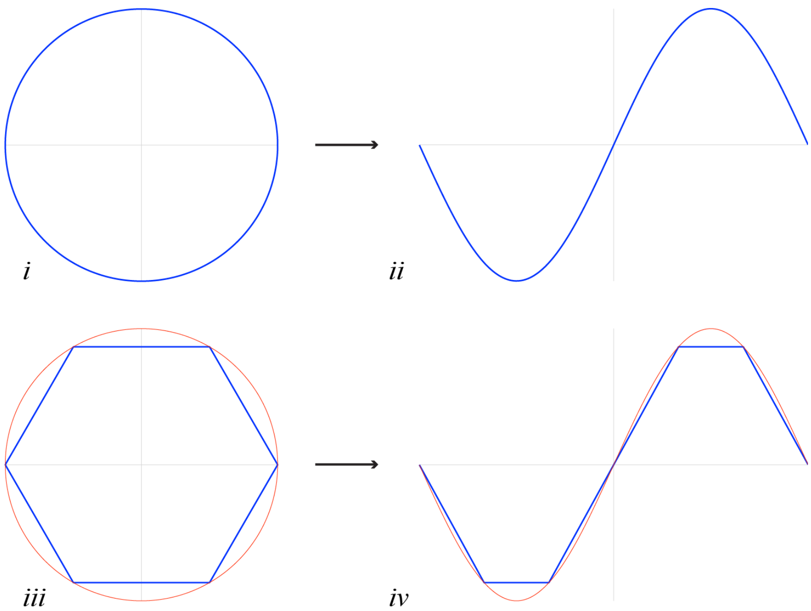


Figure 3: Mapping of regular polygons to audio waveforms in 'Colour Projections'

6.1 Medium

Development

When considering a relationship between sound and geometry I suspected that there would exist a particular one-to-one mathematical mapping between a closed 2-dimensional geometric shape (in cartesian space) and an audio-style waveform (loudspeaker cone displacement against time). Any polygon can be described as a series of angles and distances, each defining an edge in relation to the end-point of the last edge, or an arbitrary starting point. Likewise an audio waveform can be described by a series of angles and distances, with the restriction that the geometry of a waveform can not turn back on itself with respect to its axis of time. If a short audio waveform is played back repeatedly, it will act as an oscillator, producing an audio tone of a particular pitch and timbre.

The mapping developed begins with an assumption that a geometric circle maps to an audio sine wave, as shown in Figure 3, *i* and *ii.* If points were be placed around this circle, spaced at regular intervals, these points could be joined to produce a regular polygon (*iii*). An analogous effect could be achieved by placing points along the sine wave, equally spaced along the time axis and joining these with straight lines (*iv*). This process defines the mapping for all regular polygons. Simple calculus can be used to generalise this procedure for all polygons (bearing in mind that curved surfaces can be approximated by a polygon with many sides). An elegance of this mapping is that all closed polygons will produce a wave starting and ending with the same displacement, producing a continuous waveform.

To aid an understanding of the mapping, it helps to imagine a point travelling at a constant speed in a loop along the perimeter of a geometric shape. With each cycle of the perimeter, a new cycle of the waveform has been generated. An implication of this is that the length of time for a single iteration around a shape (in which a single cycle of the waveform is produced) is directly proportional to the perimeter of the shape. Therefore a shape twice as large as another, similar shape will produce a waveform of twice the period, half the frequency, or one octave down. The pitch of the tone produced from a shape is therefore directly proportional to its perimeter.

A system was implemented to receive changing descriptions of geometry in real time, and visualise and sonify them using the above mapping. The system can process multiple instances of geometry at once, and was implemented as a series of objects for the software *Pure Data*, in C.[44] The sonification process requires a relatively large amount of calculation, and implementing a real time version of it within the limits of available computing power involved some complex optimisations and various compromises. For example, curved surfaces had to be approximated using many polygons. Also, it is not reasonable, computationally, to recalculate all geometry at every sample, or every sub sample, so a geometric 'frame rate' had to be decided upon. This discrete approach would have produced artefacts in the audio, so the audio output actually fades between waveforms over very short periods of time. A more advanced system would model geometry entirely continuously, both spatially and temporally, but this would be computationally prohibitive with existing technology.

Synaesthetic effects

This systematic relationship between sound and geometry has various interesting properties. Single shapes can only really produce sounds of limited complexity over time, being composed of just a single oscillator. This is particularly desirable as it draws attention to the timbre of the sound, which is consistently related to the shape of the geometry. An effect, documented by the gestalt psychologist Wolfgang Köhler, known as the 'bouba'/'kiki'

44 Puckette, *Pure Data.*

effect describes how these two 'nonsense' speech sounds are consistently mapped to soft and sharp shapes respectively by subjects of various ages from various cultural backgrounds.[45] The study (and many others since) imply that humans consistently find some sounds to be more related to some shapes than others. A commonly suggested reason for this (though purely theoretical) is that sharp shapes imply hard physical objects, which have a tendency to produce acoustic sounds with higher frequencies when struck or dropped, for example.

In the mapping for *Colour Projections* described above, soft, curved shapes with no pronounced corners produce soft, curved audio waveforms. These waveforms, when cycled as an oscillator create sounds with fewer high harmonics (and therefore fewer higher frequencies) present. On the other hand every corner on the geometric shape will produce a corner in the waveform, and these will introduce higher harmonics and frequencies into the generated sound. This relationship supports the perceptual associations noted in Köhler's work. Plenty of studies have also shown a perceptual relationship between low-frequency sounds and size. For example, Sapir's famous study shows that nonsense words containing an 'i' as their main vowel were related to a small object, and words with an 'o' or an 'a' sound, related to a larger object (the 'i' sound contains many higher harmonics than the 'o' and the 'a').[46] Bien et al have also shown a common association between pitch and object size.[47] This may be related to a correspondence between the naturally occurring resonant frequencies of objects. In *Colour Projections*, the mapping's characteristic of producing lower pitched tones for larger shapes is consistent with this effect.

6.2 Structure

As with *Four* the system to sonify and visualise the geometry (and hence control the relationship between sound and image) was defined and implemented first, and effectively defines a medium for the piece. To create material, mathematical descriptions of multiple geometries and their changes over time are sent to it. To aid with experimentation, many new objects were created for *Pure Data*, that generate and transform geometry. For example, one object outputs a regular polygon with a specified number of sides. Other objects translate, scale and rotate geometry. More complex objects perform operations such as geometric unions, intersections, and polygonization of overlapping shapes. These were written in C incorporating the open-source library GEOS to accomplish the more complex

45 Köhler, *Gestalt Psychology*.

46 Sapir, 'A Study in Phonetic Symbolism'.

47 Bien et al., 'The Sound of Size'.

transforms.[48]

I initially approached the medium with complex constructions of geometry including various indeterminate and statistical elements. An early experiment included randomly placing twenty or thirty lines approximately crossing the centre point of the geometric space, then very slowly and randomly rotating them whilst moving them away from the centre of the geometric space. As this was occurring, all these lines were run through a single 'polygonization' process that at every instant identifies all polygons formed by the intersection of these random lines. It was these polygons that would be sonified and displayed. This produced clusters of tessellated, gradually mutating polygons. I was dissatisfied with this approach – the complexity and randomness of the processes involved tended to obscure the 'synaesthetic' elements of the relationship between the sound and geometry. I began to experiment with simple, precisely-defined, deterministic systems. I found that these simple systems had an intelligibility and predictability that allowed quite unexpected effects to emerge (I will describe some of these later). This change in practise, from directly composing complex structures, to allowing interesting structures to emerge from relatively simple systems has reflected itself in virtually every work in this folio following *Colour Projections*.

As with *Four*, what emerged from this process was a series of related but independent, compositions within the medium. As with *Four*'s use of colour-sets to discriminate the three algorithms working, colour-sets are used in *Colour Projections* to group together compositions working with related systems. For example, the series of compositions dealing with circles moving with sinusoidal horizontal motion all have a red background, with lighter red lines for the sonified shapes and darker red, dashed lines for the source shapes that are being manipulated.

6.3 Discussion

Complexity

Colour Projections is in many respects a response to issues I encountered when producing *Four*. There are similarities between the pieces – both were created by manually imposing temporal structures on emergent, often unpredictable systems. However, in *Colour Projections* there is a precisely-defined relationship between the imposed temporal structures and these emergent effects, and this relationship is often self-evident when

48 *GEOS - Geometry Engine Open Source.*

observing the work. This contrast may be clarified with an example from each work.

In the first (of three) sections in *Four* the chaotic, statistically generated background texture shifts slowly from favouring low-frequency sound components and one set of colours, to high-frequency sound components with a different set of colours. This shift occurs over several minutes, and is a direct result of smoothly changing a parameter over this time. This was a compositional choice affecting the temporal structure of the work. The shift is clearly identifiable when experiencing the piece, but the 'finer-grained' aspects of the temporal structure, its chaotic texture, is effectively independent of this change.

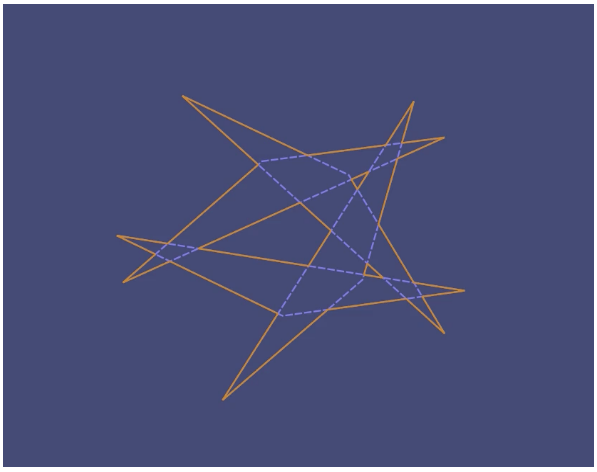


Figure 4: Still from Colour Projections

Contrast this with a relatively complex section of *Colour Projections*. Four identical shapes, elongated isosceles triangles, sit 'on top' of each other exactly. The system sonifies only the geometric union of these four shapes. The shapes begin to rotate anticlockwise at different, but related, speeds. As this occurs, the shape of their union becomes more complex, producing changes in timbre and pitch that are clearly related to its outline. The axis for the rotation is outside the triangles, so they effectively shift in position as well as rotation. When this happens, the shape of the union becomes dramatically more complex, occasionally producing a single shape with several 'holes' in the middle. A still from this process is shown in Figure 4.[49] The outline of these geometric 'holes' is also sonified. What results is strikingly complex and often unpredictable, yet is quite explicable given the process that is observably taking place. It is clear that the moment to moment complexity is a result of the wider temporal structures.

49 The shape in Figure 4 can be seen to be structurally composed of four elongated triangles (light blue, dashed lines). The geometric union (orange lines) is being sonified. This includes the outline of the union, and the three 'holes' generated by the union.

Process

The geometric processes that form and create the compositions in *Colour Projections* are both simple, and can often be intuitively understood. It is the combination of the intelligibility of these processes and the form itself that provide much of the interest when observing the pieces. It could be said that these processes provide a context for the sound and image that they generate. As I discussed in section 3.4, it is perhaps the temporal nature of the medium that affords this. It is considerably more difficult to provide material that emphasises the process used to create it in a temporally static media such as painting or sculpture, without providing extra disambiguating information.

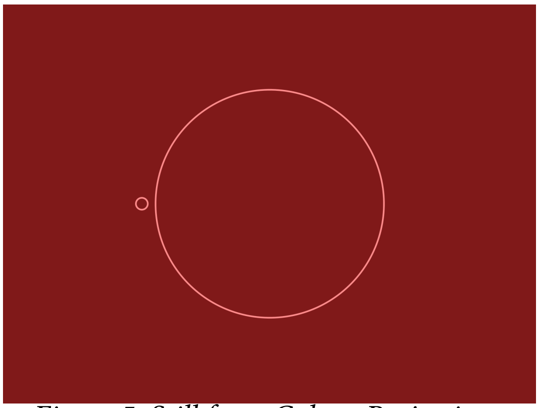


Figure 5: Still from Colour Projections

Temporal Effects

The predictability of the systems often appears to change the character of longer durations of time, by forcing an anticipation of future events on the observer. I will analyse one such structure here. A small circle moves across the screen from left to right over a period of three minutes (see Figure 5). In the centre of the screen is a much larger stationary circle. As the small circle moves towards the large circle, we can hear a steady high and a low sine wave (generated from the sonification of each circle). There is a period of approximately 70 seconds before the small circle 'touches' the large circle, and during this period there is no change in the sound and the only visual effect is the slow, steady movement of the small circle. This sound alone, repeated for this length of time, might well provoke boredom. However, due to the simplicity of the system, it is clear that at some point the small circle will overlap the large circle and from previous experience we can be reasonably sure some kind of sonic event will occur, although its exact nature is unknown. The effect of this expectation is that what may have been a frustrating period of boredom becomes a frustrating period of anticipation. The psychological effect of attention on perception of time has been well studied, for example by Block et al.[50] If we are anticipating and directing our attention towards the circles, this may causes us to perceive a longer duration than is actually occurring. As the small circle nears the large, we may focus even more intently on it, causing time to appear to draw out even further in these final seconds. I explore this effect in several other works within *Colour Projections.*

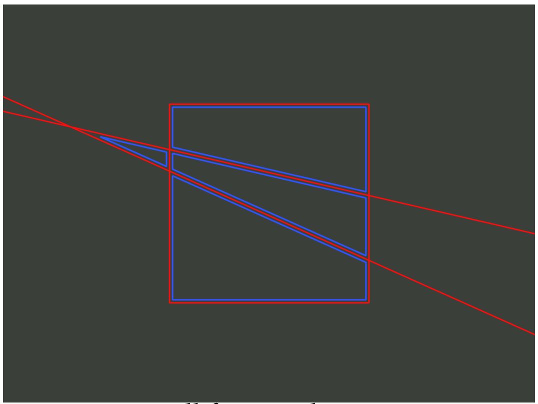


Figure 6: Still from Colour Projections

Illusion and its Breaking

There are various events that occur in the compositions that are surprising the first time they are experienced. The most surprising moments tend to come from systems that seem simple and predictable, and can be followed and understood as they are being observed. These moment occur when the results deviate from our expectations, or complex behaviour emerges from a simple system. They are not contrived – when they occur it becomes obvious why they occurred, it is our assumptions or generalisations that were wrong.

An example of such a moment occurs in the following system. There is one large stationary square, and two lines, each passing roughly through the centre of this square. This geometry itself is unsonified. The lines are slowly rotated anticlockwise at different speeds. The system runs a 'polygonization' on all geometry at every instant. This creates new polygons formed by the intersection of the square and the two lines. Each of these new polygons is drawn and sonified, changing in timbre as they gradually mutate. Initially all these new polygons are within the bounds of the square, covering its whole surface. At one point, however, the two rotating lines intersect each other *outside* the square, forming an external polygon, as shown in Figure 6. This often comes as a surprise, but after it has occurred, it is clear why it did.

I will suggest a way of describing some of these effects, if we consider geometry as a spatial metaphor. A visual representation of geometry must cover real space. When

50 Block, George, and Reed, 'A Watched Pot Sometimes Boils'.

observing it, we may at times forget that the geometric shapes that we are watching are part of this metaphor, and interpret the situation as objects existing in real space, subject to the constraints of the world as we understand it. These moments of surprise occur when a geometric operation causes a state that does not correspond to a situation we could understand in real space (such as the polygonization operation described above). It is at this point we are jolted from an illusion of real space back to an understanding of the system as a spatial metaphor, or geometry.

Conclusion

I continue to consider the *Colour Projections* project, and still perform and screen it. A later set of work in this collection, *Colour Projections / set 2* returns to the same system and uses it to investigate some specific ideas. I suspect that there is still much potential and much left unexplored in this medium, and intend to work with it indefinitely.

7 Control Processes

2010. Screening work. 2 channel digital-audio, projected digital-video.

Please view/listen to work before reading commentary.

Control Processes is a series of 6 sound and image compositions, each based around a relatively simple, deterministic process. A series of images representing the current state of the process are shown in synchronisation to the sound generated by the process. Images are held for long enough to perceive them as images, rather than animation, removing the potential for any directly 'synaesthetic' links between sound and video. *Control Processes* is probably the work I have exhibited the least. I presented it with *Colour Projections* at Museu d'Art Contemporani de Barcelona, but other than this have only presented excerpts from it during presentations and seminars.[51]

Colour Projections was an important step for me. It develops a 'synaesthetic' link between sound and geometric shape and uses precisely-defined processes to produce compositions with relatively simple structures. These structures seem to be experienced quite differently from the chaotic, textural material of *Four*. *Control Processes* began as a sound-only piece with a specific objective – to use precisely-defined processes to temporally structure sound, in an attempt to produce similar effects to some of the compositions in *Colour Projections*, but with no visual element. On 'testing' early material on people, I found they rarely understood the sound as the result of process, but tended to listen for formal characteristics only. Interestingly, on presenting the same audio material with a visual representation of the audio's waveform, observers tended to listen for wider structures. It seems likely that we understand and interpret temporal structures very differently from static, spatial structures. However, it is unclear in this case, whether my inability to communicate these structures sonically was due to this, or whether we are simply conditioned to listening to music in a somewhat passive, non-analytical manner. These initial experiments led me to redefine the objectives of the work – instead of rejecting any use of image at all, I would disallow any direct synaesthetic relationship between sound and image. In this way, image could be used only to provide cues to encourage an analysis of the temporal sound structure.

It is highly recommended that *Control Processes* be watched in full before reading

51 'Audiopantalla MACBA - Monochromes'.

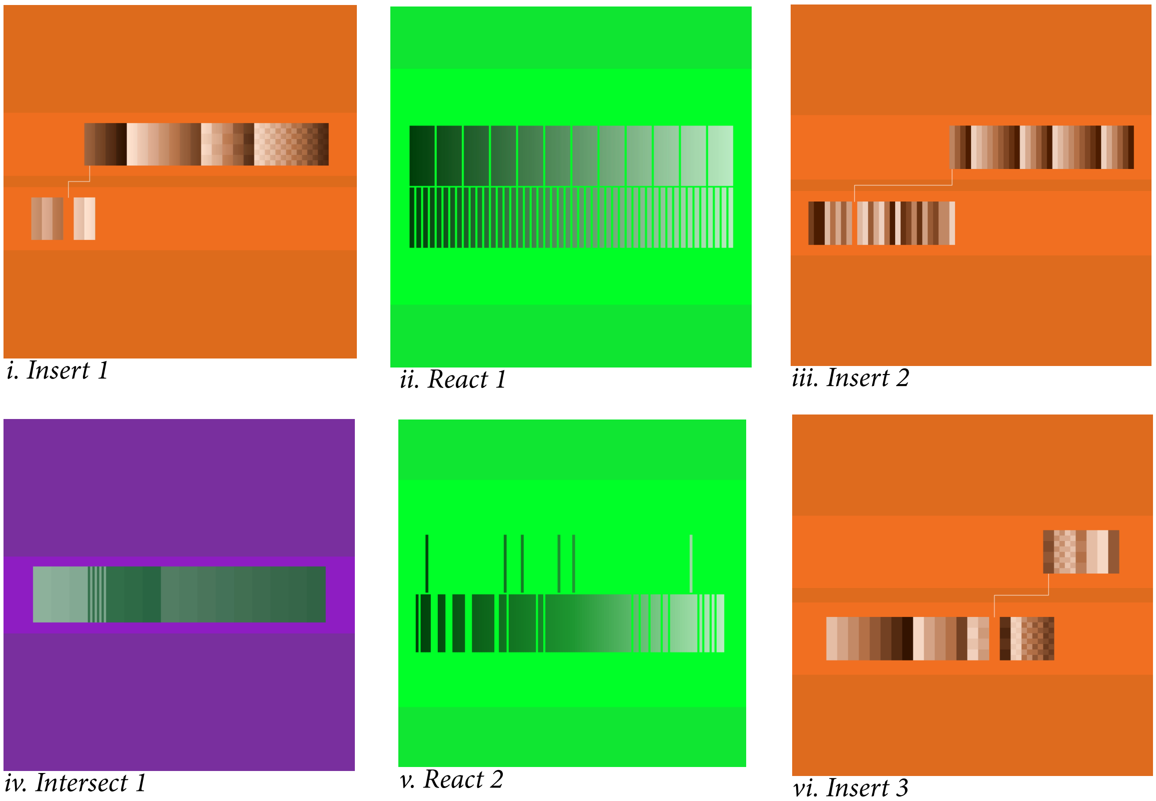
the rest of this commentary.

7.1 Medium

I felt the most appropriate way of producing these simple sound structures would be to return to the sound synthesis system created for *Four* (based on audio frequency-shift keying). Each 'channel' of the synthesiser system accepts continuous lists (or streams) of integer numbers between 0 and 8. Each number corresponds to one complete cycle of a square (or similar) audio waveform, with different numbers corresponding to a different cycle period. The synthesiser stitches these waveform cycles together seamlessly producing an audio output. Please see section 5.1 for more details.

In *Four* I had built processes to generate the lists of numbers for this synthesis system in *Pure Data*. Led by the structure of *Pure Data* itself, and a desire to create a 'synaesthetic' reaction with the video, I had tended towards producing complex, statistically generated and chaotic streams of numbers. The goal for *Control Processes* was quite the opposite – to produce no 'synaesthetic' reaction, and to produce simple material that might afford temporal analysis when listening. Chaotic and stochastic processes would only obscure such attempts.

In *Control Processes* I chose to pre-generate the six pieces rather than develop a system to generate them in real-time. The scripting language Python was specifically chosen for this, having powerful list manipulation capabilities. Each composition within *Control Processes* is generated by a single Python script running a precisely-defined process. The script is run with no interaction. When a script has finished it will have produced two channels of independent audio, synthesised using the same system as *Four.* It will also have produced a series of images, each of which is labelled (non-visibly) with a particular time, and generated according to the state of the process at that point in time. To view the work, another script combines these audio and images into a playable video file, combining images with audio, according to their timing. The effect is more analogous to a slide show than an animation.



i. Insert 1 · ii. React 1 · iii. Insert 2 · iv. Intersect 1 · v. React 2 · vi. Insert 3

Figure 7: Stills from sub-compositions in Control Processes

7.2 Structure

The work is comprised of 6 sub-compositions, each the result of a single process. The compositions are grouped into three categories, with compositions in each having related processes. These categories are explicitly demarcated in the work, using a different background colour for each. I will briefly outline and discuss each process and its output. For convenience I will use a visual/sonic/temporal language to discuss the processes, relating them to the generated material, however the processes themselves are abstract. The names below are my own references to each composition, and are not specified in the work itself.

i. Insert 1 (video 00:11s – 03:01s)

In *Insert 1,* elements from a top list are inserted into an initially empty bottom list. Each element is associated with a unique sonic tone. The process is constantly cycling through the bottom list, playing each tone in turn. As elements are inserted and the bottom list grows, the generated sonic cycle becomes more complex. The position of each insertion into the bottom list is not random – there is a fixed time interval between each insertion and it occurs at the current position in the playback cycle. When all elements have been inserted into the bottom list, the process terminates.

Observing the work for the first time, the process generating this material might be too complicated to comprehend entirely. But it will be relatively clear that a repeating pattern is being built up, and that there is some kind of progression in the sound events shown in the top bar. There is enough of a pattern to understand that the work is progressing, and must have a finite duration (the top bar is decreasing in length). There are unpredictable elements – it is not clear what the vertical bars subdivided into squares might represent, or how they might relate to the sound.

ii. React 1 (video 03:12s – 05:50s)

The process generating *React 1* takes two fixed lengths/durations and subdivides them into a number of pieces of equal length/duration. The top length is initially undivided, and the bottom length divided into 48 sections. At each stage in this process, one audio channel plays the same number of sound events as there are subdivisions in the top length, while the second audio channel plays the number of subdivisions in the bottom length, over the same period of time. At each stage the top length becomes increasingly divided until it has the same number of subdivisions as the bottom section. At this point the bottom length becomes decreasingly divided until it is one piece.

This process is relatively intelligible from the material alone, and the predictability of the process provides much of the structure of the work. Perhaps the most interesting aesthetic effects in the work are in the synchronisation and desynchronisation of the repeated sound events between the two output channels, and how these effects have a clear visual analogue. For example, when the number of subdivisions in one bar is an exact multiple of the number of subdivisions in the other, sound events will be triggered in synchronisation when they occur. When one number of subdivisions is not a multiple of the other, synchronisation moves in and out of phase, sonically and spatially.

iii. Insert 2 (video 06:01s – 08:52s)

Insert 2 uses an almost identical process to *Insert 1,* with an overall increased cycle speed – each element in the list is played back over a shorter duration. As a result it uses a longer list of 60 elements divided into two groups repeated four times.

Due to the increased speed, the sonic result in *Insert 2* is quite different. In *Insert 1*, the formed list is cycled through at such a speed that a repeated pattern of individual tones can be heard. Here, the tones replayed are so brief in duration that they perceptually merge to form a textural whole.

iv. Intersect (video 09:02s – 11:06s)

In *Intersect*, two ranges are defined over a sequence of 16 divisions. Each range is four divisions wide and they begin at opposite ends of the sequence. At every stage of the process, the second range is moved one step towards the first, until eventually it touches, then overlaps (intersects) the first range. At each stage, the state of the sequence is sonified by playing a sequence of tones dependent on the situation at each division. The first range is sounded as a series of steady tones in the second audio channel, and the second range as a series of steady tones in the first audio channel. Where an intersection is formed by the two ranges overlapping, multiple tones are alternated in both audio channels.

This particular section within *Control Processes* is the first I completed, which perhaps explains why it is the one most directly analogous to a specific work in *Colour Projections.* In section 6.3, under *Temporal Effects* I describe a situation where a small circle moves towards a large circle. This piece is similar in that it involves a simple, predictable progress, and encourages the anticipation of an event of which the result remains unknown (the collision or intersection of two entities).

v. React 2 (video 11:15s – 14:06s)

React 2 has a roughly analogous structure to *React 1* in that a series of steps take a first structure to the same state as a second structure, and then the second makes a series of steps to take it back to the state originally held by the first.

In this case two arrays are displayed, the top array is full, and the bottom has only a few elements filled in. At each stage of the process, elements from the top array are removed in a predetermined order, until both arrays have the same set of elements filled. Elements are then added into the bottom array in the same order they were removed from the top array, until the bottom array is full. Although not displayed visually, each element of the array contains a number from zero to eight that represents one of the pulse widths in the sonification system. The values of these numbers are arbitrary to the outcome of the process, and were pre-generated semi-randomly – their only effect is to produce a distinctive sound when replayed. At each stage the contents of each array are played to an audio channel, fast enough that the result is perceived as textural rather than as a series of individual tones. Wherever an element has been removed from the array, a quieter tone of fixed pitch is played for that moment. In this way a fragmented, sparse area visually will be accompanied by a fragmented, sparse sound.

vi. Insert 3 (video 14:16s – 17:01s)

Insert 3 provides a final variation on the initial insert process (*Insert 1*). In this case, the elements shown on the top bar appear to be in a random order. Otherwise, the process proceeds using exactly the same algorithm as *Insert 1*. In fact, the initial order has been defined such that when the entire process is complete, they will have been assembled on the bottom bar in the order first shown at the beginning of *Insert 1*.

7.3 Discussion

Control Processes occupies an interesting position in relation to *Four* and *Colour Projections,* rejecting the directly 'synaesthetic' relationship between sound and image in both. Material is generated through a series of precisely-defined, deterministic processes. These processes are at least partially intelligible through observation of the material. By repeating and varying processes (for example there are three variations of the *insert* process) I attempt to create a wider temporal structure for the individual sub-compositions.

In section 3.4 I mentioned Reich's phasing pieces, and his interest in revealing process through a gradual progression. The processes in *Control Processes* are more complex than Reich's phasing and perhaps more abstracted too – the processes I have chosen are not intrinsically related to sound or image, or even necessarily temporal, rather sound and image are mapped to these processes through time. I failed in my attempt to keep these processes intelligible using sound alone, but the addition of images at relevant times conveys a large amount of information, and allows these abstracted processes to be (at least partially) intelligible. Unlike Reich I find it interesting to allow an understanding of these processes to unfold gradually over time. I do not deliberately contrive to withhold information but rather specific elements of a process become more clear as they become relevant. This seems to encourage the listener/viewer to create their own structures of anticipation and expectation over the course of the work.

8 Summer Mix

2010 – . Stereo audio tracks and images.

Please read this commentary before listening / viewing work.

Summer Mix is a project in which an automatic mathematical transform is used to produce new material from anthemic house and trance music and its artwork. Individual instances of sound and image created by the project are independent, related only in that an equivalent process is used to generate both.

The material presented includes a number of transformed images and several sound compositions. Each sound composition is created from a sequence of several transformed music tracks. In performances, releases and exhibitions of the material, I provide a brief description of the transform process and the titles of the relevant source music or artwork. A CD of the sound material was released on the record label *Entr'acte* in 2011, with an accompanying postcard showing an image from the project. There is an intention in the future to hold an exhibition of printed images from the project. I have also recently performed live mixes of material from it, including at CTM festival 2013 in Berlin.[52]

In *Colour Projections* and *Control Processes,* sound and image material was generated from determinate processes. *Summer Mix* began as an experiment in an alternative use of process to create sound material. Rather than defining a number of processes that would each generate unique sound material, I picked one simply-defined transformation process and applied it to a number of different source materials. This was interesting to me, as I had previously always used processes with tonally simple synthesis techniques to produce sound material that would optimally highlight any relationship between sound and image. By applying a transformation to pre-existing audio, I could create material with a less restricted range of timbres. In *Summer Mix,* I state the source material with any transformed material presented, in the hope that this will draw attention to the transformation process itself.

52 'CTM.13 - The Golden Age'.

8.1 Process

The Transformation

I will outline the transformation process in terms of audio, and describe later how this technique is applied to images. A typical musical source is a three minute, stereo track. I will firstly outline the transformation process, then I will provide some relevant background information on the techniques used.

1. Apply a single Discrete Fourier Transform to the left and right channel of a stereo music track, transforming it from the time-domain to the frequency-domain.
2. Reset all the phase data of the transformed left channel to 0º and all the phase data of the transformed right channel to 90º
3. Use an Inverse Discrete Fourier Transform to bring both channels back to the time-domain.

Audio data is commonly produced and described in the 'time domain', as a sampled waveform representing speaker cone displacement over time. This is, for example, the means by which audio is represented on a CD. The Discrete Fourier Transform (DFT), and its famous optimisation, the Fast Fourier Transform (FFT) is a process by which discrete time-domain data can be transformed into the 'frequency domain' with no loss of information. In the frequency domain, signals are represented as a sum of sine-waves of particular frequencies and phases. Due to the transform being lossless, there exists an Inverse Discrete Fourier Transform (iDFT), which takes data back into the time-domain, exactly recreating the original data[53].

Data in the frequency-domain affords manipulation in a different way. There is no discrete information about time in the frequency-domain – a sine wave described is present, unchanged in frequency and phase for the whole duration of the signal. Variation in the sound of the signal reflects itself in the complexity of the relationship between phase and frequency of the constituent sine waves. For audio processing purposes, long signals in the time-domain are generally broken into smaller pieces representing short durations before they are each transformed into the frequency-domain individually, so that information about which frequencies occur when is available. This is called a 'short time Fourier transform' (STFT).

The transformation in *Summer Mix*, detailed above, does not use this STFT, instead

53 Theoretically. In actual implementations there will be tiny rounding errors.

it performs a single DFT on each of the two channels of a single three-minute track of music. Once in the frequency domain, the sine-wave at each potential frequency carries a value representing its amplitude and starting phase. These multiple sine waves add up, cancelling one another throughout their duration, and producing the complex pattern of varying frequencies occurring at varying times that forms the original source track. Intuitively grasping the relationship between the two representations is virtually impossible. It is not clear what the phase data alone represents sonically. While it is clearly to do with time and timing, it is very difficult to understand in what way this relates to frequency. In *Summer Mix* all phase data is effectively removed, and replaced with a constant value. So half the information in the audio track is effectively thrown away, and replaced with new arbitrary information, but it is difficult to say what this half actually represented in the original music. Having replaced this information, this still represents a valid audio signal, and performing the inverse DFT brings it back to the time-domain where it can be replayed.

The same amount of the same frequencies are present in the transformed track as in the source, but all the information about where they occurred and how they were related has been replaced. An immediate result is that frequencies that were constrained to particular short durations (notes for example) in the original are potentially 'smeared' over the whole track. The overall temporal structure of the original track is completely lost.

Source Music

I tried transforming many types of sound material through the process. As most source material comprised of musical pitches and noisy impulses (for example, drums), the main constituent of most transformed tracks was a drone-like layer of noise, with drawn-out musical pitches just audible within this. The type of source material that I felt produced the most interesting results, was that which had a strong, regular beat present, for example the 4/4 beat of house music. What was particularly surprising was that at certain points in the transformed track, under the layer of noise and chords a clicking pulse, at the same tempo as the beat of the source track could be heard. The timbre of this pulse has little to do with the sound of the original beat. In fact, this pulse seems to be comprised of many more melodic elements of the original track. It as if the melodic and rhythmic elements within the original track have become fused. It is likely that the reason behind this pulse is that the regular beat is present throughout the whole track and actually ends up being encoded as a very low frequency oscillation within the signal. Once encoded as a frequency destroying the phase will not eliminate this. More complex beats do not seem to survive the transformation process this way.

Certain late house music and European trance, has combinations of pronounced 4/4 beats, and relatively short, repeated melodic phrases. I found the results of transforming these tracks consistently interesting, due to the fusion of this melodic, harmonic content with the tempo of the original beat. Much of this music is associated with European club scenes, for example the UK club and record label *Ministry of Sound*.[54] The transformation was implemented in the scripting language *Python*, with its mathematical packages *SciPy* and *NumPy*.[55] Just over 100 tracks were transformed as an automated batch process over a period of days. When the transformation process was complete I listened to each of the resulting tracks and selected those that I felt were the most interesting, individually and within the context of the other tracks.

Structure

My initial plan was to present the tracks individually, perhaps in alphabetical order, but with a few seconds of silence in between each. However, with the main beat being retained as a pulse throughout parts of each track, stylistically the transformed music still has much in common with house music. I decided it was more appropriate aesthetically to continue to treat the material as a form of house, and combine it into several mixes, as a DJ making a mix from the original source material might. This involved selecting tracks that worked well leading into one another (being of a similar tempo, for example), and linearly composing them in a digital audio workstation. Simple volume envelopes were used to fade between tracks. Some dynamic processing was also required due to some very high amplitude impulses in the transformed tracks. Equalisation was also used, as the extreme hard limiting applied to many of the source tracks had resulted in an excess of high frequencies in the transformed track, which sounded very resonant and obscured much of the other detail when replayed at higher levels of amplification.

Images

The DFT and iDFT can be applied to virtually any kind of digital signal data. There also exists a two-dimensional version of these two transforms, that can be applied to two-dimensional data. Having written the script to execute the transformation with audio signals, it was a small step to change the script to apply it to each of the red, green and blue

54 'Ministry of Sound'.

55 *SciPy & NumPy*.

colour channels of an existing image, and recombine them to form a transformed image. The transformation produces effects highly analogous to the effects of transforming the audio. The spatial structure of the image is completely lost, but attributes and elements of the original survive. The entire image becomes saturated with a chaotic noise, but the texture of the noise often seems related to the original. The overall amount of individual colours is approximately retained in the transformed image, but structurally recomposed.

Album artwork from CDs relating to the original source sound material were chosen for the transformation process. As well as providing a conceptual link between the source sound and source image, much of the related artwork includes vivid colours and often relatively simple, bold shapes. These produce complex patterns and structures of colour and texture when transformed.

8.2 Discussion

Material

An issue raised by the *Summer Mix* transformation process that I find particularly interesting is the transformation's disregard for musical meaning and illusionary objects within the source material. The source music used in *Summer Mix*, like most studio produced music contains sound structures composed from layers of instruments. For example these may consist of melodic patterns played on synthesisers, patterns of kicks and snares generated by drum machines, synthesised bass lines and recorded vocal tracks. Although the dynamics of the entire mix of these layers will be considered carefully in the production of the music, it is also usually desirable that these layers be kept perceptually separable, by carefully ensuring that instruments do not share too much frequency content or dynamic structure. This is part of what is commonly referred to as leaving 'space' within a mix. Frequency equalisation, dynamic processing and the stereo field are used on these individual layers to enhance the illusion of separate sound sources. Layers will be played back in both speakers simultaneously, but with a different loudness in each stereo channel, to produce the illusion of sounds existing somewhere between the physical location of the two loudspeakers that replay the material ('panning').

Like any music, I would suggest that familiar elements in the source material may act as symbols, referring to previous musics, cultures or ideas. Combinations of certain instruments, styles, or structural conventions may together produce subjective meaning to listeners. For example, the use of sampled piano chords often evokes early house music and its associated sampling technologies. A certain set of sounds based around multiple detuned sawtooth waveforms, originally based on a preset from the Roland Alpha Juno 2 keyboard, evokes UK hard house and the rave scene (the classic 'hoover' sound).[56]

These layers of illusion and meaning are communicated through the representation of this music as a simple stereo signal. The transformation process in *Summer Mix* is a procedural mathematical transform that works on the digital information in this signal. All these layers of meaning and illusion are disregarded by the transformation – what was the music with its various meaning becomes a simple representation of a signal again. The transform treats the signal as a whole, even disregarding its linear temporal aspects. Structural ordering and cause and effect are lost.

Despite the transform's lack of regard for these symbols, small aspects of them sometimes remain recognisable in the transformed material. The output occasionally takes on the rhythmic form of house or trance music – the original tempo is usually retained as a pulsing click, coming and going over the course of the transformed track. Due to the retention of overall levels of individual frequencies, there is a noticeable similarity between the pitches present in the transformed track and the melodies and harmonies in the source track. Meaning encoded in the choice of these harmonies and melodies may still be noticeable in the transformed output. Often these regular clicks and the harmonic content have been fused perceptually, with pulses of harmony occurring synchronously with the remains of the beat.

Potential new meanings have been formed during the transformation. There is something in the sound that is reminiscent of music released on the Berlin techno label, *Basic Channel* in the early 1990s.[57] One reviewer commented that at times the material evokes Wolfgang Voigt's *Gas* project. His 1997 album *Zauberberg* is a good example.[58] Most tracks on *Zauberberg* have layers of textural noise and harmonies, with a small beat only just audible 'under' this noise. However, direct comparisons between these projects and the output of *Summer Mix* tend to highlight the differences. *Summer Mix* is based on a single, digital transform, and the output is presented with little intervention outside of the temporal structuring. The click of the beat in *Summer Mix* remains a singular impulse, dry and almost instantaneous with no reverberation or delay effects added. There is a subtly different character to the sound.

56 EVOL, 'Wormhole Shubz (sleevenotes)'.

57 Kopf, 'Basic Channel: Underground Resistors'.

58 Gas, *Zauberberg*, CD (1997).

Of course, the choice to transform existing material this way, is equally saturated with potential meaning. The restructuring or recontextualising of existing source material was described in John Oswald's 1985 essay '*Plunderphonics, or Audio Piracy as a Compositional Perrogative*'.[59] Even the use of an automated process in *Summer Mix* brings to mind a history of experimentation with process in music and the visual arts.

Process

In *Colour Projections* and *Control Processes,* there are relatively intelligible processes generating the sound and image. By examination of the sound and image, it is potentially possible to rationally or intuitively understand these processes. The process in *Summer Mix* is different. It is relatively simple to define mathematically, but its effect is difficult to understand intuitively. By presenting multiple materials transformed by the same process, there is an invitation to try and understand the nature of this process by generalisation.

59 Oswald, 'Plunderphonics, or Audio Piracy as a Compositional Prerogative'.

9 Colour Projections / set 2

2011. Performance / Installation / Screening work. 2 channel digital-audio, projected digital-video.

Please view/listen to work before reading commentary.

Colour Projections / set 2 is a second collection of work using the sound and video system developed for the original *Colour Projections*. I will discuss here issues specific to this collection, as general issues regarding the system have already been discussed in section 6. These particular works for the *Colour Projections* system are isolated chronologically, in that they were produced a year or more after the original ones, and also conceptually in that they explore a particular theme. However, I generally consider these part of the *Colour Projections* project as a whole, and when presenting them in a live context, I often play excerpts from this and the original set of works. It has also been installed as a screening at the group sound exhibition 'Sound Spill'.[60]

In section 8.2 I discussed how I find the transformation in *Summer Mix* interesting in its disregard for and mutation of illusion and symbolic content within the original source material. The *Colour Projections* system is explicitly a two-dimensional geometric system. Solid lines forming geometry on the screen are sonified purely with respect to the relative two-dimensional position of their vertices. Hence the sound is related solely to the structure of these two-dimensional shapes. I became interested in whether given a geometry with further potential meaning (*i.e.* meaning *extra* to its status as a two-dimensional shape), the accompanying sound could be used to subvert this meaning, and draw attention back to the two-dimensional geometry.

9.1 Structure

Colour Projections / set 2 consists of three distinct but related works. I will describe and discuss each briefly here. Please watch/listen to the accompanying video of the work before continuing.

Cube (video 00:02s – 05:12s)

The first work creates polygons based on a two-dimensional perspective projection of a three-dimensional cube. The notional cube rotates in three-dimensional space. Each two-

60 'Sound Spill'.

dimensional polygon that would represent a face on the three-dimensional cube is subjected to a two-dimensional transformation, whereby the edges of the polygon are contracted by a certain distance towards the centre of the polygon. This distance is initially high enough that each polygon is completely obliterated. Over the course of several minutes the contraction distance is reduced, as this happens, polygons appear, change shape and disappear again (as the notional cube rotates). This initially produces the effect of several mutating two-dimensional polygons. As these polygons grow and form, at some point we can resolve their structure into the image of a single rotating cube. This switch in perception usually occurs quite suddenly. However, the relationship between the sound and geometry remains, drawing attention back to the mutation of the two-dimensional polygons representing the cube. The sound we hear is in conflict with our interpretation of the shapes we are seeing, reflecting the flat image, rather than the three-dimensional cube.

Whilst continuing to rotate, the perspective of the cube is gradually changed such that the projected surface is nearer the notional 'camera'. This results in greater fluctuations in the perimeter of the individual two-dimensional polygons forming the representation of the cube. This is reflected by greater fluctuations in the pitch of oscillators comprising the sound.

Finally, each individual polygon is contracted back towards its own centre, using the same two-dimensional transformation described above. However, on this occasion, guide-lines of a different colour are displayed on the edges of the notional cube. These guidelines continue to show the position of the notional cube, as the sounded polygons contract towards the centre of each of the cubes faces. The presence of these guide-lines make explicit the two-dimensional nature of this final transform, and each polygon's relationship with the cube.

M 1 (video 05:28s – 09:33s)

Rather than emphasise the illusionary aspects of a three-dimensional representation, this work seeks to draw attention to the geometry of familiar symbols, using a similar technique. Two typographical glyphs positioned to the left and right of the screen move towards, through and then past each other. The glyph initially to the right is a lower-case 'm' in the font *Times New Roman*, and the glyph initially to the left is a lower-case 'm' in the font *Arial*, flipped horizontally, so its stem resides on the right hand side of its arches. These fonts are commonly used serif and sans-serif fonts, and the default fonts on some word-processing systems.

As common roman characters, their symbolic familiarity is so powerful that their geometric structure goes largely unnoticed. However, the geometry actually being sonified is the geometric union of the two glyphs. As the two characters touch each other, their geometry fuses in to one shape. The related sound reenforces this geometric view of them, the two separate tones becoming one. As internal 'holes' form within the geometry, these are heard as individual high pitched frequencies, which come and go. An extra layer of representation becomes apparent here: due to the geometric union, we understand the behaviour of the shapes and their internal holes as belonging to that of a filled polygon. Yet the geometry is drawn and sounded as simple lines. The boundaries of an internal 'hole' in a polygon produces the same sound as the external perimeter of a polygon. As the two glyphs separate finally, we become aware of them as individual symbols again.

M 2 (video 09:43s – 16:27s)

The final work in *Colour Projections / set 2* uses a combination of techniques from the previous two. An 'm' glyph in *Times New Roman* is spun in three-dimensions on the y-axis of the geometric area. The axis of rotation is located slightly past the glyph so that the body of the glyph moves to the left and right of the axis as it rotates. Whilst rotating, another similar rotating 'm' glyph in *Arial* is revealed. While it is not immediately obvious what is taking place, the *Arial* 'm' is being geometrically subtracted from the area of the *Times New Roman* 'm', wherever they overlap (this subtraction is also known as a geometric difference).

Thus the 'm' in *Arial* is never seen as a direct geometric outline, only through its interference with the *Times New Roman* 'm'. The symbolic familiarity of the glyph is powerful enough for us to perceive its presence even through this indirect interaction. As the rotating glyphs pass each other they produce complex and detailed geometric structures consisting of sections of lines, curves and corners from the original geometry. Throughout the composition, this rotation process is slowed down, revealing the temporal formation of this geometry more clearly. When very slow (almost static) it may become difficult to continue to perceive the geometry as a combination of symbols at all.

9.2 Discussion

Colour Projections / set 2 adds further symbolic layers over the presented geometry, and then attempts to use the direct and detailed relationship between geometry and sound defined in *Colour Projections* to expose these layers, revealing their geometric construction.

This is related to ideas in *Summer Mix*. Of course it could be rightly argued that the geometry itself in *Colour Projections* has ample symbolic and illusionistic content. Not least that the geometry is represented using simulated lines produced from grids of pixels, and that the movement of geometry is evoked by adjusting the brightness of these pixels at appropriate times. This argument is recursive of course – the work cannot flatten itself into some kind of raw material, devoid of all meaning. But by exposing one layer of symbols, perhaps it may demonstrate the process by which we could go further.

10 Bastard Structures 2

2011 – . Collaborative performance work with Tim Wright. 2 channel digital-audio, digital-video projected on to corner of room with 2 projectors.

Bastard Structures 2 is a work created in collaboration with artist and musician Tim Wright. It combines intense projected strobing and geometry with synthesised and sampled drum machine sounds. The work is projected over two walls. We both independently control different aspects of the final whole, producing a series of compositions of sound, light and geometry. Performances are kept relatively brief (fifteen to twenty minutes) due to their very intense nature.

Bastard Structures (a work made previously to *Bastard Structures 2*) was a project in which we simultaneously performed sections of my work *Colour Projections* and Wright's work *8 Switches.*[61] Audio and video were played back simultaneously, with two projectors used to project fully overlapping images on the same area. *Colour Projections* contains slow moving, continuous geometry, with sustained sounds and monochromatic but strongly coloured geometry. *8 Switches* uses a grayscale palette, with fast changing, clustered circles, lines and often noisy, chaotic sound. These contrasting aesthetics combined well – for example, Wright's chaotic, statistical bursts of circles and noise would break up the relatively static sound and image of a piece of geometry I might be slowly moving across the video area. After performing this several times, and feeling it to be a success, we decided to create a new work. In *Bastard Structures 2,* we would continue to mix independently generated sound and video but unlike the original piece, we would conceive and generate original material collaboratively rather than combining material afterwards.

61 Wright, *8 Switches*, (2011).

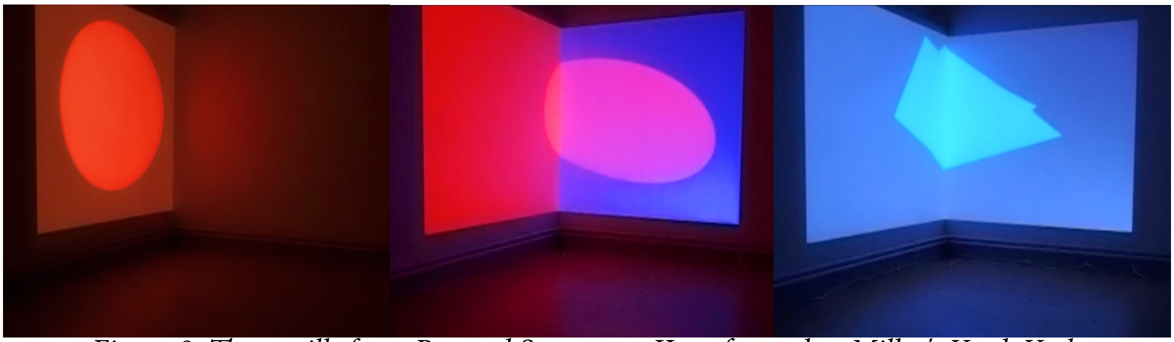


Figure 8: Three stills from Bastard Structures II performed at Miller's Yard, York

10.1 Medium

Bastard Structures 2 uses video projected onto two square, contiguous areas on separate faces of a corner (I will refer to these as squares A and B). This arrangement can be seen in *Figure 8*, in the centre of the three stills.[62] Two loudspeakers are positioned to the left and right of these two areas. This set up provides two logical areas, joined, but visibly divided by the geometry of the walls. Two projectors are used, one for my video, and one for Wright's with each one projecting over both of these squares. Analogously, we also both have the capability to generate sound through both speakers. We use independent systems running on laptops to generate material, although we occasionally share a very small amount of live information over a network.

My system presents sound and geometry in a way similar to *Colour Projections* – filled geometric shapes are sonified using the same transformation to waveform. Unlike in *Colour Projections,* where shapes are either on or off, here they have an 'alpha' parameter. This 'alpha' parameter modifies the loudness of the tone generated and opacity of the drawn polygon, at a value of 0 the shape is off, at 1, it is at maximum loudness and fully opaque. By modulating this value regularly, a pulsing can be created. The other important feature of this system is in the use of the two squares A and B. From the point of view of my geometry generation, squares A and B are defined as one geometric plane. Geometry entirely on wall A appears correct and undistorted with respect to the wall. As geometry crosses the corner seam of the wall, on to square B, due the position of the projector, geometry is skewed and discontinuities are produced at the corner seam. This process can be seen in the first two stills in Figure 8. The first still shows a circle in area A, the second shows the same circle having been moved almost entirely to area B, where it has become very distorted. This effect is produced optically from the angle the projector makes with the wall, and normally this distortion would not be reflected in the sound. However, internally the geometry is

62 Burt and Wright, 'Bastard Structures 2'.

recalculated to produce the sound that reflects this distorted geometry. The result is that the visual 'tearing' of the geometry as it crosses the wall is actually heard.

Wright's system allows him to project solid squares of colour covering the entirety of area A or B. A set of possible colours is defined, and each of these is mapped to a single sample from a *Roland TR-808* drum machine (and one colour may be mapped to silence). When he changes square A to a particular colour, the mapped sample is triggered in the left audio channel. Changing square B to a particular colour causes playback of the mapped sample in the right audio channel. By alternating the colour of one square at a high frequency, strobing effects can be achieved, accompanied by repeated drum samples. By using more complicated patterns of colours and sounds, various repeated patterns and interesting textural effects can be achieved. As each of the squares A and B can be controlled independently, different strobing speeds can be applied to each area causing interesting phasing and synchronisation effects.

These two systems produce contrasting material – Wright's produces rhythmic patterns of individual sounds and solid colours that illuminate whole areas. My system produces slowly moving geometry and long, static tones, coming and going as shapes fade in and out. The distinct nature of each of our material prevents an overly complex and chaotic whole forming – it is clear that there are two distinct elements at work. However, the aspects we do share allow us to form structures in relation to each other. For example Wright's ability to create a strobe at a particular frequency and my ability to 'pulse' geometry at a particular frequency provides the potential to create short term temporal relationships and form rhythms and phasing effects.

10.2 Structure

Having implemented our systems, we were able to develop a series of compositions over a period of weeks.[63] Here I will briefly outline each of the compositions shown in the accompanying video documentation.

One (video 0:08 – 6:36)

The first work begins entirely in area A. Both of us produce material with a slow regular rhythm that speeds up over the course of about two minutes. Wright uses a red strobing, accompanied by a hi-hat and I generate a centred red circle and sine wave that pulses in

63 Working more than five hours a day was a difficult and fatiguing process due to the high intensity of the strobing lights and sound.

intensity. As these increase in speed, phasing effects occur as our material goes in and out of synchronisation. These phasing effects are apparent in both the sound and image simultaneously. The visual effects here are particularly interesting perceptually, as the optical after-image of the pulsing circle interferes with Wright's strobing, producing the appearance of a pulsing black circle. When both have reached their full speed, the circle begins to move to the right, until it breaches the outside of the square A defined by Wright's strobing. This moment is perhaps one of the most effective in the whole piece, as it forces the observer to reassess the physical bounds of the work. The brightness of the geometry combined with the strobing make it very difficult perceptually, to understand the depth of the shape, and often it appears to 'hover' in front of the wall. As the circle moves into square B (and blue has been introduced into its pulsing cycle), Wright starts a slow blue strobing on square B accompanied by a synthesised kick drum sample. This speeds up as the circle moves further into the square. When the circle is entirely within square B, the work ends.

Two (video 6:46 – 11:14)

This work establishes a relationship between geometry and time. I am configured to project a blue regular polygon onto either or both areas A and B (on B they will appear skewed of course). When a polygon is present in an area, Wright instantly starts a white strobe in that area, at a speed related to the number of sides of the polygon. The strobe over each area is accompanied by a different synthesised kick drum sample. For example, a triangle would produce three strobes per second, a square would produce four strobes per second and shapes with more sides will produce faster strobing still. Throughout the work I produce a number of different regular polygons in each area, then begin combining them in both areas to create more complex rhythms (similar in concept to 'polyrhythms'). This produces an interesting relationship between sound and light – regular patterns of phase interference between two simpler rhythms takes place sonically and visually. Unfortunately, this piece is particularly difficult to capture on video, and in the example provided, due to frame rate limitations, temporal aliasing occurs and strobing sometimes appears irregular. This was not the case during the actual performance. Note that information about the number of sides of each of the generated polygons is sent via a network to Wright's machine, allowing it to automatically generate strobing at the correct speed.

Three (video 11:14 – 15:56)

In this work we use the whole of both areas as if they were one larger area. Wright begins with a high-speed, bright white strobing with kick drum. While this is sustained, I bring in a union of three shapes, two distorted squares and a very tiny circle. The squares move and rotate based on some chaotic low-frequency oscillators. Usually one of them covers the tiny circle, but when it is occasionally exposed it produces a high-frequency sine wave. All these generated shapes are duplicated twice in two colours (blue and orange) and one of the copies distorted slightly. The distorted copy has a slightly different perimeter from the other, producing a similar timbre but with a slightly different pitch. This difference when both are heard together causes an interesting timbral thickening, much like that provided by a 'chorus' effect. The orange and blue copies are faded in and out over different periods.

The combination of the strobing and shapes produce some interesting optical effects. There often appears to be a dark halo around the shapes, 'eating into' the white background of Tim's strobe effect. Perceptual after-images of the geometry are common after it has faded out, and these after-images interfere with the geometry when it fades back in, having mutated slightly. After about two minutes, Wright suddenly changes the speed of his strobing to be approximately one every two seconds, and I change the geometry such that is 'faded in' for a lower proportion of the time. This allows the geometry to be more clearly seen (the earlier flashing was intense enough to obscure much of it). The duration between each strobe is long enough for an observer's eyes to adapt, and when the strobe is repeated, the retina is stunned momentarily, hiding the geometry for a few moments. Finally, Wright allows the strobing and sounds in the two square areas to become desynchronised.

Four (video 16:00 – 20:07)

In this work, Wright provides a series of kick drum and yellow strobe impulses relating to the number of sides in a mutating yellow polygon I am generating. Unlike in work *two*, where the number of sides of a polygon was mapped to a speed, Wright waits until there is a change in the number of sides and repeats this many impulses of sound and light at a regular speed. For example, if a triangle gains an extra vertex and becomes a quadrilateral, four impulses are played in quick succession. Wright actually treats each of the two areas independently. If geometry is covering both areas and rotating, the number of sides in each area changes whenever a corner crosses the line between the two areas. This is reflected by independent impulses in each area. Note that other operations create extra sides too, for example if a corner of a polygon goes out of the boundaries of the entire work, it will be clipped, forming an extra vertex and side.

To begin, I produce a polygon in area A and gradually decrease the number of sides.

I then set it rotating and move it towards area B. As the polygon rotates faster, repeated rhythms and patterns emerge from Wright's strobing and sound. The combination of the geometry and the strobing produce the optical illusion of a black 'halo' around the geometry. This is one of the few optical effects that is captured well on the filmed documentation, and interestingly, is not observable when looking at individual frames, showing that the effect is still occurring in the eye/brain rather than the camera.

10.3 Discussion

There are various ideas and effects that we found interesting to explore when creating these compositions, and in doing so raised many more which we have not yet fully explored. The system provides a rich range of possibilities for structure. As well as creating structure within our own material, there is a wide range of possible relationships between Wright's impulse patterns and my own geometry. There is also the possibility of relationships between the two sides of the corner.

Individually, our basic relationships between sound and light/image are largely predefined (my geometry maps to waveforms, Wright's colour is mapped to drum-machine samples). This is important, as it is the reinforcement of strobing with sound impulses (or vice-versa) that aids the perception of patterns and rhythms in both, and likewise with my tones and geometry. It is this stability between our individual sound and image that allow more complex effects to be explored, without a loss of clarity or a descent into overwhelming complexity.

The projection over the corner of the room produces a strange contradiction. It might be assumed that such a projection would highlight the three-dimensional shape of the room. But the powerful, uniform light being projected has the effect of removing perceptual depth cues – there can be no shadow or shading, for example. This leads to situations where we cannot easily resolve the three-dimensional shape of the room, and depth ambiguities and illusions occur. This is similar to some of the effects explored by James Turrell in his *corner projections* series, such as *Afrum-Proto.*[64] White light is projected onto two surfaces of a corner, producing two contiguous distorted rectangles. It is Turrell's intention that this should (initially) produce the illusion of a cube in perspective.

The geometry I produce in *Bastard Structures 2* is allowed to distort or 'tear' over the corner of the room. However, the sound is calculated to reflect this distorted geometry, rather than the internal undistorted geometry. When the geometry breaches one wall, a

64 Turrell, *Afrum-Proto*.

discontinuity producing a new corner is formed – this process is heard as well as seen. This is intended to confuse the relationship between the observers position-dependent perception of the geometry of the room and their understanding of the geometry that is being projected. This perhaps evokes Felice Varini's concern with perspective-localisation.[65] His simple geometric paintings only resolve themselves from one viewing angle, creating entirely new, fragmented forms when one moves away from this angle.

Some of the most powerful optical effects in *Bastard Structures 2* come from the combination of the strobing and geometry. I have recently found some similar effects that occur in Pierre Hébert's 1968 animation *Around Perception.*[66] At around 08:57s minutes in, Hébert displays a red circle on a red background, then begins alternating the colour of the background and circle every frame, whilst gradually changing the colours used. As the film is produced at 24 frames per second, a strobing of 12 Hz can be produced. This is fast enough to create interference patterns on the retina, and with some colour combinations produces a 'halo' effect around or inside the circle, similar to that found in *Bastard Structures 2*.

65 Varini, *Couronne Et Disque Concentriques Jaune*.

66 Hébert, *Around Perception*.

11 Tiling Sessions

2012 – . Performance work. 2 channel digital-audio, projected digital-video.

Please view/listen to work before reading commentary.

The series of performances I refer to here as *Tiling Sessions* are the result of a sound and video system I developed over the course of about two years. In these performances, a computer attempts to tessellate predefined *sets* of isometric 'tiles' (simple geometric shapes that fit on an isometric grid), with each tile having a unique colour and producing a unique synthesised tone (unique within each *set*). Different heuristic search strategies are used to place tiles over isometrically defined areas with no overlap. The system was written so that the speed at which tiling takes place can vary from a few tiles a minute to hundreds or thousands of tiles in a single second. This allows exploration of some interesting temporal perceptual effects. I have only recently began regularly performing Tiling Sessions at live events, but it has had very positive audience reactions where I have. I presented an 'in progress' version at the event Antistrophe in V22, London.[67]

The system is a fairly natural progression from ideas explored in *Four*, *Colour Projections* and *Control Processes*. In *Tiling Sessions* I wanted to return to the more chaotic, structurally unpredictable material of *Four,* but having addressed some of its shortcomings. For example, in *Four*, many of the patterns produced are generated by emergent algorithms in the short-term, but a real-time, top-down control was used to directly compose the longer temporal structures. With *Tiling Sessions*, I was looking for the possibility of producing longer emergent structures from relatively simple spatial rules.

During the development of the *Tiling Sessions* system, I became engaged in an email-based discussion on theories regarding the nature of time and its perception, with computer musicians Roc Jiménez de Cisneros and Peter Worth. Cisneros had initiated the discussion prior to a release of his work *Rave Synthesis Approximations of György Ligeti's Continuum.*[68] Ligeti's *Continuum* is a work for harpsichord with the score annotated with an instruction to play it:

> Prestissimo = extremely fast, so that the individual tones can hardly be perceived, but rather they merge into a continuum. Play very

67 'Antistrophe'.

68 Evol, *Rave Synthesis Approximations of György Ligeti's Continuum*, audio cassette (2011).

> evenly without articulation of any sort. The correct tempo has been reached when the piece lasts less than 4 minutes...[69]

Ligeti's intention is to create a continuous moving whole out of a rapid succession of impulses. He states: *'The entire process is a series of sound impulses in rapid succession which create the impression of continuous sound.'*.[70] The harpsichord is an interesting choice, as due to the mechanism by which strings are plucked, the initial impulse of every note will have the same loudness. A piano, on the other hand could be played softly, deemphasising the sound's initial impulse and creating a continuous effect at a much lower speed. A harpsichordist must create the effect of a continuous sound by playing fast enough that the impulses themselves are perceived as continuous. This effect, of the individual event or object becoming so frequently repeated that they appear as a continuous whole has become a crucial part of the existing compositions for *Tiling Sessions*.

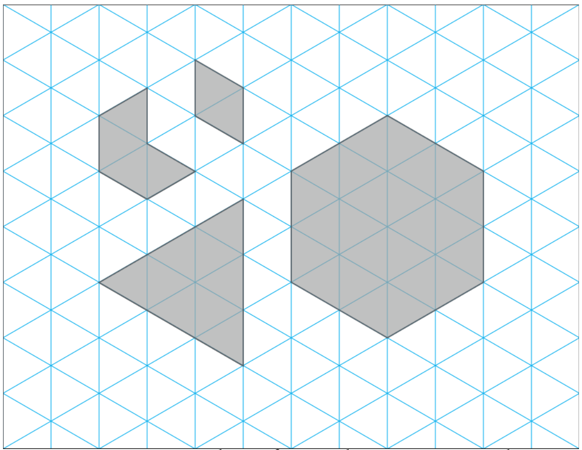


Figure 9: Examples of simple isometric shapes defined over a triangulated isometric grid

11.1 Medium

I will provide here a simplified description of the tiling system. The system was written entirely using the programming language C++. There were no appropriate existing code libraries to achieve the required functionality, so the program is large, requiring the implementation of an extremely computationally efficient sound synthesiser and fast heuristic tiling algorithms.

An isometric grid of definable size, split into triangles exists notionally within the confines of the screen. For a particular tiling run, a number of tile *sets* are defined. Each *set* consists of a number of tiles (for example 40) of a single isometric shape. See Figure 9 for

69 Ligeti, *Continuum for Harpsichord.*

70 Ligeti et al., *György Ligeti in Conversation*.

examples of such shapes. A first colour is defined for the first tile in the *set* and a second colour for the last. The colour of intermediate tiles is considered an interpolation of these two colours. In other words, the entire *set* laid out in order would form a colour gradient from the first colour to the second colour. Similarly, a group of sound synthesis parameters is defined for the first and last tile, and the sound associated with intermediate tiles is considered to be an interpolation of these two groups of parameters. When a tile is laid on the grid, this sound is generated simultaneously. The sound has an initial loud attack phase which then decays quickly to a sustained level, held until the tile is removed from the grid again. The sound synthesis system uses traditional synthesis methods, including a number of possible wavetable oscillators, frequency modulation, a resonant low-pass filter, parametric equalisation and envelopes for amplitude, pitch, filter cutoff frequency and frequency modulation depth.

A tile can be placed anywhere on the grid such that its constituent isometric triangles fit exactly over those of the grid. It may not break the perimeter of the grid, or overlap another tile. Tiles can be rotated before they are laid (as this is a triangular isometric grid each shape has six potential orientations).

A series of tiling algorithms are defined. Algorithms take one or more tile *sets* and attempt to tessellate tiles within the *sets* over the grid. Most algorithms are heuristic and parameterised. For example, one algorithm will consider all possibilities for the next tile, assign each possibility a single score or 'fitness' based on its effect on the overall grid structure, and lay the tile with the highest fitness score. The calculation of this fitness score is where the possibility for huge variations in the patterns generated lies. For example when assessing a tile's fitness in a particular position, the algorithm might look at what proportion of the tile will touch other tiles, how much area would be covered and how much fragmentation it would cause on the grid. It is varying the weighting of these different factors in the calculation of the fitness that produces very different behaviours in the algorithm. Some algorithms act with extra constraints imposed – for example, a variation of the previously described algorithm forces itself to only tile within fixed 'rows', not proceeding to the next row until no more can be fitted in the previous one. Many combinations of parameters produce poor tessellation, which aesthetically may still be interesting. Algorithms also control the timing of the tiles they lay. The fitness value of the chosen tile is converted into a time delay so that when an algorithm places a tile it is sure meets its criteria, there is a longer delay before the next tile is placed. When an algorithm is doing 'badly' (all fitness values are low) it will speed up. It also possible to manually change the overall speed of the system.

An algorithm usually runs until it can fit no more of its tiles on the current grid. The grid can then be cleared of tiles, the grid size and any other parameters changed, and the algorithm restarted. To control these broader temporal structures, the scripting language Lua was embedded in the system. Scripts can be written using a specialised vocabulary to coordinate and structure these changes over time.

11.2 Structure & Discussion

I include in my folio a video of three compositions from the tiling system. I will briefly describe each of these here, and discuss relevant issues. Please watch/listen to the three works before reading on.

One (video 00:04s – 04:21s)

The first work actually uses no tiling or spatial logic, but introduces in a simple form some of the concepts explored further in the next two works. The algorithm used is one I initially developed for testing the sounds and visual appearance of individual tiles. A *set* of 20 triangles, followed by a *set* of seven identical hexagons is cycled through repeatedly, with only one tile visible at a time. The colours of each individual triangle form a gradient, and the sounds form a timbral progression. As each hexagon or triangle appears visually, its associated sound is synthesised. Initially, there are several seconds between each shape. The system speeds up gradually. As it reaches higher speeds the individual shapes begin to blur into a continuum, and we begin to focus not on the difference between individual tiles, but between the two *sets*, the triangles and the hexagons. As the system speeds up further, the alternation between the triangle *set* and hexagon *set* becomes a single continuum also, and we are left with a single static structure. The system slows back down to the original speed before the work ends.

This effect works on the principle that as humans we have a fairly narrow temporal 'window' in which we can intuitively recognise patterns. When the tiles are presented slowly, our tendency is to notice only the difference between successive tiles, and ignore the wider cyclic structure, unless we are specifically looking for it. As the system speeds up, the proportion of the cycle that falls into the same duration is much greater, drawing our attention to the broader temporal structures within the pattern.

Two (video 04:24s – 27:50s)

The second work presented introduces the tiling process, and builds on the premise of the first work. Like the first work, a repeating pattern of tiles gradually increases in speed. As it does so, temporal patterns on different scales fall in and out of our attention.

The work uses only three tile shapes in total, but several different tiling procedures to tile them, with different colours and sounds for each procedure. For most of the composition, five tiling procedures are cycled repeatedly. At first, the total duration of the cycle is so long, that there is no indication that the structure is cyclic at all – it may appear as if there will simply be a linear sequence of compositions. Similarly, the first time the cycle loops around to repeat, so much time has passed since the beginning of the first iteration, that the observer may not even realise that the material is repeating. However, with each repetition, the speed of tiling is increased, and with a decreasing duration per cycle, our attention is drawn to larger structures within the cycle. At the highest speeds, the entire cycle takes only a few seconds to complete. At some point during this process it is likely that an observer will notice the larger cyclic pattern.

All the tiling algorithms used are entirely deterministic, but produce complex, generative behaviour. The choice of each tiling procedure was based not its ability to tesselate well, but on its production of memorable, characteristic structures for the duration of its process. This aesthetic distinction between algorithms is intended to facilitate an understanding of the overall cyclic structure of the work.

Three (video 28:01s – 36:40s)

The third work presented uses just two algorithms, with a more complex and varied tile *set* comprised of hexagons and triangles of several sizes. The algorithm attempts to tessellate tiles in rows from the top down. Each time the grid is filled, the grid is resized to be a unit higher. The height of the grid greatly affects the patterns and rhythms that the algorithm chooses to place the tiles in. I chose relatively traditional, 'musical' sounding pitches in this more complex situation – with a greater number of tiles and tile-*sets*, the harmonic relationships between pitches, actually seems to aid in perceptually distinguishing the various tile types from each other.

This algorithm is played back twice, at a higher speed the second time. At the end of the second iteration, the tiled grid is frozen and all tiles are held in their current position. The second algorithm is then activated. This removes tiles from the grid based purely on their position within the grid and then adds them back in the same order. Tiles are removed from the grid in a linear sweep over the grid at a particular angle. This angle is gradually rotated, causing the order of retiling to form an iteratively mutating temporal pattern. This whole process is slowly sped up, until finally the grid becomes a continuous block of colour and sound.

Sound and Image

There is only an arbitrary link defined between a particular tile's colour, shape and sound. There is little perceptual relationship or 'synaesthetic' effect between the sound and image when a single tile is presented in isolation: the visual appearance of a new tile occurs simultaneously to the sonic impulse of an associated sound. This simple relationship is intended to allow more complex relationships between sound and image to emerge generatively.

Although there is not enough information within one tile to convey any kind of relationship between timbre and colour, when multiple tiles from one *set* are presented, a wider relationship may become apparent. The specific relationship varies within each tile-*set*, but tiles in the *set* progressively form a fade between two colours and between two timbres. When multiple tiles from a *set* are introduced over a short period of time, a *relative* perceptual relationship between timbre and colour is produced. This is especially true when tiles are presented at a higher speed associating a continuous sweep of changing colour with a continuous sweep of changing timbre.

Above certain speeds, material generated by the system appears continuous. The rate of tile-laying at which events begin to merge into continua is comparable for visual and sonic elements. At higher speeds this produces complex tones of shifting timbre and continuously fading areas of tiles. At lower speeds we become aware of temporal and spatial patterns in the sound and image. Spatial patterns, artefacts of the spatial logic, tend to be accompanied by temporal patterns, the 'signature' of their construction. The spatial patterns are only present in the image, and the temporal patterns, though visible, tend to be perceived sonically. In addition to the synaesthetic effects, this creates a more abstract relationship between space and time in image and sound. This has more in common with the types of relationship seen in *Control Processes.* Unlike *Control Processes* where these relationships were contrived, here they have emerged generatively from simpler behaviour.

Future work

There is a still a huge amount to explore within the tiling system, and I will continue to produce new works for it indefinitely. Being the last audio-visual work to be completed in this folio, it is perhaps the system I understand the least well. It is likely that as I become more familiar with it, the compositions I produce will develop aesthetically.

12 Conclusion and future work

The works I have produced between 2009 and 2012, discussed in the preceding commentaries, represent a progression of practice and ideas throughout that period. A common motivating thread that runs through them is a fascination with the border between perception and cognition, experience and understanding. There are no rational answers I have been looking for in these regards, rather the process has been an exploration of aesthetics.

In *Four* I created a system to perceptually create an instantaneous relationship between sound and video, and found this limiting for a time-based composition, as the system suggested nothing of the temporal structure. For *Colour Projections*, a reaction to this issue was to create and explore a system that, while still defining a perceptually consistent link between sound and video, had an inherent temporal continuity, in the form of geometry. In an attempt to understand the relationship between these two works I created *Control Processes*. I now see this work as an initial exercise in exploring more abstracted relationships between sound, image and process.

I became interested in experimenting further with this bifurcation of a process and its material result and created the audio piece *Summer Mix*, taking familiar source material and transforming it using a single process – this created an interesting relationship for me between the aesthetics of the source material and the aesthetics of the transformed material. I also began to understand it as mutating much of the symbolic content of the original source material, and it was the residue of these symbols which provided a fragile perceptual link between the untransformed and transformed material. This led me to explore this idea further, and perhaps more explicitly in a second set of compositions for the *Colour Projections* system where familiar geometric symbols are sonified as flattened, two-dimensional objects.

In *Bastard Structures 2*, I continued these experiments with geometry, this time acknowledging and integrating the geometry of the projection space itself, by allowing geometry to skew over the corner of the room, visually and with a sonic counterpart. Combined with the effects of Tim Wright's strobing patterns, perceptual spatial ambiguities are caused creating interesting relationships between the symbolic nature of the geometry and its material presence over the architecture of the room.

The final collection of pieces I composed for the folio, *Tiling Sessions is* a continuation of the work I began with *Four* and *Colour Projections*. While still an algorithmically controlled deterministic system, its greater ability to produce high levels of ordered complexity, and its inherent temporal structures produce different effects from either of these previous works. One of the main effects it explores with this complexity is the perception of repeated temporal patterns over radically different durations.

The threads of ideas that I have initiated in the work in this folio I continue to follow. The sound and video pieces *Colour Projections* and *Tiling Sessions* I still publicly perform and screen. The system created for *Tiling Sessions* is a medium I have only just begun to explore, I expect to work with this system for a long time into the future. I am not actively developing or conceiving a new sound and video system at the moment. It is more important to me to develop and refine the systems I already have, and explore some of the ideas raised in more depth. A future direction I may take is to begin with existing fragments of high-quality sound and video (excerpts from narrative films) and use temporal, spatial and timbral processes to highlight the materiality of this footage. This could be seen as a marrying of issues explored in *Summer Mix,* and my synthetic sound and video works.

I am also planning a new sound piece. This work is a relatively simple modification of the system from *Tiling Sessions.* I intend to use the algorithmic processes, which produce often unexpected temporal patterns to control relatively well known hardware sound synthesisers from the 1980s and 1990s. There is an interesting challenge here, to build new sounds and sonic textures from a set of sounds that are relatively well known. I will be concentrating on the perceptual and cognitive shifts between this familiarity and the unexpected ways in which I intend to use the sounds.

The three years that I have worked on the compositions in this folio have been extremely valuable to me. I have finally established a way of working in which I can produce material that interests and excites me, and developed a critical understanding of my own and other artists' work. I have initiated several threads of ideas that I will continue to follow and explore indefinitely. Importantly, exhibiting and performing the work has brought me into contact with many interesting people, some of whom I continue to work with and admire.

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