Live Electronic Ensemble Practice

Developing Tools and Strategies for Performance and Composition

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Appendices

Submitted Works

Wayang listrik (10′42″)

Composed by Ed Perkins

Software, sound sources and hardware developed by Ed Perkins

Performed by Ed Perkins & William Vine

Sonic Intermedia 2010

Ars Electronica, Austria , October 2010

MPEG-4 video documentation

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Software developed by Ed Perkins

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The Undercroft, Norwich, February 2014

MPEG-4 video documentation

Abstract

This research is an auto-ethnographic study of a portfolio of compositions and performances in ensembles that took place across the UK and Europe between September 2008 and February 2014. This commentary analyses the work with a view to discerning useful strategies and approaches towards group work in the field of experimental electronic music. The study contains an account of the author's own physical interface and its development over a period of ten years, including a wider analysis of some considerations for design and the development of a personal instrumental practice. Ensembles formed by the author are discussed with a focus on social psychology and self-organisation through the creation of unique roles and shifting group hierarchies, afforded by the possibilities and dislocations of technology.

The commentary continues with an in-depth study of the development and performance of *The Stream*, a generative composition system that applies some of the interdependent behaviours and processes of self-organisation discovered through musical experimentation, to an agent-based societal model for real time score generation. The analysis shows that interdependent agents and social behaviours can be modelled in order to generate relationships which are comparable to those created through traditional methods of composition and improvisation. The study concludes that the possibilities afforded by technology to extend beyond the physical and social domain are most successfully

implemented when they support, rather than inhibit the natural relationships and human physicality of those taking part. Therefore, when designing a generative composition system, the simulation of human relationships and their narratives may open up a new area of research in the generation of musical composition.

In Memoriam

Patricia June Perkins

1942 – 2015

'Sharing an idea that helps another,
Is the best moment one can ever have'

Words taken from
The Value of a Moment - Bright Ideas in Action
by Patricia June Perkins 2014

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I would like to thank Dr Simon Waters for his loyal, committed and expert supervision that has continued throughout the closure of the UEA music department and beyond. I would also like to thank Lyn Marsh (Humanities PGR officer) whose support, encouragement and guidance through the process of completing my studies (in a University that no longer has a music department) has been invaluable in maintaining enthusiasm for my work and enabling the practical completion of the degree. I am grateful to Sound and Music and the Esmée Fairbairn Foundation for awarding me a residency with Apartment House and for the support of the organisation in the execution of *The Stream*, particularly that of Richard Whitelaw, whose passion and belief in the project were fundamental to its realisation. Also thanks to Anton Lukoszevieze for his guidance and the opportunity to work with him and other Apartment House musicians, Jonathan Impett, Gavin Morrison and Angharad Davies. Thanks also go to Phillipa Reive and Aldburgh Music for the opportunity to design and install *Conductable* at Snape Maltings and to work on the *Exchanging Worlds* project with so many great composers and young musicians. Thanks to all venues that have hosted the performances mentioned here, particularly Andreas Weixler who gave me the opportunity to play at Ars Electronica (Austria) and also for going out of his way to make sure I received the documentation from the performance on numerous occasions.

A huge thanks to my main co-conspirators without whom I would not have any ensembles and relationships to research: Mick Grierson, Matt Lewis, Jeremy Keenan, Jason Dixon,

Bill Vine and Mike Challis. Learning about their motives and practices through sharing ideas has helped shape my own process throughout the activities documented herein.

My greatest thanks go to my family, (most of whom were created during this period of study) who have been so understanding of my absence from family activities and lack of family holidays in order to write during weekends and periods of leave from full time work. I cannot express enough gratitude to my wife Lilith, without whose support, encouragement, musical collaboration, understanding, workspace preservation, proof reading, tea making and periods of single parenting, this thesis would have never been complete.

Lastly, I dedicate this thesis to my mother, Patricia June Perkins, a fellow artist and patron of these studies who sadly did not get to witness their conclusion. It is my hope that their completion would have made her proud, the journey would not even have been able to begin without her support.

Introduction

The focus of this research is around the practice of collaboration within ensembles in the field of live electronics. It is not primarily concerned with technological developments or their implementation, but more importantly seeks to answer questions around how (predominantly digital) technology changes the way that we collaborate and how we might go about adapting to these changes.

Using such technology affords the opportunity to produce sounds unconstrained by the physical realm, with the freedom to create new instruments, roles and group structures.
Where then do we look to inform our creative ideas and working practices? Are more historical musical forms still relevant or must we develop entirely new approaches? How might historical forms of collaborative music making help us to approach designing new electronic instruments specifically for group collaboration?

Are there considerations for ensemble work that are unique to the genre of live electronic music? How do we approach working together and what defines the choices we make when we form a new ensemble? How do members negotiate and develop their role within the group and how does the group self-organise to accommodate its members? Can lessons learnt from analysing this process be applied to improve cohesion and accelerate the progress of other ensembles?

When we improvise within a group, miscommunication can occur due to a lack of familiarity with the style and practice of one's fellow performers, due to the added unfamiliarity of custom built electronic instruments, or to the lack of a legible interface. How can we make our own practice more comprehensible to others and how then do we improve communication between performers to enable the group to work as a coherent musical force?

How far do the social elements of the ensemble affect group development and the resultant musical works? Further to this, what occurs between performers both on and off the stage during collaborative work? Could we model these interactions to design generative composition systems that create music like that of human musicians?

My research addresses these issues through first-hand experience of group practice, regarding auto-ethnographic study as providing the most productive access to this knowledge for those outside of the process. This is therefore the principal methodology informing the research.

Instruments

Chapter one is ostensibly about the development of my most long-term instrument, *The Stick*. In fact, this chapter defines the tone for the entire thesis as it begins an enquiry in to how to approach the conception of a practice that is specifically concerned with group work. My interest lies in the habits of group music making and, as a result, arguments around whether electronic musical objects are instruments or interfaces remain outside the territory of this thesis. The research lies in establishing the utility of a tool in practice with an ensemble and the first chapter documents this process historically in relation to a range of ensembles. The testing is explicitly through the practice of the work, and any paper-based element of research must therefore take the form of auto-ethnographic study.

There is a long history of individuals developing electronic instruments for musical performance. What characterises many of those instruments is that they have a relatively short life. Within this research, I was committed to developing an instrument over a longer period of time, trialling improvements and adaptations through ensemble rehearsal and

performance. So far, *The Stick* has been in development for ten years and continues to be updated beyond the time frame of the research period.

The Stick is designed and built by the composer as the primary operator, without concern for other users. There are few composer-built electronic instruments with the longevity and developmental history of *The Stick*. Notable examples would be Jonathan Impett's *Metatrumpet,* and Michel Waiswisz's *The Hands*. Whilst *The Hands* are sadly no longer developed by their designer, other users of glove interfaces such as Imogen Heap have arguably adopted similar aesthetic and performative concerns and continue to be developed. The key difference between these instruments and *The Stick* is that they were initially conceived as individual instruments for solo use. Whilst Impett has employed the *Metatrumpet* in various ensembles, it was not designed primarily as an ensemble instrument. *The Stick* is unusual in being designed primarily around the notion of use within musical collaboration. It was not conceived as part of a set of instruments, or for a specific ensemble, but as an incomplete entity that can be adapted to a range of ensembles. *The Stick* is intentionally designed to be partial, leaving room in the material it creates for others to occupy.

The Stick can adopt a variety of roles that allow adaptation to a variety of ensembles and styles, but is not designed to play multiple roles simultaneously. *The Stick* is not, therefore a 'performance or composition system'. The method of control is solely that of reaction to the user, with no generative elements or software-based decision-making. The software serves purely to administer the relationship between the physical object and the selection and control of parameters for sound making. 'Performance systems' tend to be unsuited to ensemble use as they require an intense and personal relationship with their operator which is not directly related to the other ensemble members and can be disruptive to group cohesion. Performance systems are fitting for solo performers, and may be acceptable in a group if only one member has one, but in an ensemble with multiple performance systems operating at odds with each other, interaction is significantly impeded and a unified approach is difficult to achieve.

The Stick's antecedence therefore lies not within the canon of electronic instrument design, but in the sociological roots of musical performance in general. As is discussed further in Chapter one, *The Stick* is born from the electric guitar, and carries with it the enduring

design of an instrument that allows for intricate manual playing and physical gesture. Its location in relation to the body, and the tactile method of interaction leaves the visual field clear for communication with fellow performers. *The Stick* is therefore contextualised less by the performance of live electronics than by the virtuosic style of rock guitarists, occupying a similar function within a group and then periodically stepping into the limelight when required. My performance style is derived more from the well-worn and socially comprehensible presence and posturing of musicians such as Jimi Hendrix and David Gilmour than from tabletop electronics or algorithmic performance systems. These cultural references in *The Stick's* gestural style and physical construction were consciously included to avoid some of the issues around miscommunication described above.

Although *The Stick* involves a level of complexity in terms of parameter selection and sound creation, the basic physical control method is incredibly simple to grasp both as a user and observer. Gestural legibility is clear, as the movement of the instrument audibly alters the sound's texture and volume, this being readily understood without previous experience. The relationships are sufficiently simple that they become more comprehensible over time, due to the implementation of fixed mappings, as opposed to systems that develop and transform dynamically or reactively through use.

Chapter one also features the shared instrument *Conductable* built for four players and conductor. On the surface, the *Conductable* shares similarities with the *Reactable* (Jordà et al., 2006) which was an early inspiration, and influenced the naming of the instrument. There are similarities too in terms of the physical situation of the players around a central terminal, encouraging visual communication and a shared focus on a single object. In contrast to the *Reactable, Conductable* developed into less of a shared instrument and more of a series of individual instruments situated in the same housing.

Conductable served within the study to decouple some of the technological issues from the social considerations. As *Conductable* uses the same basic granular synthesiser as *The Stick*, it allowed me to focus on the socio-musical objective without the distraction of testing the technology involved. By using the same basic instrument for each player, I was able to concentrate on the sociological aspects of the design and its use. Primarily, I focused on supporting interaction, unification and communication.

Through my previous experience of playing in ensembles I had discovered that rather than directly communicating, ensemble members synchronised their actions best through cohabiting an environment with shared access to harmonic, temporal and behavioural data. This indirect form of synchronisation gave continuity to pieces and subtlety to the homogeneity of the material. Whilst the players of *Reactable* work together to transform the sound of a performance system, the individual instruments of *Conductable* occupy a shared harmonic and temporal environment accessible to the players on various levels, but which can also be moved away from at will.

During a performance, the conductor changes the number on a die at the centre of the console to enact sectional transitions. This action resynchronises the players to predesigned settings and unifies the group. The conductor's presence identifies a clear leader, ensuring that all are moving in the same direction. Roles were predetermined by assigning responsibility for specific spectral areas to each player, much in the manner of a string quartet. My focus was on recruiting the right players for the roles, and the simplicity of the controls for each instrument allowed me to concentrate on directing those involved without requiring complex explanation of the technology.

Roles & Relationships

Chapter two features case-studies of two long running group projects in which the instrument described in chapter one was used and developed. This chapter draws on interviews with collaborators and reflects on their experience of the process and their roles within the group structure. Further analysis covers themes such as group culture, methods of communication, self-organisation and role-creation. The methodology used for this analysis draws on theories from group therapy and social psychology to encompass aspects of working in groups that habitually occur outside of the musical environment including social bonding, vernacular communication and the manner in which the group culture translates between the musical and non-musical environments.

The focus in this chapter is specifically on the process of the formation of, organisation within and practice of the ensemble. Musical examples are included as snapshots that demonstrate and represent some of that process, but the research focus is primarily on the personal and sociological development of those involved. Such an approach is uncommon

in the field of live electronics where technological issues are the most pervasive areas for study.

The value of the research presented here is twofold:

Firstly, I document at first-hand the formation of two ensembles over a significant period of time, not from the viewpoint of an external observer, but from my own point of view within the ensemble, and through conversations with the other group members. The focus is on the sociological elements of the formation of the group and the emergent roles and structure that developed throughout the active life of the ensembles documented here. I am most interested in the reflections of the ensemble members and their reflections on the processes as they occur. In order to reveal the subtleties involved, this type of research must also be auto-ethnographic.

Secondly, the ensembles were formed without regard for the research activity rather than as a project designed for the purposes of study. They were brought into being through the will to perform and a commitment to composing and playing complex and challenging electronic music in a live environment. This is not therefore a reductive study of human behavioural interaction; it involves real environments and events which cannot be constructed through occasions fabricated for the purpose of analysis. I set out to reflect upon the sociological, environmental and musical elements of my collaborative work as a whole and to share the results of the analysis of these elements. It is not my intention to scientifically extract certain elements in order to find universal truths, but rather to draw out the social and interpersonal relationships, and the development of the individuals involved over time.

The musical content is not free improvisation. Although semi-improvised, the work is quite clearly discussed and planned by the group. Scores, on-stage communication systems and terminologies for discussion are developed over time through a process of trial and error. Roles were formed over a longer period of time and refined themselves through each meeting, rather than being developed and reassigned during performance in a non-linear fashion. We also focused on evolving our own instruments in relation to roles and the type of work we hoped to produce. This process of evolution and refinement is clearly

differentiated from the 'unidiomatic' playing of acoustic instruments, spontaneity and drama that tend to characterise the work of free improvisers.

A key intention for both long-term ensembles was to observe and develop techniques to improve communication in order to execute repeat performances of specific pieces. Some of these techniques developed through processes that occurred naturally due to the amount of time spent together, such as informal discussion around influences, pair programming, long residential sessions and learning about each other's wider practice and abilities. Some were the result of targeted discussion and planning such as networked software, through characterising pieces sonically, and through developing the gestural legibility of our physical performance. We also learnt to pick apart and discuss aspects beyond the immediate concerns of the music, such as how to communicate well enough visually to coordinate group actions. Although these techniques seem obvious and are common in other genres, they are often missing from the ensemble practices of live electronic groups. Both long-term ensembles featured members who had well -established practices on acoustic instruments and had backgrounds in a mixture of classical and popular musical ensembles from a young age.

Rather than being informed by performance practices of live electronics - which we regarded as significantly underdeveloped in comparison to other genres of music - both the ensembles studied sought to improve upon the practice of performance in this field by taking inspiration from genres with a more established and well-explored performance history, such as rock, pop and classical music, and also theatre and spoken word. We sought new audiences amongst proponents of these genres, and rather than developing approaches based on distributed performances, interactivity etc. we borrowed elements from historical forms of performance in order to engage such audiences.

Further to this historical influence, for the shorter-term projects of *Conductable* and *The Stream*, I employ recognisable archetypes in order to accelerate the group formation process. *Conductable* uses a model similar to the pitch hierarchies of the instruments in a string quartet for the pieces *Hokit* and *Mantra*, whereas for *Edun* more traditional 'band' roles are assigned. *The Stream* uses recognisable roles within society of *Hunter, Medic, Worker* and *Artist*. These roles that also have archetypical political and social characteristics associated with them, and operate similarly to the genres of musical theatre and opera in

improving the tangibility and recognisability of characters without the need for significant advance knowledge of their background. Both projects also include me as musical director and ensemble leader. The inclusion of a conductor and director allows me to instil a discipline on the ensembles that I have learnt through my more long-term projects in order to accelerate the processes of group-formation and collaboration.

Chapter two attempts to uncover what lies behind the musical behaviour of the ensembles discussed, and reveals that sociological factors, mutual dependencies and group dynamics are fundamental to the formation of any musical interaction.

Societal Modelling

Continuing where chapter two left off, chapter three is the analysis and discussion of a composition system that was designed to model group dynamics and the kind of mutual dependencies uncovered in chapter two. Although it is far beyond the scope of any current software to model the complex socially-interdependent dynamics of human beings in an ensemble, I approximated these by creating a system in which four agents relied on each other for their basic needs including physical and mental health, wealth and more complex needs such as culture, resources and healthcare. As with any ensemble, each agent had a role and set of responsibilities, the success of which impacted on their fellow agents.

A performance of *The Stream* contrasts with the performance aesthetic of the other projects presented here in that the interactions of the human musicians are not the primary focus and the considerations for performance were more concerned with the legibility of the system. Rather than supporting musical collaboration or exploring role development, *The Stream* was designed to perform a specific research function concerned with the live generation of material using a social model. On the surface, *The Stream* may seem like a departure from the sociological approach described in chapter two, but it is in fact an attempt to uncover the relationships that occur when we collaborate together musically by modelling them through software. In chapter two I propose that the roots of musical collaboration lie in social interaction and group dynamics. *The Stream* uses agents with specific roles that constantly shift and adapt to each other based on their own energy, social influence and skill ability, mimicking the behaviour of a group of human musicians.

Within the software, feedback loops create vast networks of interactions that indirectly communicate, forming part of a much larger system of interdependent events. Some relationships are supportive and positive towards the group as a whole, such as the healing effect of the Medic agent. Others are more self-oriented and can impact negatively on the health of other agents or restrict their individual actions. This idea is taken from the theory of *Cybernetics* first proposed by mathematician Norbert Weiner where signalling loops occur between agents in a closed system. The rules of that system influence how the agents operate and consequently, emergent group structures develop much in the same way as those of human musicians collaborate through cooperating within systems rather than conversationally interacting with each other.

Clear archetypical roles were assigned to each agent, establishing legibility and familiarity in much the same way as I prescribed roles for the performers of *Conductable*. As I had found the inclusion of a leader a useful strategy for uniting and focusing ensembles I included a leadership role. Here the leader could be any one of the agents, and their ideology and musical style decreed not only the balance of power in the system, but also the style of the musical output.

The Stream is a conceptual departure from other generative systems that analyse and model the behaviour of human musicians such as Michael Young's *au(or)a* or George Lewis' *Voyager*. This approach reduces the complexity of information in human performance in order to be understood by software. It would seem then that the resulting musical interaction always has the system at a disadvantage. Unavoidably, the resultant AI also adopts the compositional or performance style of the composer who designed it creating in effect an artificial double for the composer to perform with.

My approach to modelling musical interaction in *The Stream* also contrasts with those methods explored by Eduardo Reck Miranda amongst others, where the software is taught musical rules and values. Other approaches feature physical agents communicating through generating and listening to audio. In contrast all interaction within *The Stream* occurs at the data level, within the software. Each agent operates according to parameters that are constantly updated by the actions of themselves, the other agents and the state of their environment. No translation occurs and therefore misunderstanding and error is reduced. The data is only transformed into sound at the output stage of the system. The software

generates a narrative with a script for the players to follow in real time, and the system needs no understanding of musical rules. This seemed more of an idiomatic approach for a system that was wholly technology based.

In terms of human group collaboration, *The Stream* would seem to be in antithetical to the approach taken in chapter two, but here the human musicians are not the focus of the sociological analysis. The performers are stripped of any opportunity to interact, as they must focus intently on following the live score in the present moment. The score is animated rather than generated in chunks, which restricts their ability to incorporate past or future events and thus curbs their own sense of agency. They are a mere part of the technology that voices the sonic output of the model, on a par with the synthesisers used to voice other elements of the system. They are depersonalised and act as complex sound modules, reading and voicing the musical parameters that they are fed in real time via individual video scores generated by the model. No external events from the 'real-world' have an effect on the system, and this includes the actions of the players who are mere actors reading a script.

In chapter two I propose that sociological dynamics lie behind the musical choices we make, and that music and sound is an alternative medium to our daily lives where this interaction can take place. The sonic and musical behaviours we express are representations of sociological parameters that we explore in collaboration with others. Chapter three explains that my approach to modelling human musical interaction is not therefore to model musical rules and stylistic elements, but instead to model social interaction in order to create behaviour patterns analogous to human sociological behaviours. The application of musical parameters happens afterward.

On the documentation of audio-visual work

The majority of my live performances have taken place in extremely dark environments in order to accentuate the effect of the projections and lighting. This has impacted somewhat on the quality of the visual documentation, as the camera is unable to accurately record the environment as well as it would be if one attended the performance. The filmed examples are all of real performances rather than those staged for documentation, and on occasion suffer in quality as a result, as many of these performances were self-documented without the luxury of second attempts. I considered the recording of live performances to be of

more value than staged demonstrations and they have been included for the authenticity of the situation and its consequent value as documentation for analysis of the subject matter.

Audio and video excerpts

Where references are made within the text to specific audio and video examples, the time reference within the full piece is given alongside a number enclosed in parentheses. This number refers to an audio or video excerpt of the isolated section and can be found on the accompanying media, in the 'Excerpts' folder for ease of access.

Any works referred to in the text that are not in the submitted works can be found listed in Appendix D: Additional Materials and on the accompanying media in the Appendix D folder.

Instruments

My approaches to instrument design engage most significantly with the matter of acousmatic dislocation brought about by the use of technology and the problems resulting from this as discussed by Emmerson (Emmerson, 1994). It is the physical and temporal dislocation brought about by the redundancy of mechanical causality with which I am primarily concerned.

Bowers states that 'Electro-acoustic music is indigenously a machine music' (Bowers, 2002: p.28). By its very nature it involves a form of dislocation and we have to choose how we respond to that. Do we attempt to relocate sound to the excitation of physical materials by human action or do we ignore it in favour of imagined physicality and the extra human possibilities offered by the spectral domain? I argue that we do not necessarily need to conceptually confine our instrumental designs to just one of these approaches, but that the two can coexist, even within one instrument. One of my main preoccupations is the design of electronic instruments and software for use in ensemble work and I have incorporated both approaches to varying degrees in the projects documented in this chapter.

i. Instrumental Tendencies

When I first began performing electronic music my practice was solely laptop based. Laptops have cultural associations for the general population that are primarily non-musical, although arguably their musical function has become increasingly familiar through the rise in popularity of virtual DJs and producers, and the accessibility of software-based effects and instruments. Their non-musical associations impact negatively on their perceived plausibility as instruments and on the whole they are not regarded as such. They also are expressively limited in terms of the fine physical control they can offer through the mouse and keyboard without the addition of an external controller.

When I started performing on a laptop, my skill and experience was primarily as a wind player, on saxophone and clarinet. I also had classical vocal training and had sung in choirs and at church from early childhood. After using the laptop with MaxMSP for some time, I felt the absence of a tactile and expressive interface that I could pick up and physically manipulate to control the envelope and texture of the sound as I would on an acoustic instrument. This desire for a tangible instrument may have been partly unconscious and due to my habitual ways of making music, but was also intentional in that I wanted to harness and exploit some of the existing instrumental technique I had developed over many years. Consequently, my ideas for an instrument began to develop, firstly through experimentation with microphones as breath controllers and wind synthesisers such as the Yamaha WX5. I soon abandoned wind controllers, primarily because the physical disconnect between the breath element and operation of keys made the instruments seem unnatural and unresponsive compared to my experience with saxophone and clarinet. Breath controllers and my use of the voice re-emerged later on in the process, but at this time I diverted my attention toward other instrumental influences.

Although fairly unskilled and mostly self-taught, I had played the guitar for many years, and liked it as an interface for its positional closeness to the body and the action of playing two handed with independent functions. Woodwind instruments harness both mouth and breath and I was interested in the potential for using my voice as a sound source in conjunction with an instrument operated by the hands in the future. On reflection, I realised that the time I had devoted to playing woodwind was mainly due to the

instruments that were available to me, and my school-based musical education had steered me towards a classical approach.

I had always been more enthused by band-based rock and the heavy metal my older brother would listen to and play in bands on guitar. I was particularly interested in the virtuosic style and sonic exploration of guitarists like Randy Rhoads, Jimi Hendrix and Lou Reed. I also considered the 'extra' accompanist and figurative gestures (Delalande, 1988) employed by Hendrix and Rhoads to be hugely effective in visually communicating sonic gestures to an audience. Their extended techniques were often created through amplification technology and effects pedals that in part required accompanist gestures and gestural exaggeration to communicate the sonic behaviour added to the initial instrumental excitation. I felt that this exciting mix of virtuosity, showmanship and engaging sonic exploration was missing from live electronics performance that I had seen which tended to be more restrained and physically inexpressive in nature.

On reflection, the guitar was perhaps the greatest influence on my early ideas around building an electronic instrument as I began to research ribbon controllers and pressure sensors as a quasi guitar neck construction, looking to MIDI controllers as the instrument body. My limited abilities on the guitar pushed me towards developing an entirely new excitation method, rather than extending the excitation of strings in the direction of more *hyper* (Machover, 1986) or *meta* (Impett, 1994) instruments.

I had little previous experience in building electronic devices at this stage and no real awareness about what electronic instruments already existed at this time beyond those that were commercially available. I began to research new instrument designs through the New Interfaces for Musical Expression (NIME) archive[1]. The instruments displayed a broad range of approaches, which were incredibly informative in terms of what technologies were available. In particular, I found that the documentation was very comprehensive in terms of how the technology operated and the possibilities for sound control that they offered. Despite this commitment to documenting the instrumental operation, I found that most of the discussion focused on the design and functionality of the instrument rather than the technique and practice. The tendency of the performers was to demonstrate the

[1] www.nime.org

instrument's functions and describe the resulting possibilities verbally instead of using it convincingly in an authentic performance situation. Similarly, most of the instruments were early prototypes and I could find little evidence that their practice and development had been pursued beyond their submission for the conference. This criticism is discussed in more detail in the article *Challenges in Designing New Interfaces for Musical Expression* (Medeiros et al., 2014). There are signs that this is perhaps changing as Christos Michalakos was awarded best performance at NIME 2016 for his *Pathfinder* project, which uses an augmented drum kit. The instrument has been in development over a period of six years and has grown out of his existing instrumental practice over many performances. As an instrumentalist, I value the rewards of exploring an instrument and developing a personal technique over a significant amount of time and it seems intuitively inevitable to me that an electronic instrument requires the same level of commitment to development and practice as its acoustic counterpart.

My approach to electronic instrument design was firmly rooted in perceivable 'physical to sonic' gesture relationships when I began to think about building my own unique instrument. Although I saw the value of exploiting the increased sonic possibilities on offer, my focus was on designing something that was more similar to acoustic instruments, relying on the action of the performer to perceptibly contour sound in real time. I realise that this approach is contrary to other stems of research in the field which further exploit the extra-human possibilities offered not only in the spectral domain, but also in the temporal domain, harnessing the possibilities of technology to create instruments that can operate outside of the present as suggested by Impett (Impett, 2010). I am also well aware from my time as a Masters student at Goldsmiths of the implementation of neural networks in a musical system that adapts to a performer's improvisations, particularly through the work of Michael Young (Young, 2007), Sebastian Lexer and Oliver Bown (Bown and Lexer, 2006). While these methods do not particularly relate to my own style of instrument design, their views influenced my early approaches to generative composition, which later found a footing in the complex network systems and social models of my generative composition systems discussed in Chapter 3.

Fig 1.1 – 'The Stick' as it was at the time of the submission of this thesis

The Stick was built specifically for my own use, and whilst it has been suggested many times that I develop it into a commercial interface by colleagues and interested investors in technology, this was never a priority for me. My mode of operation in performance is primarily that of a soloist within a group and the design aesthetic of *The Stick* is informed by a 'lead instrument' model, as suggested by its lead guitar-influenced origins. My performance style relies on being a clearly visible focal point, and as such my engagement with the audience relies more heavily on my personal presence than purely acousmatic approaches or those with visual projection, where performers are secondary to sound or image. Consequently, immediacy of the sonic response to physical excitation and the clarity of the perceived connection between physical and sonic gesture are paramount.

ii. Designing An Instrument For Collaboration

When going through the cycle of designing, testing and developing electronic instruments, it may be useful to look at the properties and behaviours of acoustic instruments to inform our design choices. What characteristics make an instrument and how do we go about creating electronic instruments that demonstrate them? Does *The Stick* share enough of these traits to be considered an instrument?

Immediacy

Within ensemble performance, there is a greater need for visual communication as an indicator of intention and action to other players than in solo performance. Whilst I do not believe that every gesture must be clearly legible, instruments intended for ensemble performance must at least have the potential for clear gestural legibility. Instruments must be responsive to employ these gestures decisively and immediately at will within a performance context.

Generative techniques for producing sound do not always match well with instruments designed for immediacy of response due to the previously mentioned dislocation in causality. Players who trigger behaviours to develop over time may find that their contributions are inappropriate to the emergent group dynamic once the sounds come into play, particularly without visual communication of their intent to the rest of the group. Such behaviours were designed outside of performance time for an imagined social interaction that may not be relevant to the contingencies of a current situation. It is also difficult for an audience to distinguish between which gestures are played and which are generated, making instrumental gesture seem inauthentic. The focus here seems to be more on interactions between performer and instrument than it does on one's fellow group members, socially dislocating the operator from the ensemble.

It is the role of the performer to think and to have the ability to control his or her instrument to a standard that they can produce behaviours that are relevant to the present moment. Physically manipulable interfaces afford these possibilities by their very nature. They react immediately to physical interaction through pushing, squashing, bending or caressing. The location of our touch on such interfaces can be instantly calibrated, and combined with other physical correlates such as pressure, allowing multiple interactions in different planes to simultaneously control complex sound in real time. Whilst we can independently craft sonic gestures offline, or leave their creation to algorithmic calculation, the process is an imagined mimicry of complex human action and loses the impetus and authenticity of the human interaction it seeks to model.

Interference

Ideally, we require an interface that can control multiple parameters simultaneously, without the performer needing to spread their attention between individual, separate data streams. As a saxophonist, I do not consciously isolate the act of supplying air from my lungs with the subtle fluctuations of the embouchure. The two are physically related and interfere with one another, yet provide potentially separate data streams, some of which may be unrelated and independent. With acoustic instruments, this interference causes emergent properties within the total sonic behaviour. With interfaces to electronics; controls are separate and lack homogeneity, as Norman et al. state:

> . . . with controllers, we are dealing with systemics at another level: where the mechanical properties of a single component do not influence the overall working of the circuit. (Norman, Waisvisz and Ryan, 1998)

In saxophone playing, embouchure pressure and the strength of breath are intertwined within the behaviour of the air flow in a physical space, and within the body by the interaction of mouth aperture size, diaphragm pressure and a multitude of other subtle muscular changes too complex to perceive (or control) entirely consciously. From here, the air excites a cane reed and the aperture between reed and mouthpiece restricts the flow of air from the lungs. The air, now audible through excitation of the cane reed, travels down a tapered brass tube, as the player opens or blocks holes in the instrument's body to alter to its structure. Due to their physical nature, the exact properties of the materials used can vary from instrument to instrument, with another level of change brought about by fluctuations in temperature and humidity. Tracking approaches tend to lack the subtlety to measure these precise variations. Electronic instruments therefore need some way of either relocating interference at the software level, or by using interfaces with controls that inherently interfere at the physical or mechanical level.

Resistance

Resistance is fundamental to instrumental practice, embedded in the behaviour of physical materials, mechanical arrangements, in our musculoskeletal system and in the resulting air pressure waves which we feel and hear as sound. It is easy to forget that sound travels by moving air, which can be felt just as readily as we can feel a strong wind push us sideways

on open ground. This intrinsically physical inter-relation between human performers and sound creation demands the nuances and complexities of well-designed physical tools to be able to be articulated and communicated with clarity. A socially attuned performer can sense the atmosphere in the room between fellow performers, a current musical situation and an audience. This atmosphere provides another form of resistance to the performer, who needs the immediacy of a reactive interface to be able to push back against that resistance with their own musical force.

Resistance provides the channels through which an instrumental practice is learnt and developed. Experiencing these resistances demands that the player explores their qualities and limits (Waters, 2013; Parker, 2014) to develop the skill to employ them for personal expression and contributions to ensemble performance. Getting to know an instrument hones the player's attention on navigating the boundary between the physical action of the player and the physical resistance of the instrument. A practice is developed through exploration of these boundaries, and as technique develops over time, the fluctuations of these boundaries become negotiable, requiring less conscious attention to traverse. In time, the action becomes less physically demanding for the player to control accurately and finer control can be achieved, allowing for subtler gestures and opening up new timbral possibilities and micro-behaviours within the auditory spectrum.

With electronic interfaces, physical resistance need not have any bearing on the sound created, but in order to vary timbre, envelope and behaviour, we require some method of control, be that generative or physical. Responding directly to resistance in performance requires immediacy, with actions determined by our own choices in the moment. Articulating this response requires some method of refined mapping of physical control to action. *The Stick* interface was designed with the considerations of physical resistance in mind, such resistance operating in three main areas:

Weight

The body of the *Stick* instrument itself is of a substantial metal construction giving it a significant weight for its size. The interface's relative position and orientation is tracked by accelerometers located in the base of the instrument, allowing control of the sound through physically angling and turning the device. This weight provides resistance to the

muscles and this influences the types and speed of gesture employed. Gravity also comes into play here, as 'rising' gestures involve lifting the instrument with the left arm requiring more of an upwards pushing force, whereas 'falling' gestures are more focused on physically limiting the speed of the descending object. Psychologically, these are two distinct types of effort and consequently they can be employed for different operations. They are particularly appropriate for enveloping, where attack is an active push to get the sound going, and release is a gradual letting go or fading out determined by the weight of the instrument in relation to the resistance of the player's muscles to the gravitational force acting on it.

Proximity

At the point at which I added an extra ribbon controller to the *Stick,* the weight of the instrument doubled and became too great for me to accurately manipulate the neck or smoothly lift the instrument whilst supporting the weight of the body. I added a guitar strap and shifted most of the burden to my shoulder, allowing me to regain the fine motor control required for subtle spectral and amplitude enveloping.

The strap had the effect of providing resistance and boundaries to gestures by limiting the distance of the instrument from my body. Previously the length of my arms had provided this resistance and the new regime at first felt quite restrictive. Reducing the 'carried' weight of the device, however, had improved the resolution and control I could exercise over my movement to a level that exceeded even that available prior to the addition of the second ribbon controller.

I began to use the resistance of the strap as an anchor from which to tilt the instrument and this provided a stable position from which to learn to precisely articulate the angle of the instrument. I adjusted the mapping ranges of the parameters controlled to a narrower band to compensate for the loss of physical range caused by the strap. My control over the Z-axis (or 'throttle' as I referred to it) also improved due to the strap. Its addition meant that on turning the stick forward through the Z plane, the strap itself would pull at my shoulder to a point where it stopped altogether. Previously there had been nothing preventing *The Stick* travelling all the way around to its original point which reset at around 180° to the floor. The limiting factor of the strap gave me a point of origin from which to

move away and return to, avoiding glitches in the data stream, paradoxically improving the range of usable and controllable gesture.

Pressure

The Stick originally used a single Doepfer Mk I ribbon controller, which gave the ability to provide pressure data along the length of the 'neck'. The sensor used for this lacked fine resolution and had to be squeezed hard to register any change, making it effectively indistinguishable from an on/off switch. The second ribbon controller I added was a Mk II with significantly improved pressure sensitivity, which registered even the lightest touch. Although the sensor was not particularly malleable in itself, the resistance actually manifested most in the pressure I felt on the tip of my finger, with the compression of my own flesh providing the physical sensation of resistance. Over some time I also gained fairly reasonable control over the Mk I pressure sensor, although gauging pressure was directly related to the amount of pain, and eventually loss of feeling, felt in the tip of my finger bone. I used fingertip pressure sparingly; mainly to drive sounds just beyond their usual limit as the force it took to register my touch negated the sophistication of the fine motor control I developed through playing guitar, particularly on the Mk I controller.

Presence

The aspects of sonic meaning which preoccupy me are those that cause us to experience physical sensations either as an indexical reference to previously experienced sensations or through their behaviour being in some way analogous to the natural world. Rather than viewing the performer simply as the source of a sound in a one-way relationship with the listener, this relationship is incredibly complex, with multiple streams and modes of information emanating from the player and reflecting back onto the player both physically and consciously from audience, fellow performers and physical environment. I find the presence of the audience combined with the environment I am playing in to be a significant influence on my ability to perform. I am prone to becoming aware of what others are thinking of me, albeit that this might be entirely imagined. An attentive audience combined with an environment free from intrusion is the best arena for me to perform successfully, where I can lose myself in the activity sufficiently to become immersed in it. The attentiveness of the audience improves the suitability of the environment, and their

immersion in the environment and levels of attentiveness are related to how well both the ensemble and I are able to achieve immersion within a given performance.

Through resistance, the relationship between performer and instrument takes place and evolves through the physical behaviours that occur between the two:

> The capacity to verify through the body may give some clue as to why musical instruments or objects used musically) serve to amplify the relationship between tactility and sound, functioning as a crucial index of the performer's 'presence', 'focus', 'purposefulness' or 'conviction'. (Waters, 2014: p.122)

The presence of an instrument or object focuses not only the performer's attention, but also the attention of the audience and other ensemble members. Visually the presence of a physical object is fundamental to understanding not only what is happening, but also what is about to happen. The simple involvement of an instrument makes it clear when playing is occurring, something that is hard to distinguish with laptops or tabletop electronics. The clues that sound gives us are less useful for determining intention than visual observation of the performer's behaviour, particularly when using unfamiliar sounds created electronically.

Electronically created sounds need not follow an arc of excitation and decay, being free to move 'unnaturally', whereas physical action will always need to travel from point A to point B, and we can predict this journey by visually observing progress. This is because we know, from experience with our own bodies, the potential for forces such as weight and muscle strength to enact physical movement, and also the boundaries within which such behaviour might exist. The physical strain shown by a saxophonist's contorted face gives extra information about the intensity of the sound and the force it might take to create it, both in terms of the breath of the lungs and the precision and strength of the embouchure.

An electronically produced sound could quite easily suggest an action that is totally outside the realms of plausibility for the human body and might require as little effort as pressing a button to execute. My more long-term collaborators have come to recognize the gestural techniques I use with *The Stick*, and they can adapt and support me by anticipating where I am about to go by watching my movements become more or less exaggerated. Even during

short-term projects collaborators have commented on how easy it is to understand and respond to what I am doing and I have received similar comments from audience members. I have found this particularly common when working with performers who play traditional instruments that are heavily based on bodily movement, such as percussion. The speed of my movement suggests the energy of the gesture, and the height and angle of *The Stick* can function like a conductor's baton, signifying my current position at extremes of register. Rather than solely using instrumental manipulation based around the hands, my entire body is employed, physically amplifying and loudly broadcasting my gestures and intentions visually to fellow musicians.

Incorporating character

Instruments become present in performance through their character, manifested not only through their sonic behaviour but also through their visual and physical design. Visual design should not be disregarded as superficial, or as something to be left until the post-prototype stage as it helps the performer develop a relationship with their instrument and influences both practice and playing style, as in the example of the *Stick* above. Anthropomorphism in interfaces might be regarded as helping to deepen the relationship between performer and instrument and can be enhanced through giving the instrument a strong visual as well as sonic character. Characterization of the instrument also helps in terms of recognition from an audience perspective, and endears the audience to its use through familiarity over time.

Visually, the instrument provides clues as to its use, and through design this can be exaggerated to enhance clarity in intention and communication. I find that some instrument builders consider visual design a low priority, but when performing with such designers I have found it difficult to understand and predict their gestures. Particularly in the case of Arduino-based instruments using sensors, it is hard to glean any character from a device's visual appearance or from the interaction styles of performers on such devices, though admittedly the sound may provide some clues.

Acoustic instruments present their behavioural and sonic intentions through their mechanical design and physical size and shape. Their use over hundreds of years combined with our musical education gives us the experience and knowledge to ascertain potential

playing styles and sounds, breeding familiarity with their implementation and the role they might play within an ensemble. Interfaces give the potential for control over sounds which exceed their physical presence in a traditional sense, but by exploiting some of our preexisting understanding of tools and instruments we can seek to design interfaces that relocate and harvest some of the character of their acoustic cousins.

Elements of behaviour from acoustic instruments can be taken and modeled in order to utilise some of their preexisting reputation and understanding from the audience's point of view. As previously mentioned, the guitar was the acoustic instrument that most informed *The Stick's* design. Visually, the gestural behaviour of *The Stick* is quite directly related the sound it produces. The guitar model is extended so that the physical movement of *The Stick* also communicates timbral and amplitude information through the use of accelerometers. The guitar reference is continued through the mapping of pitch onto the length of the ribbon controller neck, drawing on already understood cultural references and giving clues as to the area of the spectrum currently being occupied in performance.

iii. Conductable: From Playable Installation To Ensemble Instrument

A playable installation

Conductable was an Arts Council supported project that formed part of the Cultural Olympiad for the 2012 Olympics. The project initially involved the creation of a multiplayer instrument as part of the Aldeburgh World Orchestra project *Exchanging Worlds*, working with young people from Primary, Secondary, Youth Offending and Further Education backgrounds. The instrument formed part of a series of installations managed by sound artist Mike Challis who also built the housing for the *Conductable* and constructed the physical aspects of the interface. The instrument was resident in the Dovecote at Snape Maltings from July to August 2012, including the period covered by the Aldeburgh Festival of that year. Students from the University of Hertfordshire Modelling and Special Effects course designed and built the decorative panels that reflected the surrounding architecture and natural environment. I designed and programmed the software for the instrument, including the manner in which the controls were mapped, how the sounds were processed, and designing the synchronization network that supported group interaction and the

lighting system. I also selected and edited the sample material and wrote MaxMSP patches that mapped controller data to DMX lighting within the space.

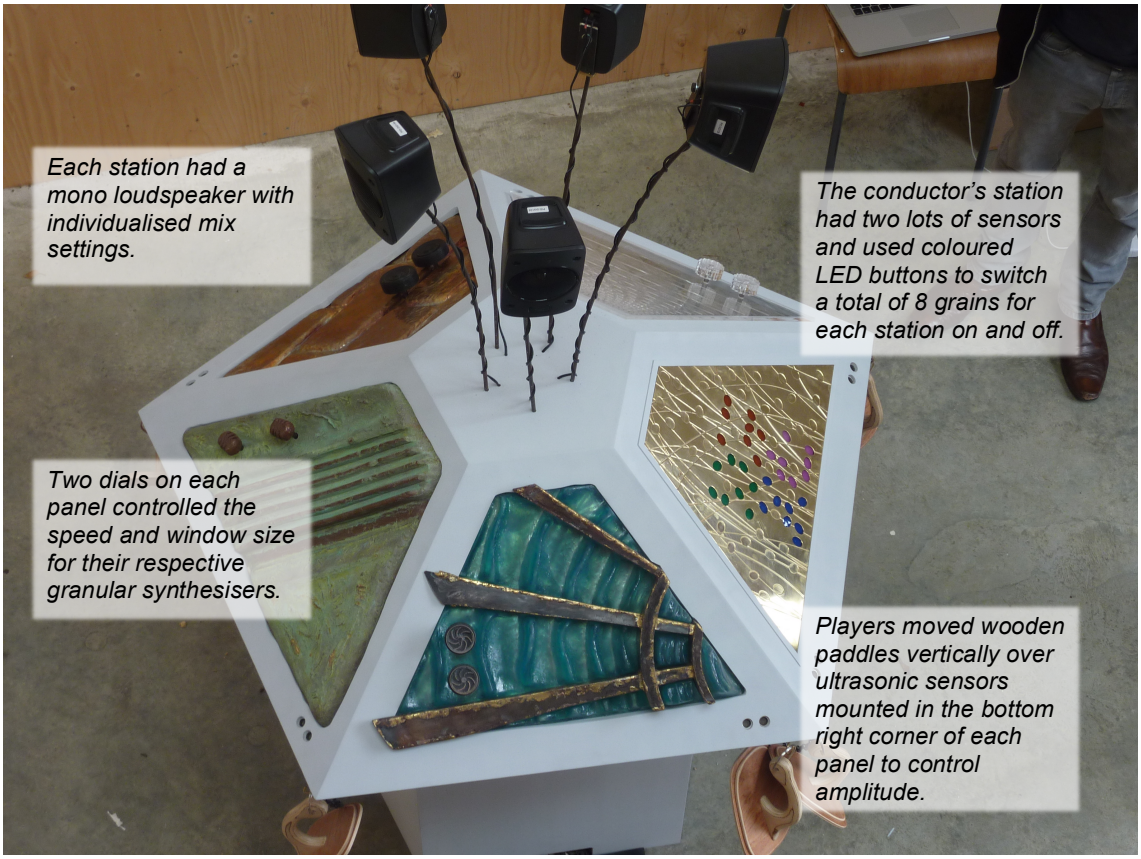

Fig 1.2 – Annotated photograph of 'Conductable' from above from the Dovecote at Snape Maltings, June 2012

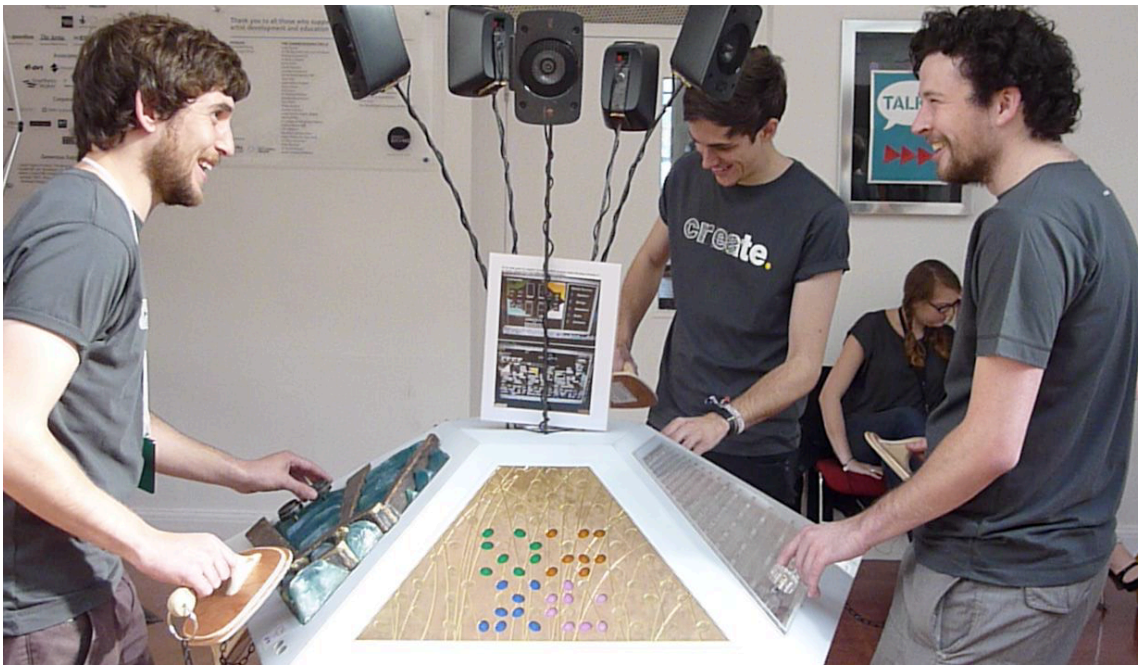

Fig 1.3 – The 'create.' software development team play Conductable at the 'Brighton Mini Maker Faire', September 2012

The main difficulty with this project lay in designing it for purpose in line with the brief. It needed to function as an immediately playable installation for the public whilst also having the depth, subtlety and quality of expression of an instrument. The instrument needed to be instantly understood while providing enough interest to reward further interaction and the development of technique over time. These two approaches seemed fundamentally at odds as my previous experience with instruments were those which took many years to master and hours of practice even to make the most basic of sounds. Designing an instrument for an installation required an approach focused on immediate comprehension and playability through interface design, where the controls and their consequent actions were instantaneously obvious in order to reward the listener with an effect from a mechanical cause.

Paradoxically given the design brief, some of the best results occurred when *Conductable* was unmanned and in 'auto-pilot' mode. The instrument was designed to sense inactivity and after a minute or so, would begin to play itself using a network of LFOs to modulate the amplitude, speed and grain size. Compare an example of the material produced by visitors interacting with the instrument (1) to sonic material generated by the 'auto-pilot' mode (2). Visitors to the installation were mainly inexperienced improvisers and not used to playing music as a group, making the classic mistakes of not listening, or feeling as if they had to continually produce sound.

The tempo that most visitors would approach the instrument with was quite chaotic, as if they were interrogating the controls to see what it could do as quickly as possible. This was most evident at busy periods where the notion of letting somebody else have a turn created time pressure and inhibited meaningful interaction. This may have been improved by a more structured approach to curating the installation to create a more tranquil environment for listening and interacting. The best results were heard when the installation was less busy and visitors felt they could relax and spend some time learning how to play the instrument. In contrast, the 'auto-pilot' mode synchronized the four voices and varied parameters gently to create slowly evolving drones that gave more space to the consideration and subtle variation of the sonic material. *Conductable* uses granular synthesis and slows the sonic material to around 25% of the original speed or less. The drawn out transitions of the 'auto-pilot' mode created compositions that were more idiomatic to both the material and the sound transformation processes. The installation as a whole was built to underscore and

consider the surrounding environment. Slowly evolving textures and gradual transitions leave more space and time for this to occur.

The installation received mainly positive feedback focusing on how much fun it was to play and how interesting the sounds were. Visitors who spent the most time with the installation unsurprisingly developed the best technique and played the most interesting pieces. Children would play it for hours and seemed well engaged by its visual appeal and similarity to Dr Who's Tardis.

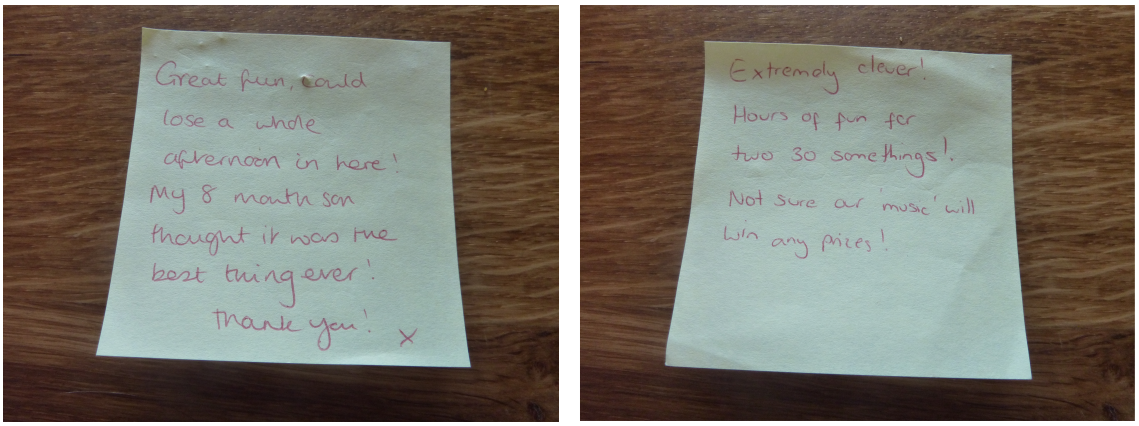

Fig 1.4 Two examples of feedback left by the installation at Snape Maltings, 2012

Fig 1.5 Children particularly enjoyed and spent the most time playing 'Conductable'. Maker Faire, Brighton 2012

Multiplayer instrument

I repurposed *Conductable* as a multiplayer instrument for the performance of three pieces as part of the UEA Sonic Arts series of concerts. This was an experiment to see if I could repurpose something initially designed for a public installation as a multiplayer instrument, on which technique could be developed and distinct works could be written and performed.

The three pieces have been included in Appendix D, alongside a brief example of *Conductable* in 'auto-pilot' mode. It may be most useful, however, for the reader to watch the video of the performance at the University of East Anglia (2013) from the submitted works at this stage. Excerpts of this performance will also be directly referred to in the text below.

I removed some of the constraints and added extra functionality in order to reengineer it to fit into the kinds of ensembles and musical structures I was used to working with. I enlisted a team of players with whom I could rehearse and provide instruction on the instrument, which allowed me to execute coordinated section changes and call upon specific types of structural and sonic behaviour at will. I created different modes of operation that remapped the control parameters and ranges, giving to distinct behaviours for three separate pieces; *Hokit, Mantra* and *Edun*. The 'auto-pilot' mode was repurposed to provide a constant selection of LFOs that modulated the amplitude globally at varying rates for each player, providing an element of synchronicity most evident during more static periods of drone textures.

The conductor's station was enhanced to include control of the pitch space and the harmonic relationships between each station. I executed coordinated sectional changes through the use of a six-sided die as a visual trigger. During the performance of *Mantra*, for example, I turn the die to indicate 'mode one' at 6m 15s (3), signaling to the players to set their dials to the smallest window size and playback speed. As the excerpt shows, this unifies the timbre of all players to a grainy drone. At this point the conductor station becomes most effective as I take control of pitch between 6m 40s and 7m 34s (4). My movements are quantized by a series of regular intervals giving rise to scales that are individualized to each station due to the mathematical relationships of the conductor's frequency and the pitch of their current sample. I am able to perform a melodic phrase

with good control at this point, utilizing my knowledge of the instrument and subtle variation in the height of my hands over the ultrasonic sensors to execute it. I avoided the use of the wooden paddles provided for the installation, as their extra weight reduced the capacity for subtle control.

Similarly in *Hokit,* the coordinated action triggered by the die resulted in a group gesture which emerges between 7m 40s and 8m 50s (5). This arose as a result of increasing the range of pitches available to the players, allowing for more complexity from the harmony of the group as a whole. The players themselves recognized that a significant group 'event' was occurring and used their experience as musicians to respond and play together. They were able to do this because of their training and practice on the instrument, and because they had been entrusted with more subtle and unpredictable control methods than were featured as part of the installation version of the instrument. My own familiarity with the instrument is also a factor here, as I can recognize an individual player's performance tendencies and respond by allowing them greater freedom or by constraining them to a particular behaviour type for the benefit of the group dynamic.

My role in this project was a controlling one in comparison to my other ensembles, where hierarchical structures, particularly outside of the performance, were much less evident. My control over the group enabled me to experiment with prescribing roles, behaviours and social dynamics in order to observe their effects and to test the success of the approach. My reflection on the success of this experimentation informed the way in which I approached the composition of *The Stream* in terms of prescribing strict roles to software agents through inhibiting the natural role development of human musicians. This is discussed further in chapter three.

On reflection, I was much more satisfied with the *Conductable* repurposed for performance, as it gave me the freedom to create an instrument informed by the complexities and instrumental subtleties I had learnt through development of *The Stick*. The installation felt somewhat more contrived and restricted, adapted as it was toward the lowest common denominator of musical and instrumental skill and understanding. The installation lacked variety and the opportunity for subtle and nuanced control, and any truly interesting compositional behaviour. Watch the example of an ensemble formed of UEA undergraduate Music & Technology students and musician/composer Simon Limbrick, led

by composer/musician Anton Lukoszevieze playing the installation version of *Conductable* (6). Then compare this with the excerpt from my ensemble playing the performance version of *Conductable* (4) & (5). My ensemble had one more rehearsal and were led by the instrument's designer (me), but the ensemble led by Anton were equally skilled and familiar with the genre yet their performance lacked the level of convincing collaborative composition evident in the performance version of *Conductable* during the same performance at UEA. The skill and experience developed on *Conductable* through rehearsal by the trained ensemble led to more interesting and structured musical results with moments of both individual and group flair.

iv. *The Stick:* Developing Both Instrument and Practice

Being both designer and performer affords a unique opportunity for short product development and release cycles. I found that success of this approach is improved when one has a clear goal in mind and implements changes gradually. One of my main flaws as a designer has been that I have tried to implement too many features at once, particularly during the later versions due to having many ideas and wanting to implement all of them. In addition to the conceptual concerns discussed during the first section of this chapter, one of my key objectives was to be able to feel like I had a good level of ability on the instrument, with the intention of one day achieving a level of skill approaching what I had previously developed on acoustic instruments.

What's wrong with virtuosity?

I would identify the skill and experience accrued over time as a kind of 'virtuosity', and this is something I strive for in my mastery of *The Stick*. Virtuosity is sometimes criticized in the field of electronic music as having nineteenth century connotations and identified as outdated, pompous, self-involved or simply pointless and irrelevant. (Klett & Gerber, 2014). Although the term originates from the Latin 'excellence'[2], it has come to be applied particularly in Western classical music to mastery of the mechanical operation of an instrument.

Stapleton, in *Dialogic Instruments: Virtuosity (Re)Located in Improvised Performance* suggests that

[2] https://en.wiktionary.org/wiki/virtuoso#Etymology_2

new musical instruments as described in the paper 'resist mastery' (Stapleton, 2008: p.2), both by being unreliable, and by having no prior associations with preexisting forms of music, making them potentially 'interesting' for use in improvisation. Achieving virtuosity is an intention; one can resist mastery and virtuosity by intentionally not practicing in combination with playing an instrument that is difficult to develop a practice on by minimizing consistent features. This seems to be an approach that specifically resists virtuosity as an intention of the performer/designer for their own conceptual reasons. My own practice involves the intentional mastery of an instrument in order to play in a range of different modes and contexts, using judgment in order to employ these in the most appropriate situations. Practising and performance experience improves playing ability, resulting in improved clarity and execution of intention. Exploring new techniques is interesting in the experimental stages, but as an audience member, personally I do not necessarily share the player's enthusiasm for this process. I would consider the process to be practicing, not performance. For example, I find it difficult to imagine audiences enjoying watching someone learn to play the clarinet, for example. Might we not also exploit some of the skill developed by acoustic instrumentalists and design instruments that draw upon the fine motor skills honed through years of a well-developed practice? Much of my own instrumental skill is vital not only in the control of sound with an electronic instrument, but also in knowing how to design the instrument to best exploit the subtle nuances of muscle control I have already developed.

With traditional virtuosity, there is an element of impressing the audience, giving them something that they can recognize as being highly skilled and difficult to achieve. The term is culturally rooted in the idea of going beyond what the body can normally do. Since digital technology already allows this possibility, perhaps we need to redefine virtuosity as a level of skill that encompasses, but is beyond, that of instrumental operation alone.

Practice and Practising

With any instrument or tool, mastery is achieved through repeated use and the application of knowledge learned from experience. Ideally each use should help inform the next of its most effective implementation, and skill is progressively improved over time. Generally, proficiency is improved in proportion to both the amount of time spent practicing and the effectiveness of the training regime. The difficulty of the instrument also comes into play

here. Typically instruments that rely on continuous tuning methods, such as strings, rather than discrete tuning, such as woodwind, take longer to master.

Ideally, this practice would involve some level of tuition on the instrument from an experienced practitioner, but due to the transitory nature of electronic instruments, such practice rarely develops on a particular interface for long enough for it to be passed on to anybody else. Experimental instruments are also rarely persevered with long enough to develop any kind of established practice or advanced skill (Medeiros et al. 2014). This limits the development of interfaces in live electronic music, and encourages players to fall back on acoustic instruments on which they may have already achieved an advanced level of skill. An instrumental practice requires a process developed in relation to exploring the resistances of the instrument, and being able to employ learned techniques at will, given the appropriate musical situation. With instruments that demand physical control, one must also learn to harness the body for the implementation of subtle control. The ability to feel comfortable enough on stage to use one's body expressively requires confidence, and the subtle control that an instrument demands requires excellent fine motor skills to move smoothly and with control.

To develop this, I have analysed videos of my performances and also practice in my studio using a full-length mirror, an idea borrowed from dance studios and vocal practise rooms. Performances in which I believed my movements were flowing and expressive often looked restricted and timid when viewed after the event. I found that I had to spend some time exaggerating my movements in order to achieve the level of visual physical expression I was aiming for. In particular, I observed that I was always very hunched over on stage in early performances. Through making a conscious effort to draw my shoulders back, I gradually developed a more confident and outward facing posture over time. This postural change had an effect on how I played and the types of gestures that I used, making my playing much more communicative and less insular. This type of reflection only occurs through time spent playing the instrument, combined with reflection and developing an instrumental practice over time. These types of developments did not occur when I spent a disproportionate amount of time building or programming the instrument.

One benefit to self-built instruments that acoustic instruments lack is that the instrument itself can be more readily developed in relation to the player, by the player. Performer and

instrument can adapt to each other without the need for any other instrument builder or designer to complicate the chain of communication. Through DIY electronics and programming the player-designer can refine the instrument over time through experimentation in performance and rehearsal. The results can be so instantaneous, particularly with software such as MaxMSP and Supercollider that the instrument can actually be refined during rehearsal, or, with live coding, during the performance itself. Even when using electronic elements like Arduino, code can be uploaded fairly readily. With acoustic instruments this is not so straightforward, and risks the possibility of irrecoverably damaging the instrument. As previously mentioned, too much modification during performance can distract the performer from group interaction; however, occasionally moments of inspiration can occur and lead to important developments in the behaviour of the instrument. For me, these inspirations have tended to be tuning-based rather than major operational changes. I found that useful parameter ranges are best revealed through live experimentation in conjunction with the ensemble rather than by practicing alone. This continued development of a single instrument has become a key feature of my practice, and *The Stick* has gone through six major developments in the last ten years, with incremental changes along the way.

The chronology and development of a *Stick* based practice

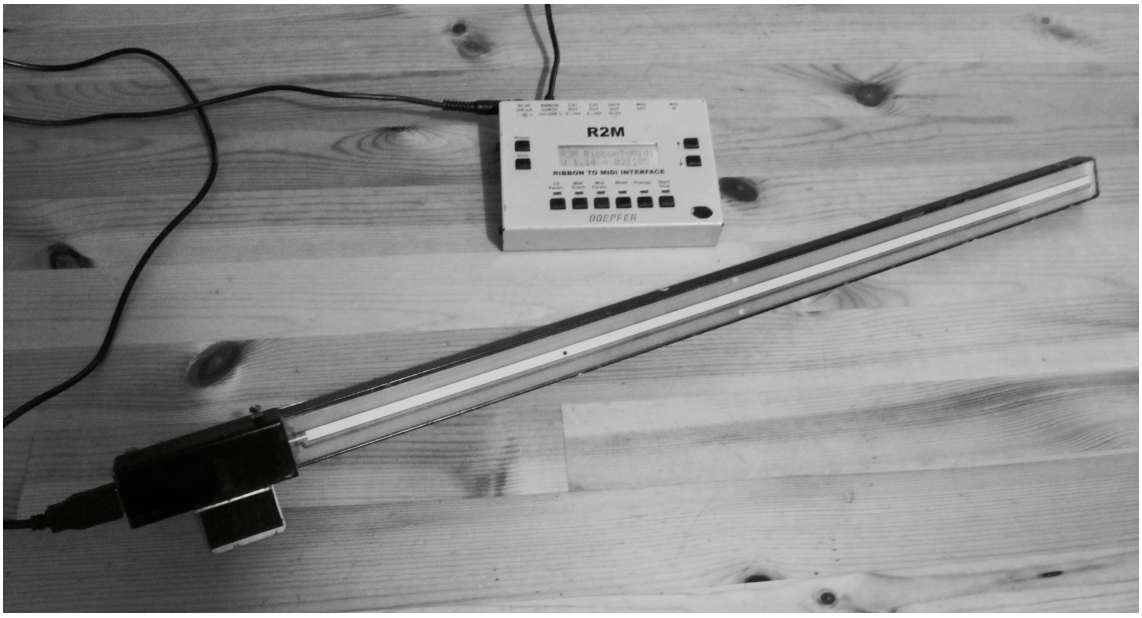

Fig 1.6 – The Stick 1.0 comprised of the Doepfer R2M ribbon controller 'manual and control box'

The Stick 1.0 'Live sampler'

The first version was physically comprised of one Mk I Doepfer R2M ribbon controller and MIDI/CC converter that could be programmed to alter the way the data from the position and pressure sensors were set. The control box sent MIDI data that I received into MaxMSP 4 via a Midisport 4x4 at the finest resolution possible of just 64 MIDI notes. Finer control could have been achieved through control voltage but I had no way of converting the signal at the time.

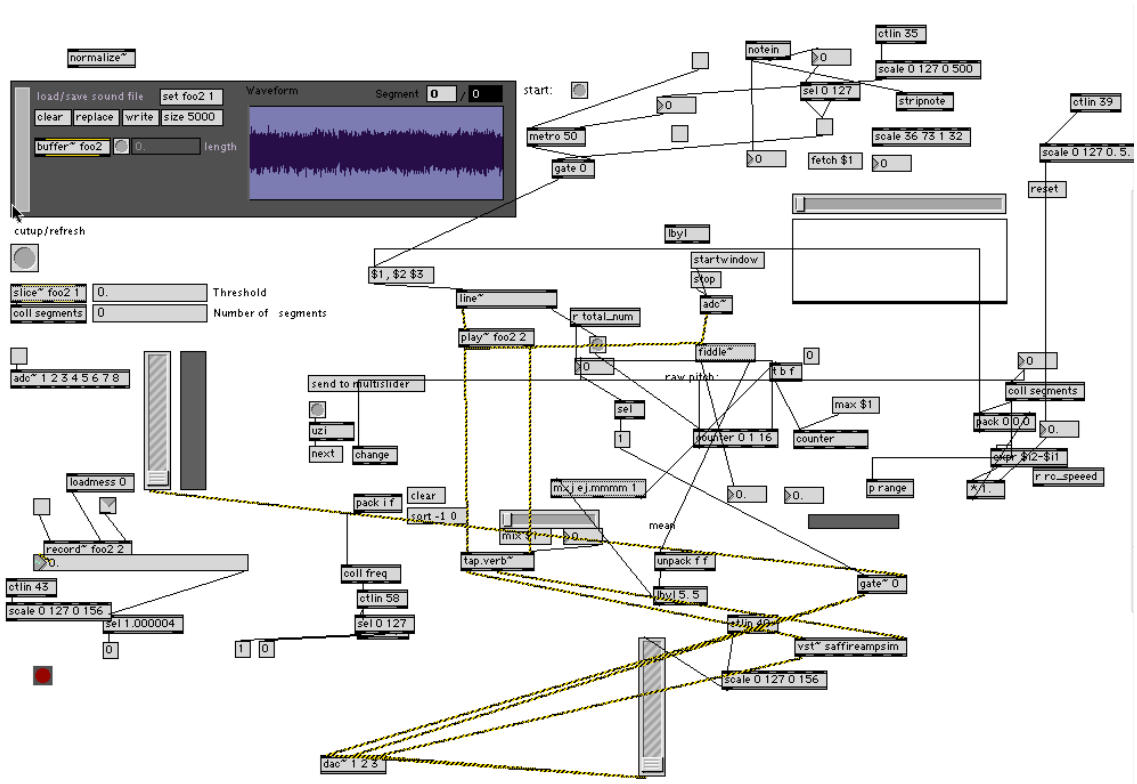

Fig 1.7 – Max patch for 'The Stick' version 1 programmed in Max 4

The software was very simple. A sample could be loaded into a 'buffer~' and the patch performed a wavefront analysis to slice the recording into segments based on attack data using Nao Tokui's 'slice~' object for MaxMSP. The object is no longer available or compatible with current operating systems, however, several updated objects are available which perform similar functions and can be substituted fairly simply.

The level of success of the slice function was dependent on the sample material. Percussive attacks were most clearly identified, with more dynamically consistent material often resulting in one long segment and many small but less useful segments. The patch could also live sample, either from a microphone or (more often) from other individual players

within an ensemble or from the entire ensemble mix. The full length of the sample was mapped to the full length of the ribbon, and divided so that corresponding areas along the length triggered the sliced portions. I would get to know how each sample was divided and consequently learn the locations of useful material in order to trigger specific sounds without needing to visually check the software. Squeezing the ribbon controller to change the playback speed altered the pitch, but in practice accuracy was difficult to develop due to the lack of sensitivity of the pressure sensor (Doepfer, 2005: 13). Reverb and distortion were employed but could not be bypassed entirely as there was only a limited single signal chain. I made some attempts to order the samples by their innate pitch, which was not entirely successful given the noisy character of some of the samples used. *The Stick* version 1 was monophonic and lacked expression control, which made its use in a range of contexts difficult. I relied predominantly on using a bank of ten to twelve long samples for each performance in order to achieve variety, and relied on the envelope and character of the original sound and how it was sliced as the main elements of expression. This can be heard in the vocal 'ay-ah' motif implemented in the improvisation *FHTA live at the EMS II* between 2m 50s and 3m 12s (7).

The Stick 2.0 'Motion control'

The second version added significant functionality and a rudimentary mixer that allowed me to apply effects in varying degrees. Polyphony was added, allowing the creation of richer textures, and further attempts were made to implement pitch ordering with more success than previously. The main development to this version was the addition of movement control through the Y and Z axis using a Nintendo Wiimote taped to the base of the ribbon controller. This was used in conjunction with a delay, using the 'tapin~' and 'tapout~' objects with the feedback amount mapped to the Z-axis and the delay time mapped to the Y-axis. Through experimentation this became a key source of expression and created a clear link between physical and sonic gesture. The base was held in my right hand and the end of the 'neck' in my left. As I turned the body to face the ground, the feedback built and when *The Stick* was held parallel to the ground created slow regular pulses that increased in tempo as I angled *The Stick* away from the ground, keeping the base steady. Increasing the angle in relation to the ground by lifting the neck with my left hand, whilst turning it on the Z-axis toward the ground would overload the delay unit, causing a ripping sound as I pulled it rapidly through the air. This technique can be seen in the

accompanying but rather poor quality documentation of an early *FHTA* performance at the Sonic Arts Network Expo of 2007, between 7m 34s and 8m 07s (8).

Later versions of *The Stick 2.0* included a more graphically pleasing GUI as I made the interface more professional and instantly controllable live through the addition of virtual switches and faders. The Wiimote was fairly unreliable in terms of connection. This was improved by adding functionality to my interface that would allow refreshing the connection without restarting the patch. As visible in the patch screenshot below, I began to notate the most effective threshold values for the pre-prepared sample material, which gave consistency to the positions of the sliced segments, allowing for more accurate repetition and the possibility for playing distinct compositions more precisely. The moniker of *The Stick* had not yet been applied but I named the instrument 'Harold Hands' in order to feel more of a personal connection to the instrument and, more practically, to have some way of referring to it.

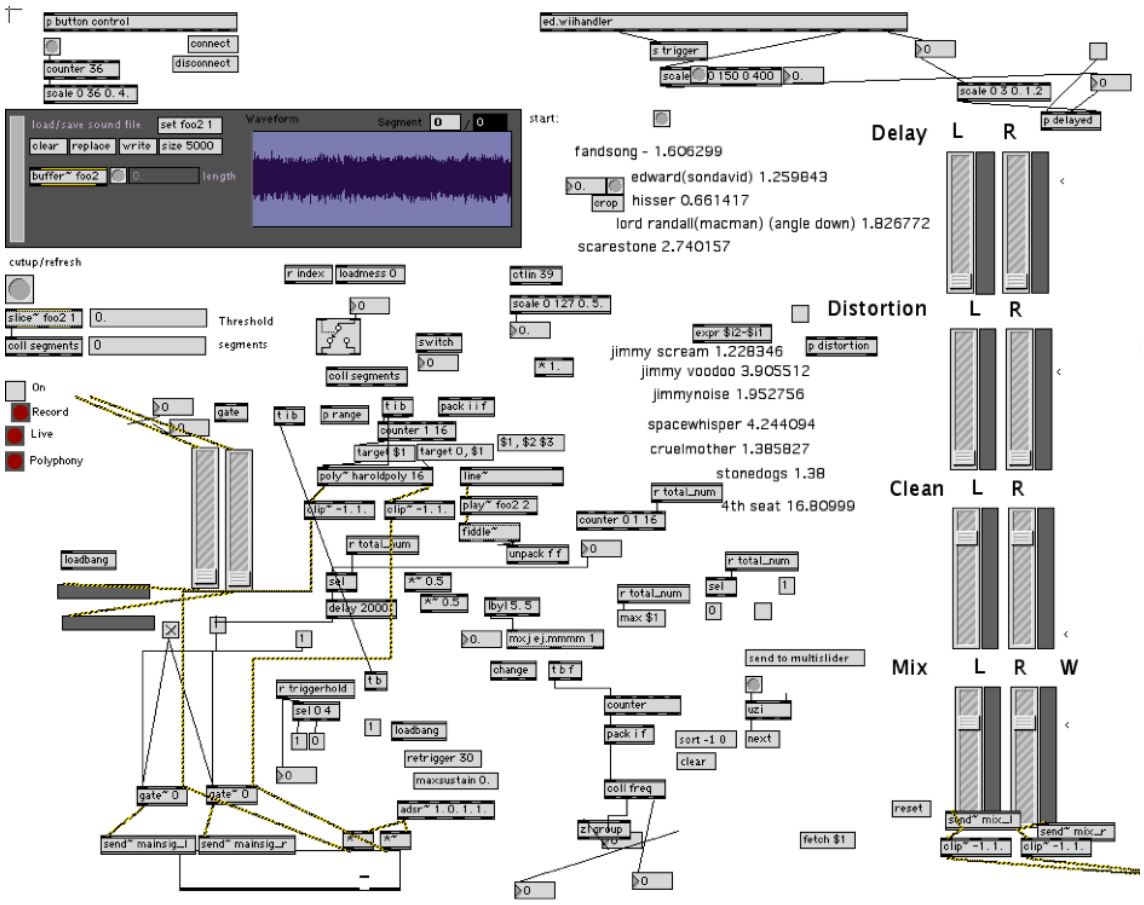

Fig 1.8 – Max patch for 'The Stick' version 2 programmed in Max 4

The Stick 2.1

Fundamentally the same functionality as *The Stick 2*, with the addition of a graphical user interface, better stability and more control over loading samples from the interface itself. Various processes were divided into separate modules that could be operated independently or in various combinations.

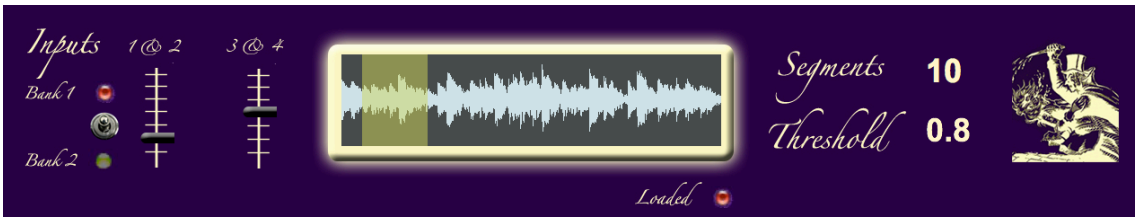

Fig 1.9 – Sample analysis and segmentation module of The Stick 2.1

The Stick 3.0 'Granular Synthesis'

In the third incarnation of *The Stick* I first implemented what would become the most timbrally and behaviourally iconic function of the instrument: granular synthesis. The sonic character of versions 1 and 2 was unsubtle in terms of envelope and of poor timbral quality, due to time being spent on the instrument's control function rather than on creating high quality sample material.

Version 3 implemented a polyphonic granular synthesiser with eight grains and was quite inefficient, replicating the entire synthesis engine for each instance of polyphony. The drain on my CPU limited me to eight grains, a resolution that was too low for the more precise temporal changes I was used to from software effects. In practice I developed sample material and choices in their implementation that exploited the stuttering qualities of the eight grains and generally played them at a grain size of between 1000ms and 2500ms. The technique involved very slow playback rates of around 1% to 20% of the original speed of the sample, allowing for sustaining of textures and the gradual movement through these, for timbral development.

Vocal samples and rich instrumental material worked best for texture due to the lack of percussive attacks, and noisy or percussive material was most usefully employed to create rhythm. The clearest example of this technique can be heard in the *From Honey to Ashes*[3]

[3] From Honey to Ashes are comprised of Jeremy Keenan, Matt Lewis and Ed Perkins and are discussed further in the following chapter

(henceforward *FHTA*) composition, *Tall Trees* where I implemented Nina Simone's recording of Jacques Brel's *Ne Me Quitte Pas* as sample material. Simone's voice provided a rich source, being a mix of sustained pitched material for timbre and a significant amount of vocal attack and disruption for the creation of rhythms. I would encourage the reader to listen to the album recording of *Tall Trees* at this point found in Appendix D on the accompanying media.

For the purposes of visually observing the techniques mentioned above, the following analysis refers specifically to the live video recording from the FHTA performance at SARC, Belfast, also included in the submitted works. An example of the aforementioned techniques being used together is evident between 4m 24s and 7m 10s (9). I removed the delay and distortion effects from the previous version and reassigned the motion control of *The Stick* to playback speed on the Z-axis and amplitude control on the Y-axis, which is visibly clear from the previously mentioned example.

The direct legibility of physical to sonic gesture is strongest in these simple techniques and their success is determined by the skill of the player, developed through practice. Upturning the instrument and physically suspending its movement in space suspends the sonic progression through the source material, temporarily removing any identifiable indexical reference to create something more recognisable as instrumental timbre. I continued to refine my physical gestures for *Tall Trees* many times over a five-year period, and my execution of it has barely changed from the technique I first employed with *The Stick* version 3.

The Stick 4.0 'Comb filtering, presets and network sync'

Version 4 was the most radical software redevelopment of *The Stick I* to date. The patch was rewritten from scratch, streamlining costly CPU heavy processes and implementing a preset manager with the possibility to blend between presets. This was useful for predictably replicating pieces live. Specific transition times could be set to effect gradual changes that often contained interesting sonic artifacts, depending on the parameter being changed. Changes in numerical parameters would smoothly transition whereas changes in sample material or the mode of operation of an object might 'ping' or 'crash' sonically as they altered over time.

Preset changes could be triggered within a whole ensemble using a network/client server model designed primarily for use with *FHTA*. Each performer in the group employed the blendable preset interface I had developed using the new 'pattr' and 'pattrstorage' objects in Max 5 and whoever controlled the server could trigger global changes at will over a predetermined timeframe. Tempo or pitch could also be synchronized wirelessly over a private network through the Open Sound Control format as evident in the ensemble synchrony of *A Kind of Logic* and *Baby Birds*, which are included in Appendix D.

I abandoned the automatic sample slicing function at this point and instead divided sample material up into six sections of equal length. I would then play these in order to learn what each section contained, tweaking the boundaries if necessary. Gaffer tape was initially used to demarcate the sections visually, but I gradually learnt to orient myself by touch instead of eye, negotiating the six zones delineated by the subtle rise and texture change caused by the tape. Sonically the major development was the addition of banks of comb filters that could be individually tuned for each grain.

I maintained the approach of a granular synthesiser for each zone on the neck, meaning that each zone when comb filtered could be formed of different combinations of eight pitches, allowing for timbrally rich and varied harmonic material to be generated. An example of this can be heard in *The Raw and The Cooked* (henceforward TRATC) performance of *The Rhime of the Ancient Mariner* that features drones from evolving gradually over the first eight minutes or so (10). This timbral development was achieved by using short grain window sizes and faster playback speeds to activate all eight comb filters simultaneously for better smoothing and richness of timbre. Longer window sizes and slow playback speeds were used to sound each comb filter in turn, creating the ringing low melodic sequences heard between 17m 40s and 19m 17s (10).

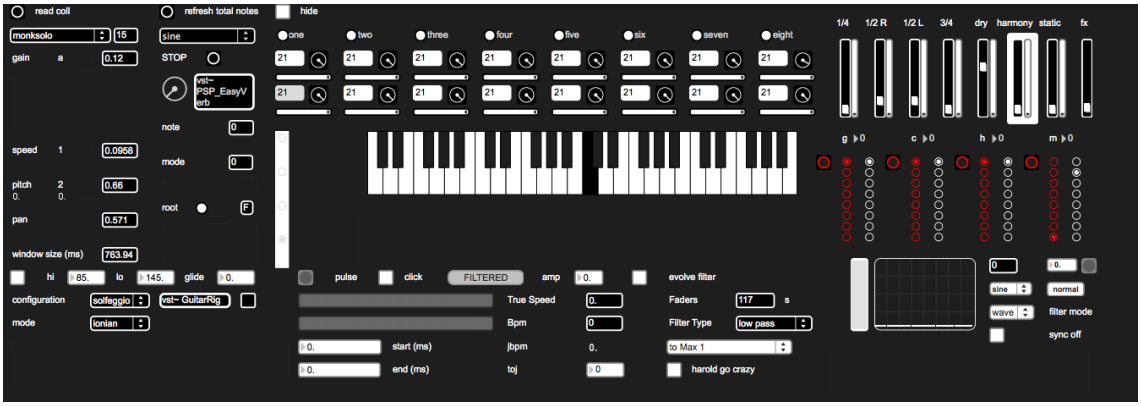

Fig 1.10 - 'The Stick' Version 4 in the 'new' Max 5 presentation mode, with loadable presets in red on the right hand side

The Stick 4.1 'Thumb stick and twin neck'

Whilst not warranting a change in software version number, this development featured the physical addition of a second ribbon controller and a Nintendo Nunchuk for use as a thumb joystick controller. These were added to add potential functionality, but a useful implementation for them did not emerge until *The Stick* version 6. This was due to the physical joining of the two ribbon controllers initially being set far enough apart to get my fingers between. The joining struts limited the possibility for glissandi and were set too far apart to allow the hand to operate both ribbon controllers at once.

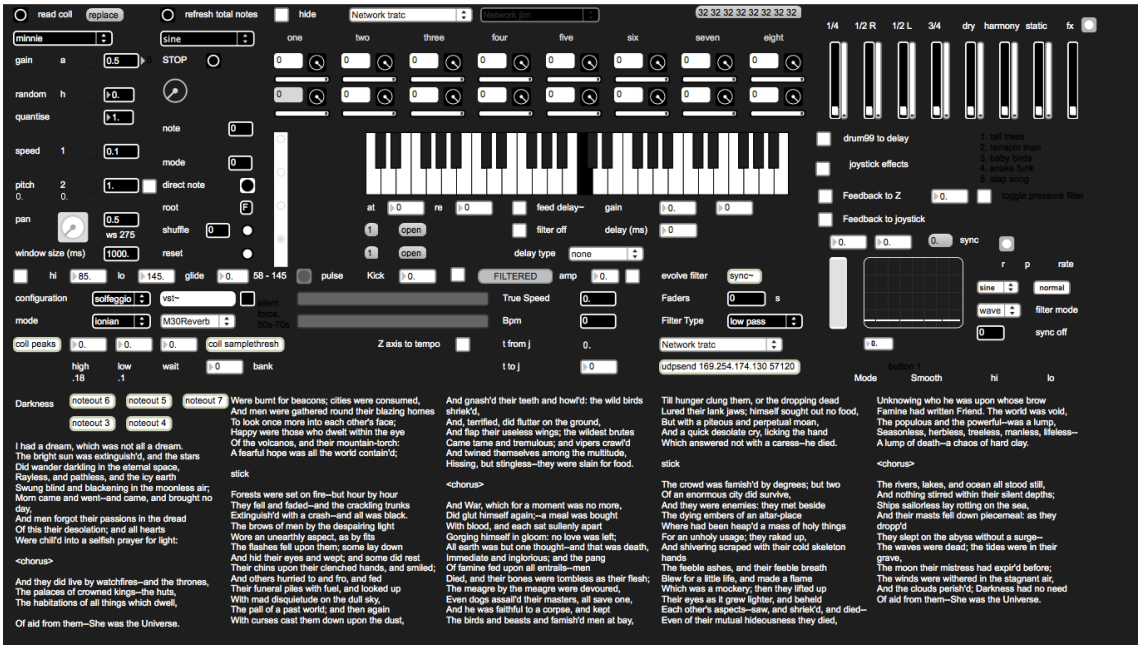

Fig 1.11 - Showing a slightly more crowded and enhanced stick version 4.1 in presentation mode. This patch was often used to accompany spoken word and I would display the text on the patch to annotate and use as a score.

I experimented with dedicating the second ribbon controller to changing comb filter pitches, which was of limited use in practice as it created a resonant attack at the beginning of each pitch change which was not always compositionally appropriate. I spent some time trying to smooth this by delaying the transition between grains but this was never successful. The thumb joystick was added, as ergonomically it was near to where my right hand rested and provided some element of gestural control, but the ranges were too small to be controlled well enough for expression. I also painted one controller black and one white as shown in *fig 1.13*, which helped me to identify their processes individually within the patch by adding a prefix of 'black', 'b' or 'blackstick' or 'white', 'w' or 'whitestick' to messages. It was not until more recently I realized the benefits of consistent naming strategies and my inconsistencies would cause me to come unstuck when duplicating processes from one ribbon controller input to another.

A guitar strap was added so that I could cope with the increased weight as the ribbon controllers are of thick metal construction. This limited some of my more extreme physical gestures but also improved fine control of physical movement. The whole unit was held together by gaffer tape and this caused an issue with access to change the battery. The tape would gradually lose strength causing the Wiimote or Nunchuck to become detached.

Fig 1.12 – The first performance with the addition of the joystick and twin neck at Shunt, London 2010.

The Stick 5 'Better construction and rhythmic sequencing'

Version 5 was another total rebuild from scratch. The entire instrument was improved both in terms of visual appeal and strength of construction and the software now included a sequencer for providing modulation and percussive sequences. I was preoccupied at this period by rhythm, and after spending significant time trying and failing to get the granular sequencers to play grains according to a global tempo, I opted instead for a sequencer that could synchronise envelope triggers to external tempo. Tempo synchronised filter modulation was added along with a drum machine that used sample material played along the neck. This entire approach was flawed and resulted in some of the most regular, predictable and uninteresting behaviours yet obtained from *The Stick*. The sequencing and synchronising with external sources made control of *The Stick* feel more automated and less intuitive. It also prevented me from enacting specific types of rhythms or gestures at specific times.

I was trying to make an instrument designed for free experimentation work within a fixed timeline, which was a conflict in design goals. On reflection I realise that what I was doing

was reducing the possibility for immediacy and negating the use of a physical interface. This version of the patch could just as easily be operated from the laptop, enacting similar behaviours.

The Stick 6 'Basic synthesis, simplified granulation and an ultrasonic sensor'

After the failure of version 5, version 6 saw another complete rebuild of the software. I had abandoned *The Stick* for some time and had returned to very basic approaches using dials and faders to control cross-modulated LFO patterns and basic FM and AM synthesis techniques on simple waveforms. I also began making my own sample material from various found objects, then playing them at incredibly slow speeds without pitch compensation and letting them evolve, bringing them out in a mix by increasing their amplitude at moments of interest. This simpler approach influenced my redesign in version 6, which focused on simple processes, fine degrees of control and mapping strategies for physical movement to parameter control. I limited the granular synthesis to just four instances, dividing up the length of the black Mk I ribbon controller into four zones to trigger the envelope of each instance. Squeezing the pressure sensor within a zone engaged a latch mode, which would sustain the sample indefinitely.

Fig 1.13 – FHTA's last performance at SARC in 2013. The most successful live performance using 'The Stick' to date (version 6). Left to right: Matt Lewis, Ed Perkins and Jeremy Keenan

Whilst operating within a specific zone, the motion of the accelerometers is commandeered for use within that zone only, allowing for the possibility of layering and mixing the output of the four granulators to create rich textures. Each granulator could be loaded with a different sound source, affording a wide range of sonic possibilities in combination with variation of pitch and speed. I was still able to execute previous work such as *Tall Trees* through operating one granulator within a single zone, but could now play much longer and more varied pieces such as *The Dream*, which required a more diverse selection of sounds to support the narrative. A filmed rehearsal of *The Dream* has been included as part of the additional materials in Appendix D. Whilst the audio recording quality is through the camera's microphone, the recording documents the varied behaviour of this incarnation of *The Stick* and my ever increasing skill in playing it.

The Mk II white ribbon controller, which until now had no fixed role, was deployed as the control method for an entirely new synthesis engine. Four simple waveforms in multiples of two could be employed: sines, saw, square and noise. Their pitches, amplitude and filters were all accessible from the instrument directly through implementation of a specific 'waveform mode' enacted by holding down the Nunchuk trigger button. For example, the sine oscillator was triggered by touching zone 1 on the white ribbon controller. By maintaining contact and holding the Nunchuk trigger, the pitch could be manipulated across the entire length of the white ribbon controller, with octave shifts available through the Wiimote buttons. One of the most effective implementations of this was the playing of glissandi as shown in *Maesteren* from the *FHTA* live performance at the Sonic Arts Research Centre at Queen's University, Belfast (SARC) between 8m 42s and 9m 13s (12). The gesture is played again in an extended form at 10m 05s and 11m 28s (13), further defining the legibility of the instrument and its identity and role within the piece. Amplitude modulation, speed and depth were controlled via the Nunchuk thumb stick, allowing for subtle pulsing. This approach was used to build up layers of waveforms which maintained whatever behaviour state they had been left in, and could be disengaged quickly by touching the corresponding zone of the neck to instigate the envelope release stage, as shown in *Maesteren* between 9m 50s and 9m 57s (14). This took significant skill and practice to achieve, as it required knowing which layers were active (without a screen based indicator) and the accuracy and muscle memory to deactivate them through touching specific points of an unmarked surface.

I later developed the use of an ultrasonic sensor to control modulation instead of the thumb stick but did not get a chance to implement this in performance. An ultrasonic sensor was chosen instead of the more common LDR so that I could operate successfully under bright stage lighting. The Y-axis of the Wiimote was still employed to control amplitude for the oscillators independently of the granular synthesisers. A new preset management system was employed, abandoning the transitioning feature of version 4, as I became fluent enough to enact behavioural changes for sections through playing. Presets launched combinations of sample banks and the initial state of parameters for each piece.

The screenshot above is not intended to be legible but acts to show the level of complexity that *The Stick* has accreted over time.

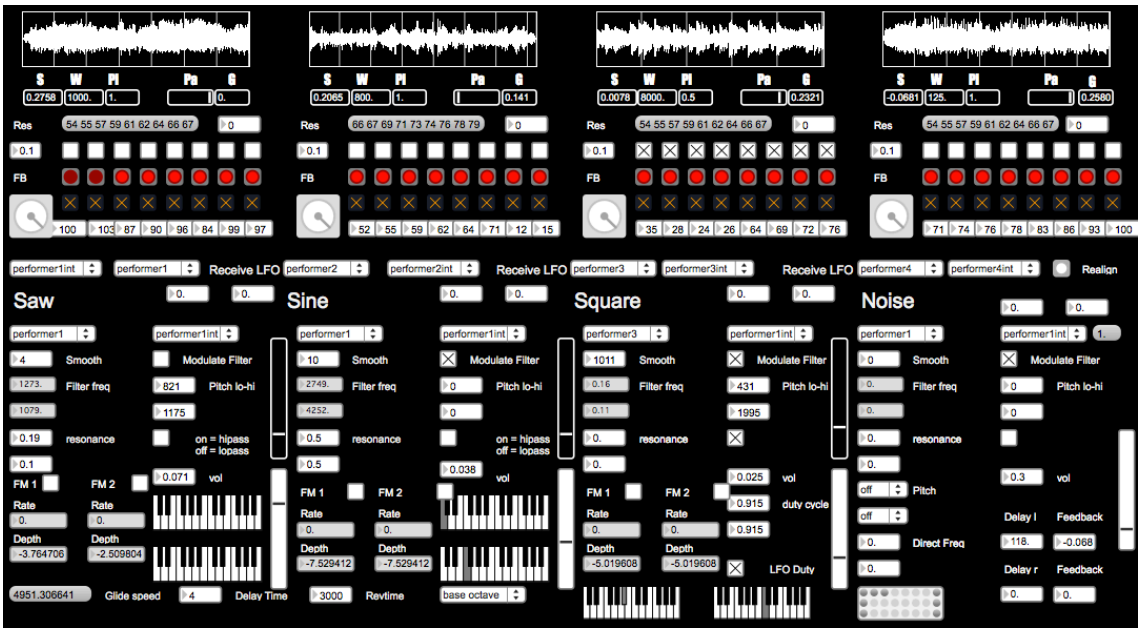

fig 1.14 – 'The Stick' version 6.3 patch in presentation mode giving visual feedback for global patch settings. The red LEDs and toggle boxes in the top section allow for routing and switching of individual grains.

Version 6 features a 'self-drive' system where a bank of LFOs I termed '*The Source*' can be assigned to various parameters. On sensing inactivity, these take over to modulate amplitude, filters or playback parameters. This was an idea borrowed from my programming for the installation and multiplayer instrument *Conductable* that shared the same basic granular synthesiser. The management of timbre and behaviour development by *The Source* meant that although I could not directly control all aspects at the same time, individual elements could be relied upon to sustain their behaviours, synchronised and

modulated as they were by banks of interrelated LFOs as shown below:

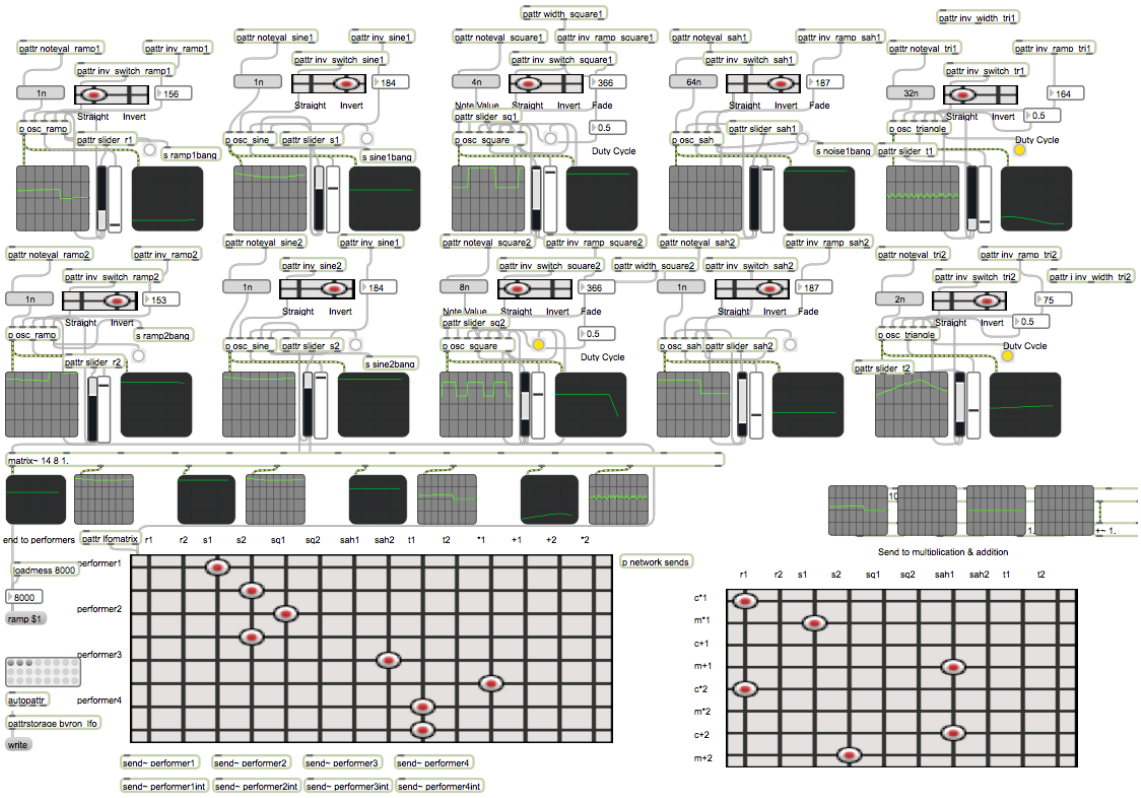

Fig 1.15 – 'The Source' LFO management patch

Version 6 of *The Stick*, whilst being the most feature-packed and complex to control, was more successful than previous versions due to the decisions made in terms of what to control and when. I barely needed to touch the laptop during a piece, and certainly to a lesser degree than previous versions. The system for selecting an element to control and then having access to the whole of *The Stick* to play it without affecting any other element was a successful strategy, satisfying my intentions of including clear physical to sonic gesture relationships. It also allowed me to layer sounds in order to create denser and more complex textures and behaviours that continued to evolve through the modulation from *The Source*. Through practice, my operation of the instrument required less effort and concentration, and the ability to access most of the features directly from the instrument allowed me to develop a style of control that was more based on muscle memory than conscious thought, making *The Stick* more convincing as an instrument in use.

Emergent Playing Techniques

In tandem with the development of its construction and software, my technique and approaches to playing *The Stick* developed over a period of ten years. My personal commitment to developing and playing a single interface is relatively unusual in this field. Other enduring examples of performers playing one self-developed instrument consistently would be Jonathan Impett (*Metatrumpet*), Sebastian Lexer (*Piano+*) and Bennett Hogg (*Resistant Violin*). Most instruments are built for a specific performance or project and interestingly, the previously mentioned examples are all based on instruments of which the composer had existing skill and experience.

My own commitment to developing a practice built around a new and unique instrument has resulted in techniques that have emerged from the instrument itself, rather than through design, contrary to my own intentions. After many years I have come to accept that this approach yields better results than imposing my personal expectations.

The Stick was intended primarily as an ensemble instrument and although it has been used to create some fixed solo works, these were never as engaging an experience as playing with others. This significantly influenced my incremental updates to the instrument; the more major redesigns being triggered by the need to occupy a new role in a new ensemble, or even within a specific piece. Surplus functionality has been incorporated and discarded over time, often through realisations during a performance, which help to clarify ideas that I had whilst in the workshop stage. Some of the most useful functions have come about purely by experimentation in performance, through some emergent quirk of the system.

For example, the technique of tapping the neck of *The Stick* that can be seen in the *FHTA* live performance of *She Moves Through the Fair* at SARC, Belfast between and 4m24s and 5m 24s (15) arose from the dissatisfaction I had with pre-composed amplitude envelopes. The envelopes were contoured in a manner that was exactly the same each time, which made my playing seem artificial. The sustain portion also enforced an unchanging amplitude which lacked dynamics and interest. In programming I had tried to account for this by randomizing the parameters of amplitude envelopes, which was unpredictable in practice as the envelopes were not always appropriate for the situation. I found that tapping the neck allowed me to start the ADSR and let it reach the decay point before I retriggered it. The

attack of the ADSR was designed to retrigger from whichever amplitude value it had decayed to, avoiding sudden drops to silence on retrigger. The technique is used to vary the speed, regularity and contact time of the taps. Regular light taps sustain a low volume that varies enough over time to provide an envelope with a possible slight pulse, dependent on the frequency of the taps. More frequent light taps raise the general volume level with a pulsing rhythm, whilst frequent sustained contact gives a smoother result. Taps that increase exponentially in their regularity and length create swells and longer form envelope control. Slower taps with sustained contact and a longer decay time on the original envelope can provide undulating drones that can rise out of the background when needed, particularly when used in conjunction with amplitude and timbral control from raising the neck of *The Stick,* as displayed in *She Moves Through The Fair* between 5m 17s and 6m 07s (16).

This example is also a good demonstration of my technique becoming more natural and instrumental, as I am able to combine various features in quick succession whilst still observing the actions of the other two players in order to coordinate a resolution to the current section of the performance.

The Stick in various roles

The array of sounds available through the sample-based synthesis employed by *The Stick* give it range and diversity, allowing me to access sound sources specific to each context. The wide range of functions offer a multitude of possibilities, and the flexible design of the parameter control system allows the possibility to alter behaviour significantly without reprogramming. The function and role of *The Stick* vary depending on the ensemble, the piece and the role that I am playing within each. All functions are available to me at any moment, although I have found it best in practice to characterise pieces and ensembles with a specific fixed selection of functions and sample material, optimising variation in both the types of sounds and their behaviours between different contexts. Some examples of this ensemble dependent variation are described below.

FHTA

My playing style with *FHTA* began with an emphasis on physical gesture and its correlation with sonic gesture. Live performances were energetic and noisy and my movements were often spikey and exaggerated. As the software grew in complexity and my playing technique developed, my physical movement became slower, smoother and better controlled. Initially these more physically fluid actions required significant concentration, but with practice I developed smoother physical movement as my body began to move more synchronously with the flow of the granular synthesiser and the speed of the LFOs. More control possibilities allowed additional layering of sound, which opened up new territory both in the type of material and in the role I could play. Although all members of the group discussed building our own instruments, *The Stick* was the only project which came to full physical fruition, and in performance, its presence helped support the development of my role as the lead performer and consequently, my influence over the group composition.

The relationship between my physical and sonic gestures aided communication with the ensemble over time as they grew to recognise them. The clearest instance of this is in *Tall Trees* where I carry the lead role throughout. The legibility of my gestures were particularly important at the composition stage of this piece, whilst during performances the others relied more on my sonic gestures to indicate the structure of the piece. During the SARC performance between 0m 12s and 12m 50s (17), this sonic communication functions so well that we barely look at each other. This is in clear comparison to *Maesteren,* a more recent composition in which Matt and I repeatedly observe each other's physical behaviour in order to coordinate our actions, as evident between 9m 07s and 10m 4s (18). In rehearsal and when collaboratively composing, we would always face each other in order to maximize communication, but soon became aware that this approach inhibited communication with the audience during a performance.

My playing style in this piece features gestures played mainly on the neck of *The Stick,* as shown between 4m 50s and 5m 21s (19). This contrast in operation is particularly evident when compared with my technique in *Tall Trees* between 5m 26s and 8m 35s (20) of the same performance where I use my whole body to precisely contour the sound and granular synthesis parameters. This drastic change in instrumental operation is implemented purely

by playing the instrument differently, and not by switching into any other mode or changing mapping strategies. This shows the adaptability of the instrument to varying styles of improvised electronic music and the virtuosic skill required to be able to implement these varied behaviours. One of my most used techniques in this more manual mode of operation is to slide my finger up and down the neck to create the sirens and glissandi heard in *Maesteren* between 10m 29s and 11m 08s (21), altering their amplitude and frequency modulation with the thumb stick. The specific deployment of *The Stick* varied between pieces and the version of the instrument used for their composition. *A Kind of Logic* uses *The Stick* version 4, characterised by its obvious rhythmic groove implemented through LFOs and by precise synchrony between elements, and the ability to clearly shift samples by harmonic pitch. My own vocal samples are fed through the granular synthesiser at low speeds to create the motif heard twice between 0s and 20s (22) of *A Kind of Logic* based on the interval of a major 3rd. *The Stick* is employed again within this harmonic role for *Blood Relations* using square wave modulation on the amplitude of a comb-filtered drone between 0s and 45s (23), creating a quasi-blues chord structure underpinning the tenor saxophone material played through another of *The Stick's* granulators.

TRATC

My technique for *TRATC* takes up where *FHTA* left off, featuring more layering, with occasional switching to direct control over specific elements for lead parts. It is likely that *TRATC* influenced my later playing style in *FHTA,* as the layering approach I developed was due to my role within *TRATC* being less in the foreground. Since Jason's focus in the ensemble was mainly on spoken word, he had less capacity to engage with other aspects of sound production, and as a result I needed to develop a more polyphonic accompanist role rather than the lead role occupied within *FHTA*. The ensemble balance was more equal in *TRATC* and the *The Stick's* adaptability in switching roles is a testament to its capacity as a musical instrument.

For *The Dream, The Stick* moved between the two main modes of behaviour using version 6, granular sample based synthesis and simpler FM and AM modulated waveforms. Unfortunately the light levels and camera angle of the documentation make the visual behaviour unclear, but my seated position was a clear departure from the centre-stage posturing of my role in *FHTA*. Layers of sound were built during each stanza of the poem,

and were then quickly stripped away when the 'scene' changes as can be heard between 13m 35s and 14m 05s (24). The technique involved setting up each sonic element in turn using the granular synthesisers or simple waveform generators until I achieved the desired behaviour. As I finished setting up each element and moved to the next, the previous behaviour sustained itself, allowing me to concentrate on directly playing the lead parts. For example, between 5m 40s and 6m 40s (25) one can hear separate parts in the form of a sine tone at around 300 Hz with modulating pitch, a bass drone around 65 Hz, and some granulated piano samples. The behaviour of all of these parts, once triggered, are under the control of an LFO mixer, which is responsible for their synchronised behaviour. I controlled the granulated female vocal directly with *The Stick* to play phrases at specific times, which underscored poignant moments within the narrative in which the female character features. My role within *TRATC* eventually settled into one of building textures and behaviours to accompany and underscore spoken word, periodically employing simple themes as programmatic references to the narrative. The layering creates sonic staging and scenery as a basis for the dramatic elements to occur. *The Stick* is used less gesturally in this ensemble, and the inclusion of self-sustaining elements results in more sequencer-like behaviour. Performing in *TRATC* felt less like playing an instrument and more like being a director or producer, coordinating sonic actions at specific times to support the narrative.

Wayang Listrik

Wayang Listrik is a 'beat em up' style game piece that involves two players acting out a romantic non-verbal dialogue using processed vocal sounds and 3D animated avatars. The piece was created through the sonic and visual choices of the two players, generating a dramatic narrative in real time.

Fig 1.16 – Wayang Listrik at Ars Electronica Center, 2010 - Standing in opposition to the female avatar

The Stick operated in this piece as the controller for the male avatar. It acted as a trigger for eight animations and vocal samples, with the length of the neck divided into eight corresponding sections. The piece is played using *The Stick* version 5 and I relied mainly on drones created by my pitch shifted vocal samples through the granular synthesiser, occasionally employing the comb filters as can be heard between 6m 0s and 6m 30s (26). Coincidentally, although the samples were recorded specifically for this piece, I also used them in a more harmonic and rhythmic context for the *FHTA* piece *A Kind of Logic* between 1m 47s and 2m 0s (27). Unfortunately I lacked the resources to build another *Stick* for the other player, but instead used a Bitstream 3x MIDI controller as the interface. The software used is an exact replica of *The Stick* but uses female vocal samples recorded by my wife, Lilith Perkins. The MIDI controller has eight faders, which were used to trigger the eight vocal samples when moved. Fader height controlled amplitude and dials above the faders were mapped to aspects of the granulator that would usually be under the control of *The Stick*. Playing *The Stick's* software from a MIDI controller led to an approach of layering sounds rather than triggering gestures. Having each parameter as a separate control mechanism also highlighted how well integrated these are within *The Stick,* which can

control numerous parameters simultaneously with one physical gesture.

Adapting to free improvisation with *The Stick*

The following two pieces were improvisations with little preparation beforehand aside from level checks. I had previous experience of playing with some of those involved, but others were entirely new and I had little knowledge of their practice. The inclusion of these documents is important in support of *The Stick* as an instrument, in testament to its diversity and immediacy and ability to shift roles by accessing a vast palette of sounds and control behaviours.

Momentum, Ars Electronica Center, Austria 2010

The improvisation *Momentum* featured a number of players occupying instrumental ranges in the middle of the audible spectrum, and consequently I decided to use *The Stick's* 'extra-human' abilities to retreat to the edges of the territory.

Fig 1.17 – 'Momentum' Improvisation at Ars Electronica, Austria 2010.
Bill Vine (left) Anton Lukoszevieze (centre) Ed Perkins (right) Simon Waters, Se-Lien Chuang and Andreas Weixler (off camera)

Between 0m 25s and 1m 35s (28) I move through the pitch space, first occupying the very low frequencies before gradually rising out of the background with low rumbling noise processed by tape delay. The amplitude, delay time and feedback amount were contoured by my physical movement between 1m 45s and 2m 5s (29), after which it settled down to

more rhythmic pulsing by holding *The Stick* steady and keeping the delay time and feedback amount constant. This technique is a development from the same implementation of movement-controlled delay seen in *The Stick* version 2. A comparison of the aforementioned section of the *Momentum* 2010 performance with that of the *FHTA* 2007 performance at the SAN Expo, between 7m 45s and 8m 07s (30), shows the evolution of both the feature and my execution of it. I continued to use noisy material in the middle of the spectrum and more pitched material at the extremes, where I found that I had more space, for the remainder of the improvisation. In this improvisation, my identification of where to operate, combined with *The Stick's* versatility in sound creation and playing style allowed me to quickly listen and respond to the sound around me, or to blend into the background to support the existing texture where appropriate.

LLEAP, Norwich Arts Centre, 2011

This performance featured Adam Jansch, Claire M Singer, Christos Michalakos and Ed Perkins as part of a workshop for postgraduate students to share practice in the performance of live electronics.

Fig 1.18 – Improvisation at Norwich Arts Centre, 2011
Left to right: Adam Jansch, Claire M Singer, Ed Perkins and Christos Michalakos

The dynamic and explosive character of Michalakos's augmented drum kit inspired me to physically move much more rapidly than usually, and the resultant noisy and sporadic sonic gestures can be heard between 1m 55s and 2m 36s (31) in combination with Jansch's manipulated samples. I particularly enjoyed playing with Michalakos in this performance, as

the contrast between action and inaction was a welcome and liberating change from my usual slow and deliberate style. I enjoyed the conversational style of interaction within the aforementioned section, and felt an instantaneous connection to my fellow players due to the heightened awareness required to respond and the increased adrenalin and heart rate from the speed of movement. The absence of pitch or regular rhythm increased the tension by focusing solely on sonic gesture and the tension of the silences between them. The pace of the interaction intensified the social relationship, and it felt as if the communication was more intimate and immediate than during the slower more sedate music I was used to playing which can feel more disconnected. The trading and synchronising of the fast paced gestures made the music exciting to play and I felt an increased sense of risk during the performance.

The final section of the piece is more sedate, between 6m 10s and the end (32), features Singer maintaining a drone on cello, her bowing action giving a subtle rhythm to the section. I began to match the bowed gesture by swaying left to right with *The Stick*, causing my amplitude and granulator speed to vary in relation to the movement of Singer's bow. As my granulation window sizes were so small at this point, at around 2m, the granulator speed affects the timbre quality, creating an indirect relationship between the sound of the cello and *The Stick*. *The Stick* was designed primarily for the regular ensembles that I played with at the time; this ensemble forced me to discover new approaches and ways of playing that I would not otherwise have thought of, and *The Stick* was able to provide me with the tools I needed to achieve this.

Ultimately, my performance practice with *The Stick* improved as my knowledge and experience of live electronic music grew, but my ongoing relationship with *The Stick* proved to be fundamental as the tool with which to realize the ideas born from this new understanding.

Roles & Relationships

Musical collaboration provides a more benign environment for social interaction than that of our daily lives. It is a chance to explore our own ideals and to try out new approaches with consequences that for the most part, remain in the musical domain. This creates an opportunity to examine behaviours and interactions between members who may be less inhibited or self-conscious than they are in non-musical social interactions. Recently, a number of studies in fields outside of music have focused on some of these communicative and collaborative aspects of musical collaboration, differing in approach and covering a multitude of other subject areas including social psychology (Macdonald, Hargreaves & Miell, 2008), (North & Hargreaves, 2008) identity research (MacDonald et al, 2004), distributed cognition (Nabavian & Bryan-Kinns, 2006) and education (Hewitt, 2008).

i. A Social Perspective

The recent inclusion of socio-cultural and educational perspectives in this area of research has begun to yield some interesting results, which are applicable to a range of collaborative situations both within and outside of music. Raymond McDonald and Dorothy Miell (McDonald & Miell, 2000) amongst others (Miell & Littleton, 2008) have explored collaboration within an educational context and focus on those making music in terms of their relationship, roles, self-organization and collaborative process. This approach is in

contrast to traditional forms of cognitive musicological analysis (Lerdahl & Jackendoff 1988) and music psychology (Sloboda, 1985 & 1988) that have focused more on the score. More recently, Sloboda has begun to move towards the inclusion of more emotional psychological elements of music with which to extend and inform cognitive theory (Juslin & Sloboda 2001, Sloboda 2005).

The brand of cognitive and psychological analysis used to examine musical output has historically focused on notation, often treating it as a definitive object within which the music resides. This approach fails to take account of not only social, but also sonic and environmental considerations that manifest during performance. Traditional musical analysis has historically been biased towards Western centric classical music ideals and European styles of notation. David Borgo summarizes the problems that arise from using empirical or cognitive analysis tools derived from Western notational analysis in the study of group collaboration:

> Our existing analytical tools, derived in great part from the study of European notated music, offer only limited insight into contemporary improvising approaches that tend to avoid pre-established harmonies, melodies, rhythms, forms–and often any strong idiomatic components in favour of the dynamic and self-organizing qualities of ensemble interaction and exploration. (Borgo, 2004: p.52)

The approach of looking outside of notation and other forms of documentation has yielded results that are applicable to the analysis of live electronic music, particularly the social and ethnographic studies of jazz. In *Saying Something*, Monson (Monson, 1996) argues that jazz is primarily a group interaction, and before the advent of experimental improvised electronic music, was the only form of music where roles and relationships are dynamically assigned and can change without verbal discussion. Christopher Small further undermines the Western musicological fixation with notation in *Musicking: The Meanings of Performing and Listening* (Small, 2011) where he asserts that music is an activity that exists primarily as a social practice, rather than as documentation.

Other more recent research looking outside of documentation has focused on supporting group collaboration through interface design, with empirical analysis carried out by the

Cognitive Science Research Group at Queen Mary University, including 'Hey Man, you're invading my Personal Space! Privacy and Awareness in Collaborative Music' (Fencott, Bryan-Kinns, 2010), 'Analysing Group Creativity: A Distributed Cognitive Study of Joint Music Composition' (Nabavian & Bryan-Kinns, 2006) and 'Interactional Sound and Music: Listening to CSCW, Sonification and Sound Art' (Bryan-Kinns, et al., 2010). This approach tends to draw universal conclusions from musical situations contrived to serve the study and the quasi-empirical tone and structure tends to satisfy neither musical nor scientific sensibilities fully. Although the introductions in these papers reference socio-psychological literature and cultural considerations, the experiments themselves lack artistic authenticity in the weaker sense of being a reliable and accurate representation of the original situation they seek to reproduce. These experiments include group composition of ring tones using an interface deigned by the research group (Healey, Leach, Bryan-Kinns, 2005) and the formation of a group to study musical collaboration (Nabavian & Bryan-Kinns, 2006).

The fact that the research method is both designed by and involves the author of the paper creates a conflict of interest. Although my own observations also involve groups that I have been part of, the work was created for aesthetic value and not initially for the sake of academic study. Nabavian & Bryan-Kinns (2006) claim that the musicians involved are experts, although the dialogue included in the study reveals them to have a fairly basic theoretical understanding of harmony and limited experience of collaborative composition (Nabavian & Bryan-Kinns, 2006; p.1859 - 1860). The complex webs of personal and social factors that provide the roots of behaviour in real musical encounters are sidelined in favour of providing pseudo scientific analysis to support universal theories. The approach tends to focus on results rather than processes and neglects to provide a discourse on the roots of these behaviours. Scientifically reporting on contributions of individuals in a musical situation is hugely subjective and the validity and relevance of such 'data' can certainly be called into question in its application to other musical situations.

Collaboration

Those who have collaborated with me for this period of research are discussed in detail within this chapter with regards to my perceptions of their personal and social qualities and how this has impacted upon our musical collaboration. These meetings are not scientific experiments. What follows is analysis of the unique qualities of musical situations that form and operate using methods that have arisen naturally from producing and performing work

in real, rather than ersatz musical conditions.

I include transcribed excerpts from recorded interviews with open-ended questions that were unique to each interviewee. I wanted to be free to follow a particular thread if this seemed fundamental to their experience of a given musical situation. My aim was to uncover alternate perspectives to my own rather than quiz my interlocutors on aspects that I assumed would be important. Due to their conversational nature, the interviews feature frank and colloquial discussions of both musical and non-musical aspects relevant to our collaboration. I have at times employed a similar linguistic style in this chapter where relevant, to enable me to discuss thematically and reflectively within the same spirit that these conversations took place. Accounts of historical events relating to each project are important and so include social and personal recollections, and as a result a more journalistic style is employed in the hope of creating a sense of atmosphere and narrative to the memories recalled.

The style of language used makes discussions around communication, narrative and thematic elements psychological, rather than scientific in tone. Scientific analysis seeks to isolate particular characteristics and study them to identify rules that can then be taken as truth. Interaction, communication and group dynamics within the field of experimental electronic music are too vast and complex to provide any real insight when studied through isolated minutiae. Whilst my findings may prove useful to those with similar musical intentions, they have been discovered through analysis of my own experiences and are therefore not presented as absolute representations of universal theory and I would argue that it would be difficult to define such a theory. As North and Hargreaves state:

> . . . we should note that arguably the most overtly social aspect of composition is where two or more composers collaborate together. The intrinsically social feature of composition means that it is, by definition, unconstrained, non-standardized and unpredictable. (North and Hargreaves, 2008: p.40)

Due to the complex, fluid and highly personal nature of group collaboration, my intention here is to distinguish what mechanisms have been supportive to composing collaboratively through an approach which analyses social behaviour both in and out of the musical

environment. I have endeavored to discuss personal and social characteristics of those involved where relevant to explore their identities holistically and the effect on how the musical result is formed and reflected on, rather than by attempting to analyze musical behaviour of individuals solely within the musical environment.

The first part of this chapter describes approaches discovered through exploration within long-term collaborative groups. The second section describes the application of that knowledge to shorter-term compositional projects.

ii. Exploring Group Collaboration

Group formation

The two longest-term projects with which I have been involved, and which have consequently featured the most development are *The Raw and the Cooked* (*TRATC*) and *From Honey to Ashes* (*FHTA*). *FHTA* was an experimental composing/improvising live electronics trio that operated between 2006 and 2014. Within this group, compositional structures were partly precomposed, abstract in nature and based on acousmatic principles. *TRATC* was a live electronics duo formed in 2008 that, having starting out with acousmatic tendencies, soon settled on a more programmatic approach, underscoring and taking structural direction from literal narrative. Both groups were formed arguably through social cohesion insofar as group members shared certain demographic and sociocultural characteristics (Hogg & Williams, 2000), in combination with the shared musical goals discussed later in the chapter.

Although *FHTA* originally met as part of a MaxMSP forum at Goldsmiths University, the group itself formed naturally as a sub-set of the forum, mainly through shared goals to do with the performance of live electronic music that produced well structured, succinct and distinctive pieces that would be dynamic and engaging to experience as a performance. The group eventually solidified into a trio compromising of me, Matt Lewis and Jeremy Keenan following a traditional 'band' model rather than being a group of individual improvisers meeting solely for performances or recordings. Jeremy and I had previously bonded through sharing our initially limited knowledge of MaxMSP and found that we had practices that differed, but were complimentary to each other in collaboration. Matt was a

PhD student; slightly older and seemingly more senior than Jeremy and I although once we began to bond as a group this became less salient. Although personally we initially appeared to be quite different, we had strong similarities in areas that defined how we fundamentally related to the world around us including artistic parents, psychological and academic interests and similar socio-economic backgrounds. We also shared a similar sense of humor, some areas of musical taste and various levels of technical skill in playing the guitar. It was clear that there was a fluid and vibrant social dynamic, discovered through conversation at the more informal social events that would occur after the MaxMSP forum.

TRATC formed later whilst I was studying at the University of East Anglia. I had met some of the postgraduate students from the UEA whilst performing with *FHTA* at the Sonic Arts Expo in 2007. The venue was the White Rabbit in Plymouth, a nightclub close to the docks temporarily taken over by sound artists and live electronics ensembles. Due to the volume levels achieved by the in-house sound engineer, I was only able to really speak to the person sitting next to me who happened to be future *TRATC* partner and long-term collaborator Jason Dixon. Although the initial conversation was short, I got a good sense of the type of person Jason was from his unassuming nature and lack of pretence. I reconnected with Jason whilst visiting UEA some months later and on beginning my studies there the following year, I asked Jason if he would be interested in some group improvisation using whatever software or instruments we were currently working on. Although our backgrounds differed on the surface, socially there was a semblance of complimentary skills and shared goals that began to coalesce the more we discovered what we were able to do musically in combination. Eventually we began to discover similarities in our musical history; we were both former choral singers, had both been classically trained on the clarinet and were both brought up listening to heavy metal and rock music. We were also both interested in literature and narrative, which would come to influence our future collaborative process, musical style and shared goals.

Shared goals

Both ensembles had a keen sense of exploring and experimenting sonically, combined with the need to work on some of the issues with performance and group composition in the field of live electronics. Defining and discussing our shared goals in this way supported the creation of a collective identity and strengthened the sense of belonging to the group. Through group discussion and reflection on our shared intentions, we identified the

following areas of importance within each group, some of which are the consistent in both groups:

The Raw and the Cooked:

1. The ability to execute improvised sections within a composed structure
2. Effectively coordinated succinct sectional transitions
3. Clear and repeatable structure with mutually agreed sectional behaviours
4. Literature as both score and a structuring device
5. Narrative and imagery are key
6. Live animation and lighting to support the immersive environment
7. Manipulation of time perception in a live performance

Fig 2.1 'The Raw and The Cooked Performing' 'The Dream' at The Puppet Theatre, Norwich as part of the Norfolk and Norwich Festival 2012

From Honey to Ashes:

1. The ability to execute improvised sections within a composed structure
2. Effectively coordinated succinct sectional transitions
3. Clear and repeatable structure with mutually agreed sectional behaviours
4. Interfaces which link physical and sonic gesture
5. Execution of spontaneous sonic group events
6. Distinct pieces that retained identity for each performance

7. Incorporation of vocal elements
8. Incorporation of rhythmic elements
9. Awareness of individual roles and group identity

Fig 2.2 'From Honey to Ashes' performing at the Shunt Vaults under London Bridge Station in 2010
From left to right – Matt Lewis, Ed Perkins and Jeremy Keenan

Both groups bonded from working together towards common goals, not only in terms of shared principles but also through the sheer amount of determination and discipline it took to create a live improvised performance that aspired to the clarity of intention and execution of pre-composed work. Many of these objectives were expressed at the formation of the group and then regularly updated and discussed, although not initially as well articulated as they appear above. Matt Lewis describes the more haphazard approach that characterized our early meetings:

> We began by doing a lot, lots of sounds chucked together fairly randomly and it was usually either a glorious success or a glorious failure and we were all definitely interested in working out why that was, and how to improve success and limit failure. (Interview May 2015)

Matt goes on to describe our approach to working on a particular piece or section once

much of the material was established. We aimed to be more concise in how we performed the pieces, and this could not have been achieved without the ability to individually recognize our own function within each piece. From there we could understand how best to contribute to the team objective, rather than focus on personal goals for each performance. Matt continues:

> It really started to work once we imposed rules and limitations on what we were doing, but once we were able to impose personal limitations on ourselves and what we did, that was when we really started getting somewhere. (ibid)

We eventually developed a filtering process formulated around reflection and discussion in relation to our agreed goals. This was an incredibly useful forum where discussion prompted a reconsideration of what had been understood by each contributor about his performance. Because we respected each other both as people and as artists, we had learnt to trust each other's judgment and had experienced the resulting benefits of applying it to our own practice. The feedback was always honest, but sensitively done and above all, for the benefit of the music rather than for personal reasons. Musical development of the group process was achieved through negotiation, and this was primarily a success because of our friendship and our ability for effective 'transactive dialogue' that had been formed and practiced through social interaction.

Supporting Transactive Dialogue

Miell comments on the benefits of friendship relationships on group composition as follows:

> This study examined the social processes involved in children's collaborative musical compositions. The communication (verbal and musical) between same-gender pairs of 11-12 year olds was analysed using measures of the relative distribution of transactive and non-transactive elements. (Miell & MacDonald, 2000: p.348)

She goes on to detail the benefits of transactive communication and mutual engagement in pre-established relationships when working together on complex tasks.

> . . . whether viewed from a Piagetian perspective in which socio-cognitive conflict is seen as the key, or from a social constructionist perspective which stresses co-operation and the establishment of joint definitions socially, the important factors affecting the degree of mutual engagement seem to be the presence of reasoned dialogue, the exploration of the ideas of more than one person and the attempt to integrate these. (ibid)

Friendships are not characterised by relationships of agreement, but rather by dialogue or a transactive process through which conflicting ideas and perceptions can be mediated and discussed supportively to reach mutually beneficial outcomes that contribute positively to the success of the task. Matt Lewis reflects on the benefits of transactive dialogue with reference to *FHTA*:

> Composition, improvisation and notation were intimately linked in a very cohesive and intuitive, sometimes incoherent way. They were all elements that I had previous experience of in other ensembles, but with us, including new elements devised through discussion was the really the most rewarding thing. (Interview May 2015)

Miell found that friendship pairs exhibited more transactive dialogue than those who did not know each other and this contributed to greater interaction, and consequently further development of the composition (Miell & MacDonald, 2000). Miell also identified other factors that contribute to the successes of group collaboration including allocating roles and the willingness to experiment and take risks within a supportive environment.

The most recent *TRATC* work included is a setting of Lord Byron's *The Dream* included in Appendix D. This was our most technically and compositionally complex undertaking with a narrative that shifts character and locational perspective in quick succession. *The Dream* was the most well discussed and planned of our collaborations and we had a number of meetings involving reading and annotating the text with how we might structure the piece, the type of sounds we might include and how we interpreted the text in terms of emotional content and story. The transactive dialogue we had developed over time was essential to coordinating our intentions and resolving disagreements for both composition and

performance. Without our previous development of roles and interaction styles, the piece would have been near impossible to write collaboratively. With verbal discussion, we maintained our musical roles, taking responsibility for compositional decisions within the areas we would be accountable for in performance. The negotiation of our individual ideas led to elements neither of us would have discovered working separately. If one of us were struggling, the other would fill in and offer suggestions as to how to approach the problem, without feeling any resentment over ownership or rejected material.

The dynamics of friendship relationships are analogous to the dynamics of meaningful musical composition in that interesting and rewarding relationships and behaviours between participants are created through the actions of the individuals in relation to each other over time. Jacob Levy Moreno, the founder of psychodrama and a pioneer of role theory and group psychotherapy, emphasized interpersonal relationships in the creation of personal behaviour and roles (Moreno, 1953 & 1985). Moreno studied the interactions between people in order to understand the people themselves. His vision of a role as 'an interpersonal experience that needs usually two or more individuals to be 'actualized' (Moreno, 1985: p. 184) was at the root of his theory. Moreno states:

> . . . every role is a fusion of private and collective elements; it is composed of two parts, its collective denominators and its individual differentials . . . (Moreno, 1953: p.75)

The group flow created by dialogue and empathy towards each other in personal relationships creates an interesting dynamic within a supportive environment with the capacity for both the relationship and the individual to grow and develop. The comfort of familiarity born through a shared personal history and regular interaction gives rise to a sense of safety and less personal inhibition where new developments can flourish. These longer term relationships are of benefit to group collaboration due to features such as joint planning, mutual interest, empathising with another's perspective and developing a shared language. Matt Lewis from *FHTA* comments on his experience of this characteristic in relation to our work together:

> On one hand it felt like a devised experience, working like you might in a vernacular music context like in a band where stuff is more devised. On the other, we developed a language for talking about what we did. A lot of the success that we had from developing methods of negotiating came from all the time we spent listening back to recordings and talking about them. We recorded and talked about pretty much everything we did, maybe not as much for live performances but definitely for the recordings. There was a process of negotiation that took place over a number of years that gradually became more concise and effective and eventually became non verbal. (Interview, 2015)

Fig 2.3 'From Honey to Ashes' performing at The Whitechapel Gallery, London, 2009
From left to right Ed Perkins, Jeremy Keenan, Matt Lewis and Mick Grierson

Empathy, Group Therapy and Role Reversal

As asserted by Amabile (1983) socio-psychological factors such as empathy and sensitivity can be beneficial to creativity, task motivation and group collaboration. These characteristics can enhance our abilities to understand the roles and behaviours of others through our relationships with them (Moreno, 1953 & 1985). The qualities of empathy and emotional sensitivity have a potentially more costly side that leaves one vulnerable to criticism and can hold back exploration and experimentation due to social anxiety and the perceived cost of failure.

Improvised electronic music, or that composed through collaboration draws parallels with Moreno's concept of 'Psychodrama' (Moreno, 1985). A fundamental principle of psychodrama is Moreno's theory of 'spontaneity-creativity' (Schacht, 2007). Moreno believed that the best way for an individual to respond creatively to a situation is through a readiness to improvise and respond in the moment (Blatner, 2007). By encouraging an individual to address a problem by reacting spontaneously and through impulse, they may begin to discover new solutions to problems in their lives and learn new roles they can inhabit within it (Schacht, 2007). Group psychotherapeutic processes developed by Jacob L Moreno (Moreno, 1953 & 1985), Samuel Slavson (Slavson, 1943) Irvin Yalom (Yalom, 1970) have found that working through problems in a supportive environment of one's peers can lead to learning about one's own self through the experience of others. As with group psychotherapy, playing music in a group with a solid foundation in trust develops the mutual understanding that anything discussed is valid and accepted and will not under any circumstances lead to expulsion from the group. On the contrary, you are contributing to the development of the group as a whole through the reflective abilities of the others.

Further to this, empathic abilities are essential in understanding the roles of others as a method of self-development and exploration (Yaniv, 2012). For example, a musician who is passive in character may wish to try out a more active role in a musical collaboration and conversely, a leader might wish to take a back seat in order to experience leadership from another perspective. This ability to switch roles became an important part of our practice within *FHTA* and allowed for variation in the dominant personality of the music. Matt comments on the benefit of switching roles as an opportunity for self-development.

> Personally, I felt that was only able to happen because it was such a supportive environment, we all knew that we were trying things out and were having our own struggles with our own processes and often used the group as a safe environment to test those things. (Interview, 2015)

Spending social time together facilitates this type of role development. The development and occupation of our individual roles in relation to each other was essential for the success of the group and our collective ease and confidence within it. The sense of personal identity gained from finding a role within a group, particularly when an individual is operating at the fringes, creates a protective milieu where confidence can develop and

extend beyond the musical domain.

The bonds formed through social cohesion and the confidence developed through improving self-worth lead to generosity between musicians and a vested interest in mutual success. Free jazz drummer John Stevens reflects on his experience of this in the sleeve notes of *Karyobim*:

> Music is a chance for self-development; it is another little life in which it is easier to develop the art of giving, an art which makes you more joyous the more you practice it. The thing that matters most in group music is the relationship between those taking part. (Stevens 1968)

In order to develop, there needs to be mutations in ideas formed through risk taking. Risk taking is a costly process, but the potential damage caused by failure is minimized in a supportive and forgiving environment. Failure is less costly in the musical environment of a rehearsal or performance where 'real' and long-term consequences do not exist, and can be as much a valid part of the piece as a success. Ultimately, this leads to more risk taking, further mutation and consequently the further development of compositional material.

Role differentiation and self-organization

Some of the key considerations facing anyone who begins to play within a collaborative group situation is 'what do I do, how do I fit into the music and what are the others doing?' Such considerations inevitably begin a process of negotiation with group members who are constantly adapting their own contributions with the same concerns in response to one's own. This process of self-organization is facilitated by the creation of roles, identities, attitudes and 'norms' within the group. Roles can be defined as a tendency to behave, contribute and interrelate with others in a particular way. Roles may be assigned formally, for example in an orchestra or rock band, but in more experimental forms of music they are more often defined through the process of role differentiation where group members have specialized functions developed over time that are specific to the group. Within music, roles can be defined as the responsibility for a certain aspect of the composition. The beginning of this personal role identification is perhaps the most interesting period. Jason Dixon comments on his experience of our first musical encounter:

> When we first met up, we just set up in the studio and both started playing before we had even discussed anything. Before you had arrived there wasn't really anyone to play with, so I had developed my solo practice based on what I had been working on in Belfast (SARC). My role was generally lower frequency focused and that's how I started playing the first time we played together. From then I was playing and listening to try and work out what sort of role and space you liked to occupy. (Interview, 2015)

The improvisation *Extremely Acatalectic Eschatological Musings* is included in Appendix D and is a recording of one of our first collaborative sessions. Whilst this improvisation is not a particularly fine example of composition in of itself, it was created during the very early stages of our work and as such is a useful example for the discussion of role creation in relation to *TRATC*.

I used my custom built instrument *The Stick*, with software written in MaxMSP whilst Jason was live-coding using Supercollider. Despite Jason's claim six years later that he was 'listening to see what type of space I liked to occupy' (ibid), the first ten minutes or so of the recording is a battle for territory. I had been used to playing with Matt Lewis in *FHTA* who occupied a similar role to Jason, but was less dominant in both low and high ranges. In *Extremely Acatalectic Eschatological Musings*, I begin by using drum samples with a low pass filter that have more trouble penetrating Jason's low frequency drone than they did Matt's characteristically more gestural low frequency utterances that would periodically leave gaps for me to rise out from. I add a repetitive drone phrases gradually, which settle down around the four-minute mark. This had somewhat more success in permeating the rumbling blanket that Jason provided. Although these sounds allowed me to be heard, I felt that they weren't adding anything to the piece and continued to search for better compositional choices.

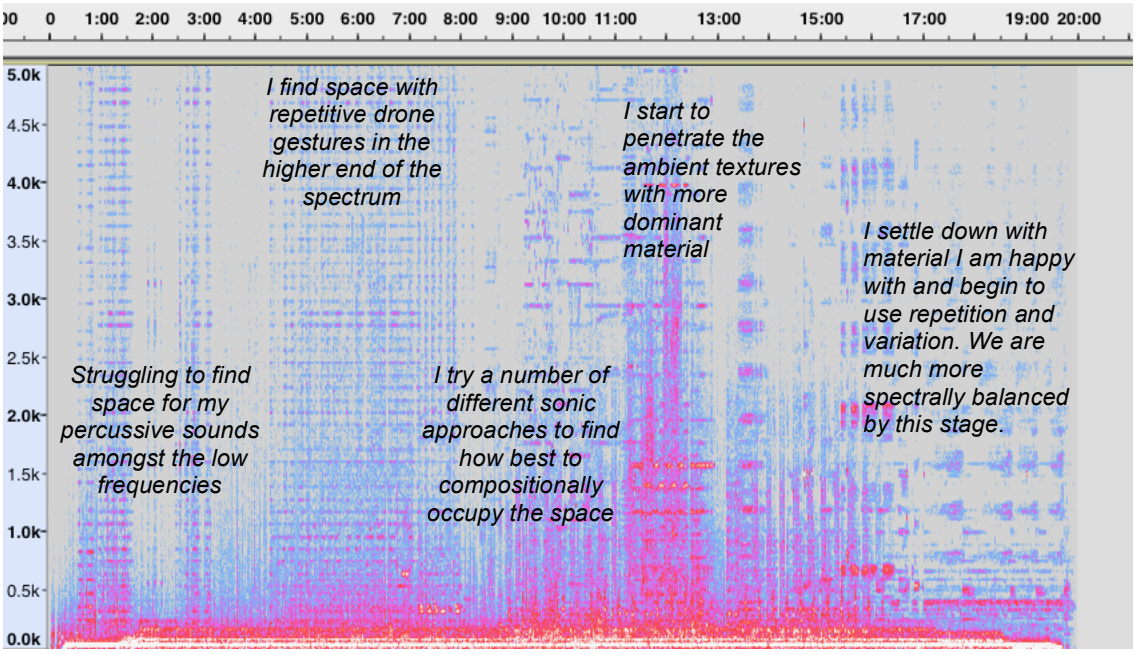

Fig 2.4 A Spectrogram of 'Extremely Acatalectic Eschatological Musings'
annotated with my effort to find territory within the pitch space during the improvisation

I developed the drone gestures into the glissandi heard between 9 and 11 minutes (33). The output from the granular synthesiser was filtered using pitched comb filters to support my harmonic elements, and provided resonant frequencies at higher ranges as I searched for unoccupied areas of the spectrum. Around 11 minutes into the piece (34) I started to permeate the ambient layers, by changing my grain window from a smooth sine envelope to a harder triangle wave, eventually adding a sample and hold modulated pure harmonium sound, emphasizing the rhythmic elements I had previously incorporated through percussive sounds. By the end of the piece between 18 and 20 minutes (35), we have struck more of a balance and are playing together more effectively once more defined roles have been established. This was the beginning of a fairly lengthy process of working out our roles and responsibilities as an ensemble, thrashed out through musical meetings such as this one.

This process of self-organization through role exploration was key to my work with *FHTA*. We would rehearse every week at Goldsmiths and play live at least a few times a month in London and occasionally at festivals around the UK. A large part of our early rehearsals was spent sonically negotiating roles of which we were not necessarily aware at the time. I discussed our relationship and roles reflectively with Matt Lewis:

> In any dynamic you take on a certain role or roles, some of them are about being in control but some of them are about being subordinate to other elements of the music, maybe not personally, but while you are in that role at that time. (Interview, 2015)

During the interview I wanted to ask Matt directly what his response was to my taking on a lead role within the group as there had certainly been some unspoken tension in the past. As we had not played for some time I felt that this might be an appropriate time to broach the subject and his response gave me some clarity in understanding the roots of the role he came to occupy:

> I was reading Steve Goodman's *Sonic Warfare,* where he writes about why individually, you have a tendency towards certain frequencies when trying to define yourself in a group. You might have a struggle to establish yourself and end up feeling almost marginalized and move to the edges. In that moment, you can then begin to reestablish yourself by becoming comfortable at those edges and find a role for yourself. (Interview, 2015)

In contrast, Jeremy occupied a more ambient role, adding a sense of an environment to the piece without standing out, in a role that was somewhere between melody and harmony. Jeremy's role was largely passive and consistent, and mine was mostly active and gestural, whereas Matt was free to move between the two at will.

> This is where the collaborative process is interesting; it gives you the ability to take on any role. I think people should be able to take on roles that aren't necessarily the role they might usually take on and playing in a group gives you a place in which you can play out other roles and I think that's really positive. (Interview, 2015)

Matt alludes to the idea of exploring roles that might not, for whatever reason, be given space to exist outside the musical environment, and the benefits of having music as a place to do that. As psychotherapeutic research shows (Moreno 1953 & 1985), exploring a role is a group process, as our social behaviour only manifests in relation to how we behave

towards others and respond to their stimulus.

I had progressively taken more and more of the lead both in terms of the musical output and the group's direction. This process began when we sadly had to part ways with the fourth member of the group who due to increasing responsibilities elsewhere, lacked the time available to attend the regular rehearsals and recording sessions I felt were necessary in order to develop in line with our goals. He was also the unofficial director and founder of the group, and whilst we didn't formally agree a replacement leader, my role in deciding we could no longer work together started a process of increased responsibility for both writing and directing. Matt should have been the natural choice, given that he is both a strong personality used to leading roles, and had more experience than both Jeremy and I in this area of music. Matt comments on this process:

> I felt it was necessary for someone to take the role of leader within the group, and you playing most of the lead parts was important for the dynamic of the group . . . Where I had most difficulty was in that I had previously had the experience of your role and leading the group, but I was aware that in terms of programming, you and Jeremy were light years ahead of me and in some ways we tended towards ways of working that on some level were technology focused, and you were able to do something quite quickly that I didn't have the ability to do. I was then forced to find other ways of working, which was difficult for me at first, and then later became quite liberating. (Interview, 2015)

Matt's role within the group happened through a gradual process of musical and verbal dialogue, becoming clearer and more distinct as we began to identify and discuss our roles and the group dynamic. Matt often operated at the extremes of the frequency range, particularly in earlier pieces from the album *Meme* such as *Housemaster or Stranger* and *A Kind of Logic* included in Appendix D. Later on in the process, Matt would contribute more obviously indexical materials such as spoken word, instrumental samples or sound effects. This can be heard in the subtly processed trombone samples of *Tall Trees* (36), and in the chimes, tweeting birds and wine glass resonances heard throughout *States Vaporise* (37) and the various samples that often characterized our live performances such as the aeroplanes flying overhead at 1m 25s (38) or squealing pigs at 2m 35s (39) of the *Live at EMS*

performance. At points he might occupy an inaudible role, determining some global aspect of our shared network such as the harmonic choices of my comb filtered vocals in *Mästaren* between 8m 04s and 8m 39s (40). This role became identifiable within the group over time, but was certainly not a role that I could identify as having previously existed in other forms of music.

TRATC also eventually settled into more permanent roles as can be heard in the spoken word and live electronics performance of *Cú Chullain* recorded live at the St. Peter Mancroft Church in Norwich and contained in Appendix D. The excerpt used is from a tale of the Irish folk hero Cú Chullain, which details the physical and psychological transformation or 'war spasm' he undergoes as a result of battle frenzy. The spoken word elements in the piece gradually transform into something ugly and obfuscated through live processing. This performance was our first real attempt at including spoken word in performance, and this format would eventually come to define our later work. *Cú Chullain* featured a dialogue between spoken word passages, which Jason leads, and instrumental sections where I provided the lead with choral samples and synthesized elements. *The Stick* echoes the broken text with snarling broken melodies and rhythmic patterns between 8m 40s and 11m 40s (41). We began to use more direct storytelling methods in *The Rhime of the Ancient Mariner* (included in Appendix D), in which the structure maintained a dialogue between sonic and spoken word sections as we did with *Cú Chullain*, but the two roles have more obviously found their own space. The narrative serves as a score, synchronizing our interactions and providing an environment in which both roles have equal importance.

In the opening section of *Cú Chullain* between 0m and 2m 39s (42), I was responsible for setting the intensity level and gradually raising it to the point at which Jason could begin telling the tale. I was surprised at how difficult this was, and generally I would pass the required level and then fall back to it a few times before getting it right. We never verbally discussed what level this was, but I began to recognize it the more times we performed the piece. This recognition of a mutually agreed level was signified by a combination of physical posture, environmental location and time spent at one consistent musical level. These signs indicated that we were both ready to progress to the spoken word section, and over time needed to be less pronounced in order to trigger this sectional transition. I developed a technique of very slow paced, controlled and repetitive yet subtly varied movement that set the pace to ensure that the energy remained constant. This was

something I had learnt through playing with Jason who often repeated the same motif over long periods of time in order to manipulate the listener's experience of time.

Although we eventually developed fixed roles through self-organisation, we were able to shift and change roles where necessary for the benefit of the group and the music. Electronic music affords a unique perspective on the creation of roles in performance, as interfaces, through their dislocation with physicality, allow fluid shifts in role at any moment or for any given work. Historical types of musical roles such as melody, rhythm, bass etc. are less relevant as digital interfaces are not limited by physical constraints on frequency range, volume level, timbral choices or gesture type. Very few predefined roles exist, also due to the fairly recent emergence of the genre, potentially allowing the individual freedom and creativity in defining their own niche. This also extends to the practice of being able to move between roles for distinct pieces, or even within a particular work.

Within *FHTA,* this role fluidity often resulted in each of us taking turns with responsibility for lead elements, counter melodies and rhythmic motifs as in *Baby Birds*[4] and *Blood Relations*[5] where each of us contribute repetitive rhythmic gestures that form the composition. Matt comments:

> The roles would sometimes shift, but in terms of musical material, before we realized it, the roles had defined themselves. Once we realized what had happened, all three of us realized that we were happy with it. (Interview, 2015)

iii. Strategies for Group Performance and Composition

What follows are descriptions of my compositional process in relation to two commissioned works, both of which involved designing systems for group musical activity. The commissions were both quite prescriptive in nature, and the vast amount of time that I was used to having with an ensemble was not possible. Although I have previously stated that the themes present in group collaboration are too interdependent for the empirical study of them in isolation, I have observed improvements in writing for ensembles by

[4] FHTA/Meme/03 baby birds.aif
[5] FHTA/Meme/02 blood relations.aif

applying knowledge gained through the experience of my work with *FHTA* and *TRATC*.

The first project is *Conductable*, a playable installation introduced in the previous chapter and presented here as a multiplayer instrument. The second is *The Stream*; a generative composition system, written as part of a residency with a pre-existing collective of high-level musicians. Whilst the first project applies some of my findings from the analysis of socio-psychological elements to a group of people, the second seeks to model sociocultural interactions through software.

Enhancing social collaboration: *Conductable*

The brief for the installation involved consideration for those uninitiated with electronic music and a shallow learning curve. It needed to be playable by a regular turnover of participants in any configuration of numbers between one and five. My five main goals in designing an instrument to support group music making, and my approaches to addressing them were as follows:

Designing a multiplayer instrument where the users can clearly distinguish their own sound

This concern was apparent from performing with *FHTA*. In rehearsal, we usually had a multichannel setup that allowed each of us to have our own loudspeakers placed in close proximity to us, giving each of us a personalized and controllable mix. For most performances we struggled to locate our sounds due to the absence of individual monitors. As such, sound choices were influenced by their ability to penetrate the background as much of what we played became shaped by the need to be heard. In *FHTA* we reacted to this problem by occupying frequency spaces and developing recognizable behaviour to sonically distinguish ourselves within the mix, but this often led to a less detailed and subtle version of our pieces. With *Conductable*, I was able to position a speaker directly in front of each station, ensuring good monitoring.

Fig 2.5 Conductable' installed in the Dovecote at Snape Maltings showing the individual built in monitoring system from the point of view of the conductor's panel. Played here by students and staff from The University of Hertfordshire.

Designing an interface that is accessible, with enough depth to afford technique development and variation of sound

For my first few performances with *FHTA,* I had used a laptop and relied on a visual screen based interface designed in MaxMSP and controlled by the mouse, keyboard and in later performances, a Bitstream 3x Midi controller. My early interface designs featured direct control over all aspects of my patch simultaneously, an approach which could prove debilitating when improvising with a group. Most of my attention would be on my patch, rather than listening to the others, and this restricted my ability to participate in the group flow. In designing *The Stick*, I reduced the number of controls to just three parameters; sample position, speed and amplitude. Their minimalism allows greater focus on the moment of the performance as they did not need to be observed visually, and when used in different combinations, gave rise to a wide range of timbral and gestural possibilities. I had given *The Stick* over to others to try on occasion, and although they could not instantly do some of the things I had developed over time, they were able to rapidly understand the physical control method and soon started to develop their own idiomatic technique. I applied the same simple design method to *Conductable*, using a modification of the granular

synthesizer I had built for *The Stick*. Each station of *Conductable* operates as an individual instrument with just three parameters, controlled by two dials and an ultrasonic proximity sensor. The conductor's station is different from the instrument stations and features two ultrasonic sensors, the left sensor controlling the amplitude of the two stations to the left and the right controlling the two to the right. The station also uses a series of coloured light buttons to toggle the grains for the granular synthesizer for each player.

Creating an environment that supports immersion and social cohesion

During collaborative writing and improvising, I found the most effective spatial configuration was one where players would face each other. This was effective for facilitating dialogue and allowed players to observe each other's actions and communicate visually through eye contact whilst playing. With *Conductable*, players operate around a central podium so the actions of each player's upper bodies are clearly visible and eye contact can be maintained, as the physical controls are simple enough to operate without observation. We were often unable to achieve this in *FHTA* and *TRATC* as most performances would have to fit into a traditional stage and audience relationship so that one of us would not always have our back to the audience. With *Conductable*, both installation and performance were set up with the audience around the entire circumference of the instrument to maintain a balance between audience and performers. *TRATC* and *FHTA* rehearsals would often be conducted with the main lights off, the glow of our screens creating a more intimate space that both encouraged immersion and reduced external distractions. Both the installation and performance took place in darkened spaces, with lighting from a reactive RGB LED Parcan focused on the back of each performer as can be seen in the submitted works; *Hokit* and *Mantra*. This gave an extra visual locator to each player's sound and also helped to immerse the players by creating an isolated light source that focused attention on the immediate vicinity of the instrument and performer space.

Fig 2.6 showing the performers of 'Conductable' highlighted by their individual DMX controlled lights situated on the floor behind them, UEA 2013

Clearly identifiable roles to allow for self-identification and pre-established pitch space territory

Due to the short-term nature of both installation and performance, players would not be able to spend time finding their roles and some existing information about the player's role needed to reside within the instrument itself. Each station on *Conductable* features identical controls, housed in panels that were visually distinct from each other in terms of materials and colour, enhancing the identity of each station and suggesting unique roles.

Fig 2.7 'Conductable' individually designed instrument control panels

Sonically this was reinforced by carefully choosing sample material that would be distinctive to each station. For the public installation, this comprised of varying combinations of orchestral instruments that could be chosen by the invigilator or automatically changed at random throughout the day. The distribution of roles was primarily determined by pitch and set out with higher frequency range instruments to the left of the conductor and lower to the right as shown below:

	Station 1 left/high	Station 2 mid-left/ high mid	Station 3 mid-right/ low mid	Station 4 right/low
Sample banks	Violin Flute Oboe	Viola Clarinet Trumpet	Cello Trumpet Horn	Double bass Bassoon Trombone

Fig 2.8 Sample assignments for 'Conductable' installation

Providing a software platform that synchronizes behaviours

From my experience with both *FHTA* and *TRATC*, we had spent some time developing ways of synchronising the behaviour of our software. This went through a wide range of different possibilities from shared timelines to globally controlled parameter changes. The usefulness of synchronizing systems versus the extent that they limit personal volition must be taken into consideration in order for them to support and not restrict within a performance. *FHTA* eventually settled on using a central oscillator, from which multiple oscillators related to the original were derived. This meant that over many cycles, larger scale patterns would emerge, whilst rhythmic counterpoint on the micro level could also be accessed. Multiplications and divisions of the original signal according to various ratios ensured that a regular pulse did not dominate, but had a centrally unifying role that would provide emergent and unpredictable long scale cycles.

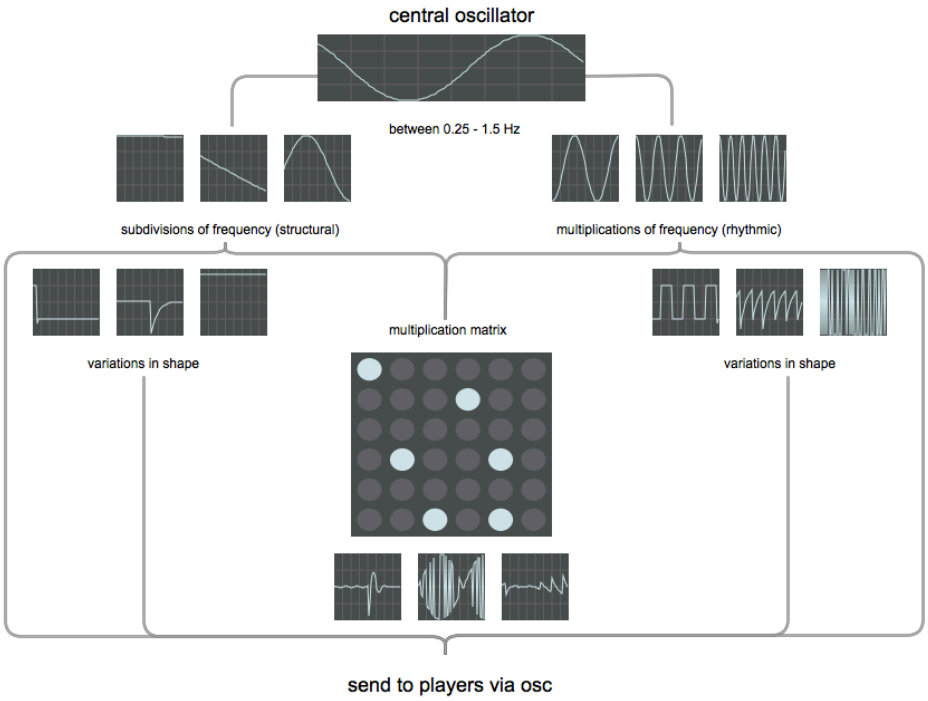

Fig 2.9 Representative diagram of LFO distribution network in 'FHTA'

It was the result of this experimentation that I applied to *Conductable*, where the oscillating output of a core 'phasor~' object in MaxMSP was multiplied or divided to subtly modulate the parameters of the granular synthesisers and effects for each instrument. This created a similar effect to that experienced with *FHTA*, where synchronous events would occur emergently. This approach was enhanced for the installation version of *Conductable*, where

oscillators were used to modulate the amplitude of each station when the instrument was not being played, causing it to make its own generative soundtrack to encourage members of the public to enter the space.

For the performance, I added an extra synchronisation function through the use of a six sided die placed in the middle of the *Conductable* interface which I could turn at any point in the performance. The die signified a universal setting of the physical interface, which I had pre-composed to trigger particular behaviour styles for each piece. Once the setting had been enacted, the players were then free to move as they wished. This design allowed me to take control where necessary and served the dual function of instigating sectional changes and resetting the player's controls. The ability to reset was occasionally useful due to the inexperience and lack of preparation the players had in relation to the instrument which could lead to them becoming stuck on a particular setting or area of the sample. These techniques was incredibly effective at executing clear sectional changes in behaviour and sound, examples of which can be seen from the UEA performance occurring twice between 5m 28s and 6m 34s (44) in *Mantra* and at 7m 34s and 8m 20s (45) during *Hokit* where the players even recognize my removing of the die and pre-empt the sectional change by executing a group crescendo.

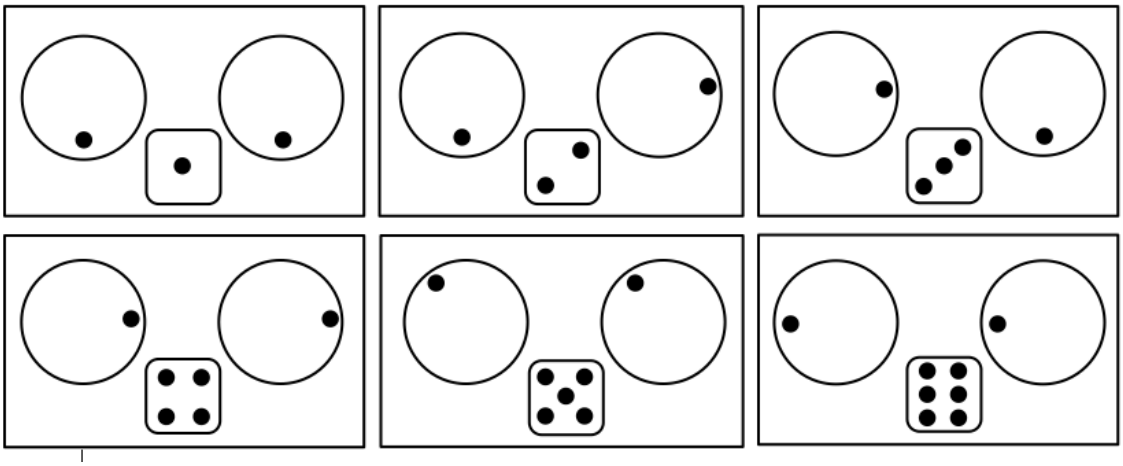

Fig 2.10 Dial settings in relations to die numbers in 'Conductable' positioned on a paper strip at the base of each station's front panel

Installation or instrument?

The dual functionality of *Conductable* as both instrument and installation would impact on its suitability in both areas and it was a challenge to balance the two. The installation aspect slightly skewed my ideal of working with a team of experienced musicians, although it did

mean that any techniques I had for designing an instrument that encouraged social interaction would be well tested. What features as part of the portfolio is a compromise of intentions, although I was able to remap and rescale many of the functions of the installed *Conductable* to provide more subtlety and variety for the performance (as discussed in the previous chapter). This steered the design towards being less playable to a person without prior knowledge, but vastly more nuanced to an experienced musician. I also broadened the sound choices, using an approach developed in *FHTA* to distinguish individual pieces with a unique set of samples for each piece per station. Self-identification was further supported through roles that I had predefined and explained to each player before and during rehearsal. The performance at UEA includes three pieces with sample material as follows:

	Station 1 left/high	**Station 2 mid-left/high mid**	**Station 3 mid-right/low mid**	**Station 4 right/low**
Mantra	Hang drum (pitch shift range set to x2 - x8)	Hang drum (pitch shift range set to x1 - x4)	Hang drum (pitch shift range set to x1 - /2)	Hang drum (pitch shift range set to /2 to /4)
Hokit	Flute	Clarinet	Tenor Horn	Double Bass
Edun	Vocal	Guitar	Percussion	Bass Guitar

Fig 2.11 Sample assignments for 'Conductable' in performance

I knew that I would not have the time necessary for a group of strangers to successfully bond, negotiate roles and develop strategies for communication and improvisation. Group collaboration would need to be supported by preparation on my part in terms of facilitating a clear way to organize learning, rehearsing and performing the piece. This included choosing specific people who all, to some extent, had previous social relationships with each other and more importantly, with me. My relationships with the players would be crucial to the preparatory dialogue needed to quickly realize the pieces. They were also recruited for their varied experience of experimental electronic music and for their enthusiasm towards being involved with the performance.

Picking the team

Station 1: Lilith Perkins

Rather than picking composers, I wanted to choose some players who had varying experiences and knowledge of electronic music traditions to bring a unique approach uninfluenced by a live electronics practice of their own. Lilith has always been my main discussion partner for my own work, and has followed my own development over a long period of time. We had met at University when Lilith was the vocalist in a group that I led, and for the last five years had been playing and writing in various bands together. We had also collaborated on my work *Wayang Listrik* which we had performed together and used our voices as the sole sample material. In this piece Lilith had played another granular synthesis based instrument I had built and had developed a technique and understanding in relation to its operation. Lilith was also aware of my work on *Conductable* and had played the installation numerous times at various stages of development. Lilith was used to playing in various bands that I had led, and as a married couple we had a preexisting transactive dialogue, which transferred well to this project. Her reliability and openness to play music in any form was vital in how quickly she understood and became engaged in the pieces. Lilith is predominately a vocalist in the soprano/alto range and also an expressive arts therapist working primarily with voice. She occupies the highest frequency range in *Hokit* and *Mantra* and uses the voice as sample material in *Edun* due to her preexisting familiarity with that pitch space and timbre. I also gave her the position to my left nearest to me as we were used to performing alongside each other and this would provide a familiar environment for us both. Her position would also be next to Sherry, whom I had met initially through Lilith who was part of the same gig circuit in Norwich, sharing some musical influences with us both.

Station 2: Sherry Armstrong

Sherry was also in a band with Lilith and I at the time, and we had developed our working relationship and interaction style over time with me as bandleader. This would be useful in supporting the quartet and conductor dynamic that I needed to operate the pieces effectively. Lilith had known Sherry for some years and they were both incredibly supportive towards each other's own solo practice. Although Sherry played bass in our band, this was a recent role development for her as she was predominately a vocalist, although occupying lower frequency range than Lilith. Sherry had no previous experience

with improvising or the playing of experimental electronic music, but had a diverse knowledge of music in general. Her professional background in architecture had led her to an interest in acoustics and the resonance of materials. We had many discussions around this, both learning from each other's experience and developing musical ideas. Sherry had also heard me talk about *Conductable* during the design stage and had brought her family to Aldeburgh to visit *Conductable* installation. Sherry spent a lot of time playing the installation with her daughters and was incredibly enthusiastic and supportive about it. This greatly contributed to the group dynamic and flow in rehearsal and performance. I found Sherry to be a very calming influence in musical situations, and the familiarity and communicative style both Lilith and I had already developed with her was fundamental in supporting the collaboration of the group.

Station 3: Pablo Cook

Like Sherry, Pablo had no previous experience of playing experimental improvised electronic music. He also only vaguely knew Lilith and had not met Sherry and Jason. I had met Pablo whilst working on a music education project and we instantly developed an intense social dynamic that was reminiscent of how I communicated with Matt and Jeremy in *FHTA*. Pablo was a highly versatile percussionist who used electronic technology as part of his practice, including one of the first Korg Wavedrums and a Space Echo delay machine. He was familiar with using technology as a producer and was interested in sonic experimentation, although had no academic training in this area. Pablo had many years of performance experience and had toured with Joe Strummer, Captain Sensible, Moby, and William Orbit and also played on albums by Madonna, Madness and The Grid amongst others. I had a few free improvisation sessions with him to gauge how well his preexisting skills and our social relationship would cross over. It was clear very quickly that our social dynamic was replicated musically, and he was keen to get involved with *Conductable*. His openness and keenness to play was the deciding factor in his recruitment to the team, and I wanted him to have a real experience of something that he was eager to do. By the nature of his burgeoning interest in experimental electronic music, and my greater experience, it was natural for us to fall into a role where I was able to maintain my role as group leader, despite his greater performance experience. It was clear from our previous improvised sessions that Pablo would be able to quickly adapt to any musical situation, and his ability to immerse himself within the music was infectious when playing together. I wanted to bring his enthusiasm, skill and reputation to the team to in order to provide some hype to

the performance, both unifying the team and creating just enough discomfort for everyone else to be a little extra alert to their own musical contribution. Pablo is given a percussive or rhythmic role where possible due to his experience in this area, or else occupies a harmonic role in the lower middle frequency range.

Fig 2.12 Team 'Conductable' after the performance at UEA Sonic Arts Series Concert, 2013
From left to right - Pablo Cook, Jason Dixon, Ed Perkins, Lilith Perkins and Sherry Armstrong.

Station 4: Jason Dixon

Whilst the others were fairly fresh and inexperienced to the type of work that we were to produce, Jason was a seasoned professional who could be relied on technically. Our musical and social relationship was already established and I knew I would have to explain very little and could leave him to explore whilst I focused on training the others. I gave Jason the role of providing bass, which I knew he would be comfortable and familiar with. Although the speakers on top of the instrument were small, it had a subwoofer housed inside its body and he was able to replicate some of his characteristic gestures and sounds. Jason and I were able to change between different hierarchical roles during our work as *TRATC*. For this project he understood that he would take my lead in terms of what I asked of his role, but would bring his own expertise in controlling bass frequencies to it.

When things go wrong: Support from preexisting relationships

The two who knew each other best were Lilith and Jason and at a time when the group cohesion failed through a technical issue, they would be the two who were able to quickly synchronise their actions and cover the interruption in flow. Lilith comments on this moment:

> I remember looking over at you and then suddenly you were opening up your patch and I realized something was wrong and you were trying to fix it. That's when me and Jason looked at each other and I could tell we were both thinking 'shit, we need to do something now!' (Interview, 2015)

Due to a lack of familiarity with the interface and because of the short time available to develop familiarity with the instrument, at one point Sherry lost the ability to make sound. A quick look over at her confirmed that she was becoming distressed and confirmed from her body language that she was not able to hear any sound from her speaker. The audio excerpt of *Edun* (46) in the 'Excerpts' folder on the accompanying media shows the full two and a half minute sequence I am about to describe:

I identify that Sherry is struggling at around 3 minutes into the performance of *Edun* at UEA and have begun to delve into my patch at around 3m 30s. Jason and Lilith worked together independently of me to carry the piece whilst I worked on the technical issue. They both assessed the situation and decided how to respond without verbally communicating and without instruction from me. Both have been personally incredibly supportive to me and I have always felt that they strongly want my endeavours to succeed. In this musical situation, they translated their supportive natures to cover for me whilst I identified and resolved the issue. Interestingly, although having been fairly low key for most of the piece, Pablo seems to sense this change in energy and begins to take a more leading role in answer to Lilith's vocal material and creating one of the most dramatic points of the performance beginning around 3m 30s. Pablo experiments with a technique for creating tumbling clouds of percussive gestures, before switching to more obfuscated material at 5m 00s, something I had not previously heard him do during the rehearsal. Without my presence, the group seemed to take more responsibility for the piece, and perhaps felt they could operate more freely whilst not under so much scrutiny from their conductor.

After opening up the patch and checking the audio output, I realized that Sherry's current playing position was in a silent area of the sample, and she had slowed her playback speed sufficiently for that area to become essentially vast, something I had protected against for the installation. As she frantically moved the controls back and forth she made the issue worse by playing backwards and forwards through the silent area without progressing through to more audible territory. The issue was actually one of experience, and although I was not able to explain verbally to Sherry what had happened, I was able to temporarily take control of her instrument and reset the sample position so that she was able to make sound and continue with the piece.

My response didn't explain to Sherry anything about what had gone wrong, because we were in front of an audience and it was too technical to communicate non-verbally. Instead I altered the environment so that she could carry on being part of the group and continue to have a positive experience and contribute to the success of the piece. Aside from the brief misunderstanding, Sherry comments on what she took from the whole experience:

> I felt I was completely immersed in the music and lost my sense of time and self completely. It created a situation and environment where I could focus entirely on what was happening. I loved the feeling of being part of the sound, in a much more whole sense than when playing an instrument, and the freedom of the playing, complete improvisation without worrying about being on a right note on a fret and being absolutely in the moment in the experience. I wasn't thinking about anything else. There was a fantastic connection with the other players and my usual stage fright didn't come. (Interview, 2015)

Composing social collaboration: *The Stream*

The Stream was an attempt to model some of the social aspects of collaboration, and to investigate whether the interactions of agents with predetermined roles and relationships would produce music similar to that of their human counterparts. The system is designed to fabricate complex social interactions between agents by creating interdependencies. Archetypes are employed, onto which I have projected my own social understandings in order to create clear roles and ways of behaving for each agent. *The Stream* does not focus

on producing certain musical and sonic behaviour - rather it generates social behaviours, patterns and cycles that are produced form the self-organization of the system as a whole. Similar to a social relationship, *The Stream* comprises of a vast network of feedback loops that constantly realign themselves to best suit the needs of the whole group.

Depersonalizing *Apartment House*

Apartment House are a contemporary collective of musicians that play in various configurations, led by cellist Anton Lukoszevieze. I had been given the opportunity to work with Apartment House through a two-year residency I was awarded by Sound and Music and The Esmée Fairbairn Foundation. The award was a part of Sound and Music's Embedded programme for emerging composers and offered a unique opportunity for me to work with a Royal Philarmonic Society Award winning group of musicians. The Musicians were Anton Lukoszevieze (cello), Jonathan Impett (flugelhorn), Gavin Morrison (alto flute) and Angharad Davies (violin). I had page turned for Anton Lukoszevieze during a performance of a series of works by John Cage at the Queen Elizabeth Hall in 2011. It struck me how open the score was to interpretation, and consequently the piece became more of an *Apartment House* piece than it did John Cage as the well-worn social and musical dynamic of the group began to take precedent.

Rather than supporting collaboration amongst the human players of *Apartment House*, I wanted to inhibit their interaction so that they operated more as mouthpieces for the interactions of the (non-human) agents. I attempted to dehumanize the players, using them for their technical abilities rather than for their personal previous experiences of playing together. It would prove difficult to entirely eradicate their previous relationships as they were so familiar with playing with each other and would evidently fall into the kinds of patterns of interaction that they had formed through previous experiences. This level of depersonalization and control proved valuable for me in asserting my leadership over the group, particularly as they were used to being led by Anton, who is not only a highly experienced and skilled musician, but also a strong personality and leader. I benefitted from the fact that the system was both complex and unique, meaning that I held more expertise over this particular project than the musicians, which allowed me to maintain control over the realisation of the piece. The musicians were all incredibly supportive in terms of their enthusiasm for the work and their helpful feedback on the system and scores, which aided the development of the piece.

I designed the system to be incredibly prescriptive, requiring the players to follow a real-time score with a constantly moving visual indicator. The level of attention required was such that it reduced their awareness of both the overall structure of the composition and of past and future musical events. It also gave them less time to adapt the material to their own playing style, which helped in asserting my authority over them. I seated them behind cardboard cut outs of their agent's symbol[6], and speakers, laptops, microphones and cables fenced them in on all sides. It was my hope that this would immerse them more in their own individual role, inhibiting their own social behaviour in favour of that provoked by the system. This approach was in stark contrast to that of *Conductable*, where the technology is mostly hidden to support group interaction and play.

The agents in *The Stream* have specific archetypal identities and it was important that the players could identify with and understand their own agent's role. I supported this through careful explanation of the agent's characters to each member of *Apartment House*, and asked them to wear outfits that matched their agent's colour, green for the Hunter, blue for the Medic etc. During rehearsal I would call them by their agent names in an attempt to depersonalize them and further bond them with their agent. The techniques I had learnt for supporting group collaboration were useful both in supporting collaboration between agents and in inhibiting collaboration between *Apartment House* as a preexisting group.

[6] Each agent has an individual emblem that represents their character and is used to distinguish it from the other agents non-verbally when required.

Fig 2.13 Rehearsing 'The Stream' in The Strode Room at UEA with 'Apartment House', December 2012
From left to right – Ed Perkins, Anton Lukoszevieze, Jonathan Impett, Gavin Morrison and Angharad Davies

Summary

My own experiences have shown that the analysis of musical collaboration is highly beneficial to its development when focused on its roots in social interaction. This approach can reveal the motivations, behaviours and relationships that trigger and shape both individual and group musical outcomes. Statistical data gained from the analysis of interface operation or musical output within an isolated study is difficult to apply to multiple and varied real musical occasions. In contrast, social elements must be understood and observed over time, through the understanding of, and the participation in, well-established groups. Groups constructed for the purposes of study lack the history and the resulting matured social dynamic that gives rise to successful and interesting collaborative work. As more experience is gained through transactive dialogue and observations of the role creation processes, a picture can be built up of the group dynamic. A considerate and appropriate application of knowledge gained from these experiences is fundamental to fostering productive collaborative relationships.

For shorter-term projects, factoring social elements into the compositional and project design process is paramount. Choosing groups with better preexisting social and musical relationships gives a better chance for the group to form cohesively and develop musically. Social and musical cohesion can be supported by providing shared goals and through fostering as much opportunity for social bonding and dialogue as possible. Archetypes and

familiar musical roles are useful in facilitating rapid understanding of how to act within the group, and clear leadership can help to unify the team towards their shared goals.

Whether or not the musical output of the groups was successful is of course highly subjective. My interviewees reported improved success in the realization of our shared goals and a feeling of musical self-development as a result of a consciously collaborative process.

Verbal feedback from performers that describe unexpected moments or failures are essential in forming a full picture of the circumstances that lead to the occurrence. Not only do these unexpected moments provide new ideas and challenge one's own, they provide further bonding experience through transactive dialogue that focuses on improvement and joint task accomplishment.

Societal Modelling

i. Mimesis and Relationship Modelling

One of the first articles that brought clarity to my musicological understanding of the aesthetics of electroacoustic composition was 'The Listening Imagination: Listening in the Electroacoustic Era' by composer Denis Smalley (1992). For me, the most interesting and rewarding aspects of music are the human relationships explored between those who are involved in the music making and the behaviour relationships that exist between aspects of the piece. Smalley describes elements of the music as being *mimetic*:

> The notion of the indicative field/network comprehends relationships that are considered mimetic. Mimesis in music is the conscious or unconscious imitation or representation of aspects of nature or culture. (Smalley, 1992: p. 522)

I found this idea to be helpful in practically understanding sound based composition. Although I often felt that the rationale behind electroacoustic composition and its associated aesthetic approaches was not always clear, I could understand the inner workings more clearly from a method which involved modelling natural and social relationships. I was not only interested for the benefit of further exploring my own practice, but also as a way of framing sounds and structures which might seem alien to an

audience, increasing the possibility for familiarity and comprehensibility. A performance system within which social and natural relationships and behaviours are modelled has the potential to be more readily understood by the audience, and on some level this strengthens comprehension and improves accessibility. This type of model works on two levels, where the audience can empathise with both those who are performing the music and the resultant narrative of the piece, similar to the experience of watching a film or theatrical production. I could also foresee how this could be extended to the representation of interpersonal relationships. Smalley goes on to discuss behaviour:

> The behaviour-field can first be defined by discussing two pairs of oppositions: *dominance/subordination,* and *conflict/coexistence*. Naturally there are continuously mediating positions between the polar extremes. (Smalley, 1992: p. 526)

The 'continuously mediating positions' Smalley mentions are where the narrative of the piece could unfold through sequential changes. The navigation within the boundaries of two fixed points creates a third element that describes the path of an individual caught within these two poles and their resultant forces on its behaviour. The fields of *dominance/subordination* and *conflict/coexistence* are not independent objects and only exist in relation to the interaction of agents within a system, affording the possibility for multiple relationship outcomes and styles to take place. The potential for representing interpersonal relationships in a constant state of unrest gives rise to the possibility of generating a narrative over time. This is further defined through the aforementioned relationship types:

> Dominance/subordination is concerned with the inequality of participating morphologies . . . (Smalley, 1992: p. 526)

> Conflict/coexistence is intended to highlight temporal relationships within the behaviour-field. On one hand sounds can exhibit competitive tendencies, and on the other they can exist in a reciprocal, confluent environment. (Smalley, 1992: p. 526)

This explanation personifies aspects of the composition and supports a model where the music is described in terms of naturally occurring relationships. Whilst intended as an

analysis tool for fixed work, I began to develop ideas of reverse engineering the theory to create a live model that could compose these relationships in real time, realised through bespoke software that would communicate the resultant relationships musically, either to other sound making applications or to instrumentalists by generating notation or a graphic score.

Frogs

Toop (Toop, 2014: p.190-191) discusses how mimetic elements have more globally informed the process of composition, explaining that the observation of nature has led some musicians to the creation of emergent systems based on non-human source material. He goes on to quote Felix Hess discussing the limitations of fixed composition after recording a chorus of frogs in the outback of Australia:

> A recording has a definite beginning and end, whereas a real chorus continues indefinitely with a diurnal and even annual rhythm. And there is a lack of something utterly fundamental. The essence of the moment of listening, *this* moment in time is absent in any recordings: the "past" and the "future" have been arranged already along the tape. (Toop, 2014: p.191)

Hess' notion of what is real about this chorus is that it exists in the interaction between the frogs, rather than in the actual arrangement of the sounds themselves on the recording, and it is real because it is happening endlessly within the moment, rather than being a prearranged composition or a recorded document of a particular occasion.

Toop explains that Hess' response was to build a group of small electronic machines to imitate the structure of the frog chorus. Hess gave each machine a microphone with which to listen to its neighbours and a set of rules which determined its response, emitted through a speaker. Whilst contemplating the possible difficulties of creating a machine that responds to sounds but can acoustically distinguish and choose to ignore its own sound, I began to think about more complex communication systems and their design. It struck me that software agents might communicate more accurately and richly through data streams, without needing to consider the physical world until the result needed to be heard.

Social Robots

Eduardo Reck Miranda, amongst others, has written extensively on the use of artificially intelligent systems that model human behaviour to compose music (Miranda 1994; 1999; 2004; 2009). Miranda discusses two common methods that use mimetic models and their associated discourse for composition abstract algorithmic approaches, using patterns from nature mapped to sound, and gesture and knowledge based systems, where the composer arms the software with more cultural references such as a harmonic system or an understanding of rhythm (Miranda, 2008: p.321); Miranda reflects on the algorithmic method as follows:

> Abstract techniques tend to produce rather complex music, most of which may sound too remote from what the majority of people, including expert listeners, would consider musical. This is possibly so because abstract algorithmic music tends to lack the cultural references that people normally rely upon when listening to music. (Miranda, 2008: p. 321)

Many algorithmic composition techniques focus on global data concerning large populations or natural processes which tend to have cycles that occur over months, years or even decades. These macro structures are not useful for composition in their raw form, as they cannot reasonably be perceived within the time frame of a performable musical composition. Felix Hess explored sounds recorded from infrasonic machines that were sensitive to air pressure fluctuations over long periods of time. He tells of how he needed to use time compression, not only to make the frequencies audible, but to allow the listener to fast forward through time and shrink the macro level cycles to a structure that could be understood as musical to human observation (Toop, 2004: p.191).

The sonification of the output of these algorithms could be made more traditionally musical by scaling or filtering through musical rules, quantising rhythms, or rounding values to the nearest degree of a harmonic scale. Miranda criticizes the application and mapping of too much traditional music theory as it produces music that lacks both innovation and authenticity:

> Conversely, knowledge-based techniques tend to produce pastiches of existing musical pieces, which often are of little interest for composers aiming to create new music; that is, music that is not based on mimicking existing pieces or well-known musical styles. (Miranda, 2008: p.321)

The author goes on to propose a synergy of techniques involving flexible algorithmic data generation and a creation of shared knowledge or culture by agents within the system. Miranda implemented this by building two software agents that have a real physical presence in the form of two (already commercially available) robots. Miranda adds cultural reference by giving them high quality synthesis and analysis tools by which to communicate through their voices.

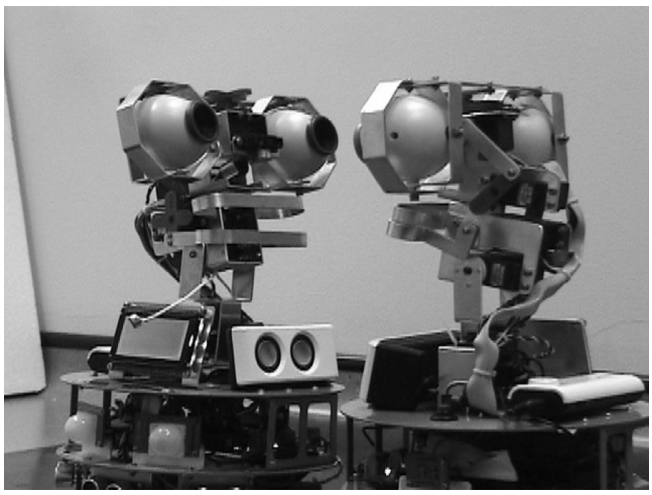

fig 3.1 Eduardo Reck Miranda's Social Robots at ICCMR (Miranda 2008, p.320)

Miranda uses the term *agents* to describe a program with a set of rules acting autonomously by listening and responding. Groups of agents interacting with each other create *multi-agent systems* where the actions of the individuals form larger structures through interaction with each other.

The approach used by Miranda for his robots creates a call and response style interaction similar to that of Hess' chorus of frogs, but adds the element of cultural learning between the agents. Each robot can speak and listen to develop a shared repertoire, analysing the output of other agents and using knowledge developed over the course of the interaction to inform a response. This style of music making is similar to free jazz improvisation, where players attempt to form a cohesive musical language throughout the course of the

improvisation, with minimal obvious or conscious reference to common genres or techniques.

Fuzzy Logic

I created an earlier agent-based model using eight individual agents for the generative composition system *The Four Zoas* (2007)[7]. Due to the sheer number of complex decisions that need to be made for live composition, it is often difficult for a composer to adequately monitor and adjust specific elements effectively during a performance. One solution is for the composer to delegate responsibilities to an artificially intelligent agent - a computer program, which can be programmed to the composer's design and can be given a simplified version of the composer's decision-making process, or the autonomy to make decisions based on its own observations and consequent reactions.

The *Lobjects* created by Peter Elsea were familiar to me from previous experience of managing and configuring data in the software environment MaxMSP. I later became aware of his work on the application of fuzzy logic to music (Elsea, 2011). Fuzzy logic can be used to make decisions that are more approximate than exact. It emulates a more 'humanised' concept of rules as opposed to the exacting logic of standard computerised decision making.

> Fuzzy models . . . are a fairly straightforward translation of the linguistic statements of a group of rules. The model begins to function roughly as soon as two or three rules are stated, and is easily refined by tuning up the sets or by addition of more rules. (Elsea, 2011)

Using this method, a series of probability values can be assigned to a list, giving each parameter a weighting and therefore a certain likelihood of being generated. The software has the option of making decisions that vary each time, but the output of the system may be understood as a behaviour exhibiting aspects of the more humanised concept of preference. For example, the instruction to play a sound for seven seconds could be made fuzzier; play sounds for around seven seconds but between four and eight seconds, with the highest probability weighted around an anchor point of seven, e.g.

[7] Not included as part of this portfolio as it preceded this PhD

Seconds	1	2	3	4	5	6	7	8	9	10
Weighting	0.	0.	0.	0.2	0.4	0.6	0.8	0.6	0.	0.

fig 3.2 Sequence of numbers with fuzzy logic weightings

The program now appears to have a concept of what playing 'sounds around seven seconds long' means, and will more likely play a sound shorter than seven seconds with this particular set of rules. This notion of preference gives a fluid variation within a range rather than a set response to a given stimulus. The preferences can either be altered directly by the composer or autonomously by the system itself through some other development in the software or database. The change and development of preference over time can generate memories of past states that are taken into consideration when making new choices. Multiple preference weightings can then be assigned to compositional attributes, creating complex webs of decision-making processes that lead to consistent behaviours over time and create the illusion of a personal character within the software.

The Four Zoas implemented fuzzy logic decision-making in agents who each had a unique set of preferences, and although predesigned, the preferences were sound based and not traditionally musical. The preferences were based on my interpretation of the personalities of characters in William Blake's pantheon featured in his prophetic works including *Milton, The Book of Urizen and Europe a Prophecy* (Blake, 2000) The characters made decisions about what type of timbre and gesture to make, with preferences informed by my own presumptions about how sonic gesture and utterance could represent social behaviour and interpersonal relationships. Rather than analyse the sounds being created, the use of a software environment (MaxMSP) allowed the agents to communicate directly with each other on the data level. The physical sensation of sound needs to be analysed and translated before being understood by a software agent, which seemed an unnecessary step for agents who do not inhabit a physical world. Like Miranda's social robots (Miranda, 2008) the interactions were limited to call and response that resulted in conversational structures that did not always provide the most engaging compositional material. Like human improvisers, the agents needed a world to inhabit that they could draw shared experience from, that would be affected by their actions, and in turn change conditions to

alter the agents' personalities and decisions. This world may also display properties and characteristics that are not designed, but tangibly emerge from the system, determined by the actions of the agents who inhabit it.

Both Miranda's robots and the agents of *The Four Zoas* are interesting in that they mimic communication. However, there is no purpose to their communication, they merely talk for the sake of talking. For real communication to occur, the communication must be about something. This communication may be eventually represented sonically or visually, but the subject of the conversation and the need to communicate is really what is at stake here. Therefore if we seek to model communication, the agents need to be part of something that it is vital for them to communicate about. This is where the composition lies, and any perceivable outcome is secondary.

ii. Games, Simulations and Emergent Behaviour

Economist Jeffrey Goldstein defines the phenomena of emergence as:

> . . .the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems. Emergent phenomena are conceptualized as occurring on the macro level, in contrast to the micro-level components and processes out of which they arise. (Goldstein, 1999: p.49)

Rather than being limited to listening and responding within the physical world, agents in a system capable of producing emergent structures need to be co-dependent, inhabiting a closed ecosystem, so that their behaviour is influenced and limited by a shared set of laws.

An environment that fosters emergence might be created by using a system that has its own way of sustaining the agents within it. The system would need to be self-regulatory, or very carefully balanced, to avoid decreasing or increasing entropy, leading the system to either overload or to stagnate. This could be implemented through co-dependent relationships that use multiple feedback loops to facilitate interaction, similar to those described by the field of Cybernetics. First proposed by Norbert Weiner in *Cybernetics*

(Weiner, 1948), the term is applicable when a system being analysed is involved in a closed signalling loop. Actions carried out by the agents generate change in the environment, and that change affects the behaviour of the agents in turn to create a feedback loop. The agents also have a direct impact on each other in combination with their environment, creating further complex feedback networks. Webs of these circular causal relationships (Weiner, 1948) amongst individual agents quickly obtain a great degree of complexity, and cyclical behaviours and group gestures emerge over time. Applying this idea to musical improvisation, David Borgo explains how extremely complex systems can spontaneously give birth to delicate forms and structures:

> . . . complexity theory deals with highly interconnected systems that may at certain times and under certain conditions, self-organise in a way that produces emergent forms of order. These emergent forms cannot be deduced from the equations describing a dynamical system but can describe the patterns arriving from the evolution of such systems in time. (Borgo, 2005: p.83)

Life models

An ecosystem with agents that have individual styles of behaviour and interact within an environment draws obvious parallels with the natural world. By creating agents with mimetic characteristics and facilitating their interactions, one can create an analogy of a natural system by modelling relationship rules of complex beings or even simple organisms. Miranda contemplates the micro world of cellular automata as a way to make music in his article 'On The Music of Emergent Behaviour: What Can Evolutionary Computation Bring to the Musician?' (Miranda, 2003). Miranda observes that artificially intelligent composition systems that operate with musical understanding are fundamentally 'hard-wired' to the style that the composer has programmed (Miranda, 2003: p.55).

He proposes that mathematical models that 'embody our understanding of the dynamics of certain compositional processes' (Miranda, 2003: p.55) have generated interesting results and may prove to be a way forward in creating 'new' music. Miranda goes on to implement mathematician John Conway's cellular automaton, the *Game of Life* (1971) as a means of generating data to be used for composition. Miranda's social robots (2008) listened and

responded to sound whereas Conway's automata inhabit an environment with a system of rules that affect the evolutionary progress of a cellular organism within a community. The software does not need to be taught musical rules, and thus divorces itself from the knowledge and experiences of the composer. Miranda concludes his paper with a suggestion of how life models for composition might progress in the future:

> I suspect that we would need to add generative models that take into account the dynamics of social formation and cultural evolution. In that case, we should look for modelling paradigms where phenomena (in our case musical processes and forms) can emerge autonomously. We have strong evidence that the adaptive games paradigm might shed some light on this problem. (Miranda, 2003: p.57)

Games

My main experience of simulations of life models were from playing simulation games that modelled real life paradigms. I began playing *SimCity* by developer Will Wright at around the age of eight. My aim was always to create a balanced society that would autonomously maintain its own survival through just the right combinations of commercial, residential and industrial 'zones', which in essence functioned as agents themselves. The point of the game was to ensnare the player in a relationship of constant interference with the simulation, but I was more interested in the dynamics of a well balanced system, the roles that each building played in society as a whole, and the consequent emergent cycles and narratives that would develop over the course of time.

I eventually moved from *SimCity 2000* and *SimCity 4* onto *The Sims*. *The Sims* functioned on a social level, where artificially intelligent human characters created a narrative of basic day-to-day functioning, including going to school, going to work, socialising, eating and other basic bodily functions. What was most interesting to me was the internal health levels of the characters, and what effect they had on their behaviour and ability to operate. Leaving characters to feed themselves would often result in behaviours that led to quickly diminishing health levels, creating an emergent and dramatic narrative for both the Sims and the social groups in which they were involved. What was also interesting was the ability of the system to generate individual and social actions that were not part of real world

behaviour, but a result of the rules inherent in the simulated world. Sims would often go temporarily insane, creating new but perfectly 'logical' social interaction styles such as crying at other Sims in the park when hungry or wandering into the back gardens of other Sims because they considered them cleaner than their own houses.

This seemed to me to be a model that might make interesting material and structures for composition similar to those behaviours described by Smalley (Smalley, 1992). The complexity of the world, and the hierarchies of individual, group and social data streams could be harnessed for use as behaviours for sound making devices or instruments. Whilst the system will always ultimately reflect the social assumptions of the designer, the benefits of a non-musical model is that none of the relationships within the system are linked to pre-existing knowledge of rhythms, harmonies or other musical factors.

The role of the composer is then focussed on mapping strategies that will best present the data produced by the model, selecting from those most suited to composition. The use of a social model and the evolution of social relationships give a useable narrative, in the form of numerical data generated by the system over time. The data can be interpreted as an unfolding series of events in the life of each agent, describing how they are shaped by the actions of each other and the effect of their behaviour on the group as a whole. The use of a character-based narrative is also a useful tool for framing more seemingly abstract concepts of experimental composition.

iii. *The Stream*: Composing Social Relationships

The Stream is a societal model comprised of four virtual agents and the environment that they cohabit. The system began life as the central server for *From Honey to Ashes*, sending simple low frequency waveform oscillations to each member of the group for use as personal control data for our patches. The problem, as mentioned in previous chapters, was one of control. The system needed to be autonomous and self-sustaining enough to continuously create and send new data to our patches, but the data needed to be meaningful and not too random in order to create interesting but coherent control data for live composition.

For the *From Honey to Ashes* server, I had facilitated the waveform interaction through simple mathematical functions and a mixer that allowed them to cross modulate. This created behaviours that were directly related but not always sonically discernable, as intended, but lacked the more evolutionary and adaptive behaviour changes that I was looking for. I needed a way of including permanent change in the agents as a result of their interactions, or at least a semi-permanent change in their abilities, rather than just temporarily altering their current behaviours manually.

The core concept was to design software that could model relationships over time and generate Smalley's (Smalley, 1992) behaviours as control data, for use by either software agents or human musicians in performance. Smalley's relationships were mimetic, so it seemed a natural course of action to create agents with mimetic qualities who could cohabit an environment where the rules of survival would underpin the success of each agent. Taking ideas from the field of cybernetics, each agent could affect this environment, causing permanent changes in the system and influencing both the environment and the 'lives' of all inhabitants. In this system, inhibiting or allowing the fundamental behaviours of each agent would produce temporary behavioural changes. Permanent change would be realised through irreversible changes to the agent's fundamental behaviours, or through simulated evolutionary or technological developments in the society that could alter the balance of power between the agents.

The agent interaction would not be call and response based, as this approach would be limiting in generating new and emergent behaviours. Rather the agents would be co-dependent in a bid for survival, requiring a sustainable environment where they were all needed, but each agent would also be motivated by self-interest. Instead of being motivated by the goal of a balanced society, I wanted the agents to both compete and collaborate for the benefit of their own success, with opposing forces and a resulting complex social dynamic creating an interconnected web of data for use as compositional material. This would be realised through systems that allowed the trading of resources, resulting in relationships that could be supportive and mutually beneficial or conversely involve struggles for power and battles for resources.

fig 3.3 Setting up for The Stream' at the Undercroft, Norwich

The algorithms and data generated by the system are essentially abstract, in that they have no connection to, or influence on the real world outside of their function for the piece. I applied models of economic, social and personal relationships to give myself a clearer method for creation and use, with a pre-understood framework that would aid my own design and management of the system. The characters and their stories enabled me to navigate complex systems by aiding my memory as to how each sub-system functioned. A comprehensible model is much easier to implement when the data streams are characters that one can imagine performing tasks or playing an archetypical role in society, and consequently much of the decision-making is implied by what is being modelled.

With abstract streams of data any relationship might be possible, but modelling a self-sustaining system such as an interdependent social group supports the creation of a composition system which can also self sustain. For example, early on in its design, the system would generate huge reserves of resources that could be lived off for long periods of time even when food was scarce, making the data and consequent compositional structure stagnate. By adding the possibility for resources to spoil, and for high yields of resources to have less value, I ensured that the system would be unable to sustain one level

for long periods of time. This eventually led to the programming of a functioning economic system, described later in the chapter. Initially, rather than looking at how the economics of a nation works, I ended up creating limiting factors within the data stream and then realised I was modelling how a real-world economy actually functions, albeit on a very basic and simplified level. Soon there were taxes, government funding and a national health service.

The system also features a gradually increasing level of technological innovation that develops when the economy is strong, allowing features such as the storage of food to gradually improve conditions for the agents over time. By modelling real world attributes, the model became not only more believable, but more engaging and comprehensible to create. Although the idea was complex, it gave me a way of talking about the data to others, and gave the whole system a cohesive framework on which to build on my original concept.

The Stream is a unique simulation designed by the composer and its credibility lies in the validity and complexity of design that are not apparent through listening alone. This raised issues around how much information to give an audience before and even during the performance and is discussed in more detail later in the chapter.

I have included a detailed explanation of the objects, structures and relationships within the system and how these translate into musical behaviours in appendix A. I would suggest that the rest of the chapter might be better understood by both reading the explanation contained in the appendix and by watching The Stream performance from The Undercroft in Norwich (2014) that forms part of the submitted works.

I have also included a trailer video for the premiere of *The Stream* in Appendix D: Additional Materials. This is a useful summary of the project filmed as part of my residency with Sound & Music and Apartment House.

Instrumental Techniques

Each agent has four possible techniques that are unique to their instrument and are triggered by a change of leadership. Despite my careful theoretical planning before the

workshop, I ended up completely reallocating techniques after hearing the piece performed. Initially I had tried to weave some sort of rational system into my choices, trying to match effect types such as tremolo across the instruments for one style of leadership. Eventually I divined my final choices through listening and combining different types of effects to create well-balanced structures that contrasted between each change of leadership.

Rather than using more avant-garde techniques, I often opted for vibrato and tremolo as the modulation created interesting patterns amongst the instruments, particularly when the line of the score jumps between speeds causing rhythmic patterns that vary between each note. These effects are also more easily scored by the system as they depend on temporal modulation, which can be communicated more easily and precisely by denoting ranges of speeds. There is a good example of this in the December 2012 workshop recording from Jonathan Impett playing the Flugelhorn, beginning at 4m and ending around 6m (47). The final techniques used were as follows:

	Hunter		Worker		Medic		Artist	
Hunter	Pure tone		Disruption		Staccato pulses		Pizzicato	
Range	Straight	Vibrato	Less	More	Slow	Fast	Less often	More often
Worker	Tremolando		Pure Tone		Flutter tongue		Tremolando	
Range	Sul pont	Pure	Straight	Vibrato	Less	More	Sul pont	Pure
Medic	Glissando		Staccato pulses		Pure		Glissando	
Range			Slow	Fast	Straight	Vibrato		
Artist	Pizzicato		Tremolo		Bend notes		Pure	
Range	Less often	More often	Slow	Fast	Down	Up	Straight	Vibrato

fig 3.4 – Instrumental techniques by leader. Subcategories show technique ranges (see score below)

fig 3.5 – Screenshot of the Artist's score. Hunter is the current leader, as denoted by the green indicator bar

Sound Processing & Diffusion

Originally, the technical setup was designed so that each element could have its own speaker as shown in the layout below:

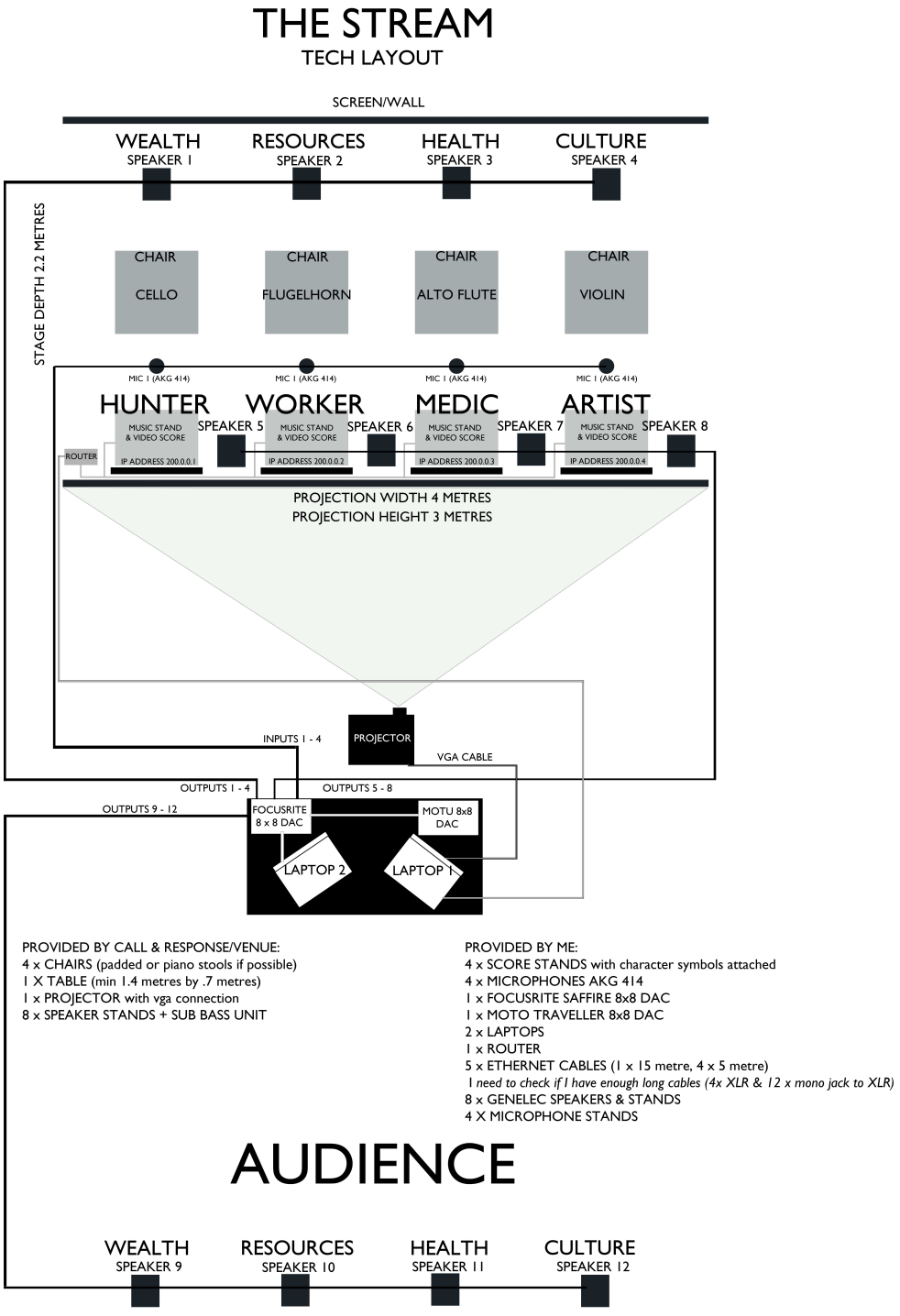

fig 3.6 – Technical layout as provided for the premiere at Canada Water Culture Space, June 2013

The workshop at UEA took place in the Strode Room, which is an extremely reverberant space and the instrumental and synthesised sounds blended well. Canada Water Culture Space was quite the opposite and was almost totally acoustically sterile. This created disconnection between the electronic elements and the instruments that led me to abandon the individual loudspeakers for each element, and instead mix both instruments and electronics together on the fly through all loudspeakers for the performance. For the next performance in The Undercroft (Norwich) I decided that in order to improve homogeneity, I would also process the live instruments through effects, with parameters controlled by the system. The effects are simple and rely mainly on harmonising and using delay to thicken the parts, creating the effect of a larger ensemble.

Some instrumental techniques are extended by the effects, such as the combination of subtle distortion, disruption and *sul ponticello* to increase the rasp of the strings at points heard between 19m 24s and 19m 50s (48) in the Undercroft performance. I abandoned the multichannel system entirely for a standard stereo speaker setup that was actually more effective in blending all the elements. It also makes the piece much more performable and transportable, allowing more people to experience it and making it more cost effective to execute. The Undercroft is also an incredibly reverberant space, which aided the acoustic blending and made it a much more fitting acoustic environment for the piece.

Visualisation

As well as being sonified, much of the data in the system is also visualised through a live animation system written in openGL and uses a physics engine to give emitted particles their behaviour. The players' symbols are mounted on the front of their scores and for the first workshop and premiere I projected onto them and the players. There were some issues with light dazzling the players so for the Undercroft performance I used back projection onto a translucent screen situated behind the players. Although this made the visual less clear, the players felt more comfortable.

Each agent has a distinct particle shape and their particle stream is comprised of three separate streams made up of white particles for mental health, blue for physical health and green/gold for economic health. Economic health particles become more golden as wealth increases, and similarly, the other particles grow stronger in colour as their level increases.

The size and number of particles is denoted by the health level in that the higher the level, the larger and more numerous the particles are. Purple particles represent mental and physical illnesses. The overall effect is that in prosperous and healthy times, the background is filled with brightly coloured particles, and in less fortunate periods, the particles are pale and scarce. Floating text represents the **needs**; primary needs are in capitals and secondary in lower case. The text becomes larger as the need becomes greater.

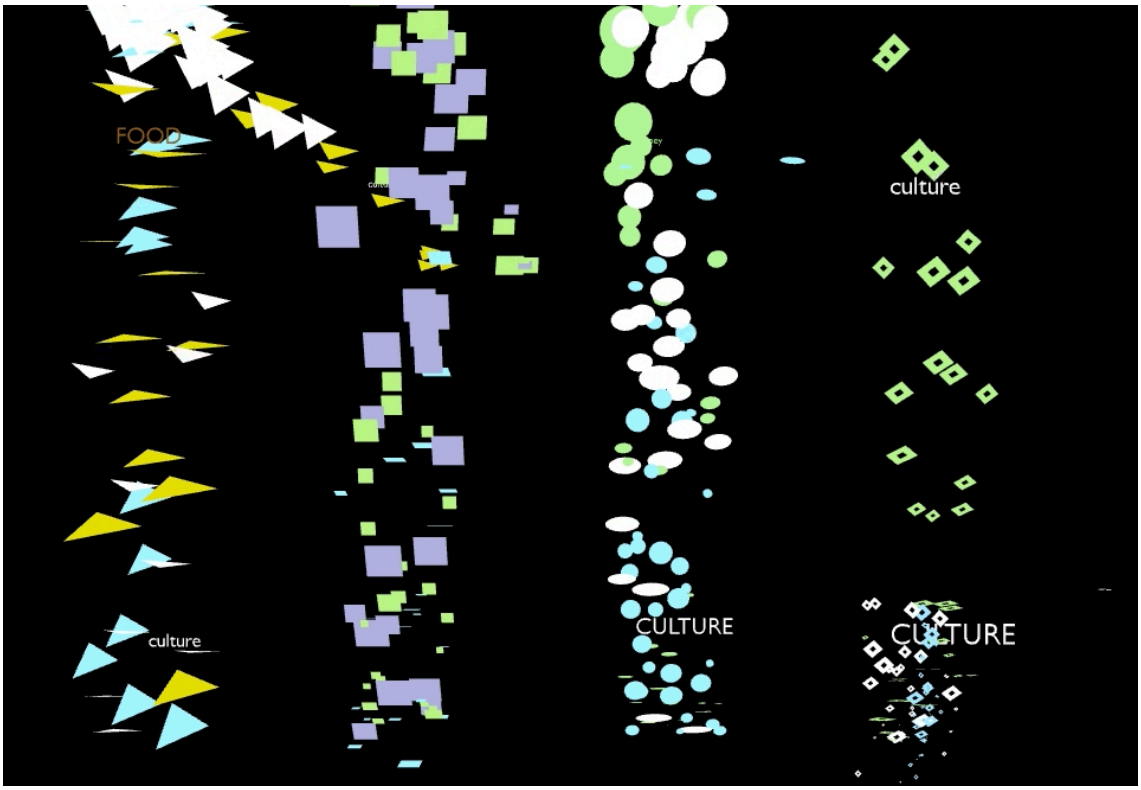

fig 3.7 The animation patch visualises the data in the system through the size, behaviour and colour of particles emitted from behind the players

Composer control

After the premiere I added possibilities for live sound processing, mixing and recording. Due to already using four screens and a great number of different patcher windows in MaxMSP simultaneously, I decided to use Ableton Live in combination with Max4Live to deal with the sequencing and effects load. This made the live performance much more stable and controllable, and also meant that I could record everything live, including the data being sent from the patches as modulation data, shown in the screenshot below. After the premiere, I felt that the performance was quite frantic and overwhelming as everything was sonified simultaneously. I needed some way of focussing in on aspects of the

performance while being able to shut out some of the other erroneous material. I used a Bitstream 3X controller to adjust data ranges during the performance, which meant that if, for example, the **Medic** and the **Health** themes were doing something interesting, as they are between 12m 19s and 13m 46s (49) of the Undercroft performance, I could fade the other parts down by limiting the range of their waveforms, and illuminate the more interesting content. The controller operated like a mixing desk, but for data streams rather than audio. This method was highly effective in creating a successful composition and engaging performance, as I could operate like a director, choosing certain parts of the generative composition to highlight at will. As can be seen throughout the video of the Undercroft performance, I utilise four screens; two that give me live and historic data about the system in MaxMSP, one that displays the scores in Apple Remote Desktop and one that shows the **Needs** synthesisers and audio/data recording in Ableton Live. This comprehensive monitoring system allows me to both shape the sonic outcome and also be able to predict narrative trends in the system during a performance. The amount of data generated, including the particle animation and physics engine, required me to split the processes over two Apple Macbook Pros, communicating data via OSC over the network.

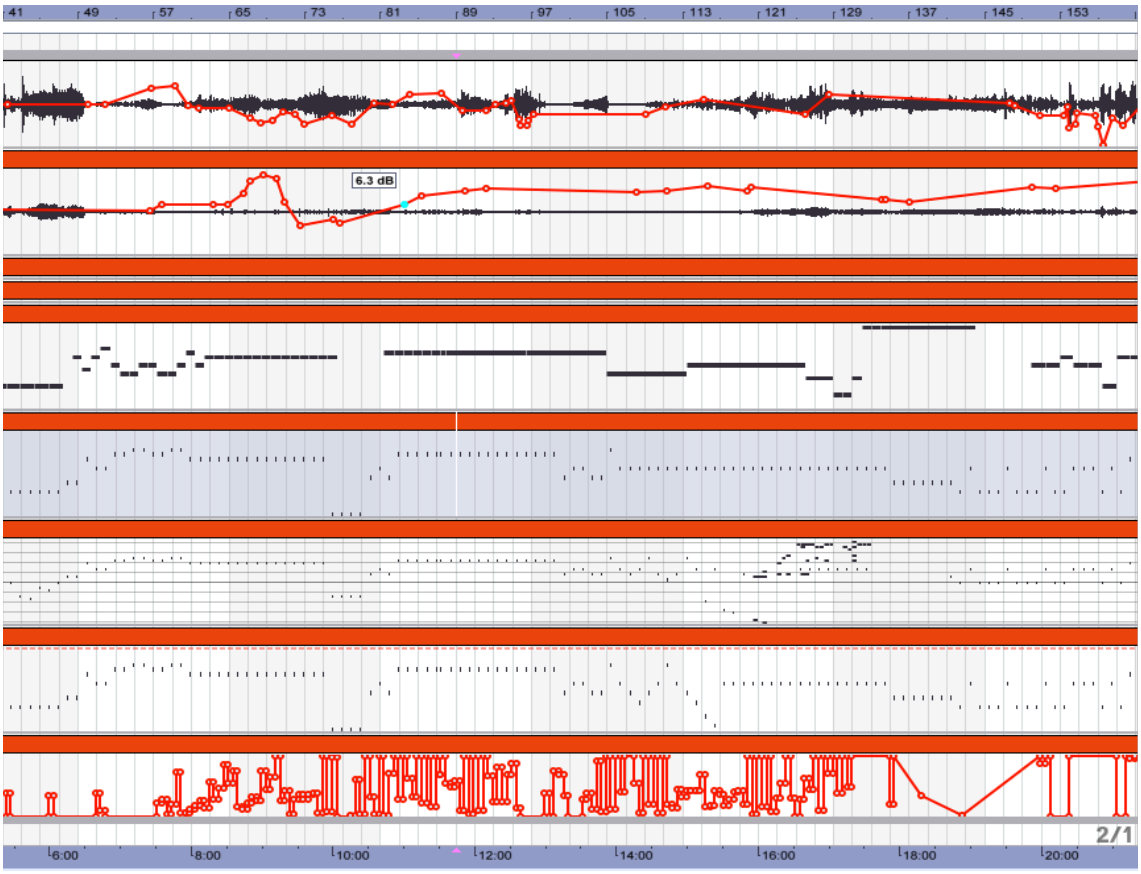

fig 3.8 Audio, MIDI notes and automation data generated by The Stream patch and recorded in Ableton Live 9 during the performance at The Undercroft, Norwich

Dramaturgy

The concept of the piece was difficult to communicate in writing to an audience or prospective venue. Although the basic concept of the piece as a model of a society seems like a simple idea once explained, the level of complexity makes it difficult to get across in fifty words or so. What becomes more of an issue for an audience to understand is how this relates to the resulting composition, which is essentially a lot of data streams mapped to my own compositional choices. After writing numerous paragraphs that barely covered the basics, I decided to become more creative with dramaturgy. As part of my residency with Sound and Music, I had a film trailer made that can be found in Appendix D, and the combination of image and narration was perhaps the most effective format for elucidating the concept and realisation. For the premiere, I added text to the visuals to display the current state of society. The same data that was used for the sound and visuals also made selections of words that communicated information about the narrative, including current political stances, hunger levels and mood, amongst others. I felt that although this may

have worked well for an installation, it distracted from the act of listening due to the presence of the words which made the audience try to understand or 'follow' the narrative which was difficult as they had very little information about the system prior to the performance. I removed this function before the Undercroft performance, in which the visuals were much more ambient and allowed the audience to focus more on listening than reading which was a much more immersive experience.

fig 3.9 'The Stream' visuals with data from the system projected as text at the Canada Water Culture Space, June 2013

Similarly, for the premiere I had a live narrative at key moments in the piece in the form of a quasi-biblical story, detailing the creation of the agents and their world. Again, I felt that this distracted from engagement with the piece and removed it for the second performance. I incorporated the story by producing handouts using the text from the narrative, detailing the creation of the agents and their world. I had written the text to sound like the biblical Old Testament and visually continued the quasi-biblical theme with the style and layout. This was given to the audience on arrival and has been included as appendix. I also gave a short talk before the second performance, which, from audience feedback, gave people context for the piece and allowed them to engage more with the story.

Reflections

My inspiration for *The Stream* began as an idea for modelling the interaction of frogs, became an agent-based model of William Blake's Four Zoas pantheon, and was first brought into being as a system for facilitating group improvisation by providing synchronised materials and behaviours. It gradually became more prescriptive than simply providing material for improvisation; the system itself improvises an algorithmic narrative based on multiple data streams feeding back into each other.

The Stream goes beyond the dry sonification of data to encompass more nuanced interactions, and to create dramatic narratives that can be described on a personal and social level. In contrast to agents that communicate verbally or sonically with each other through recognition and response, *The Stream* is made up of complex beings with a central priority of survival at their core, for which they must work together to achieve. The decisions being made in *The Stream* are not fixed or prefabricated responses, they are a result of each agent doing its best to fulfil its own needs and carry out its duty. The resulting composition is therefore not limited to call and response gestures or sonic analysis of utterance, but it represents the modelled society directly, weaving a rich narrative that describes events occurring within each moment.

As a system for generating data translated into believable composition, it eventually became very effective after realisation through multiple performances. I believe that the complexity of the system was actually the minimum necessary to achieve a model of a society that functioned well enough for the data to be self-generating, convincing and useful for the purpose of composition. Nothing is faked; none of the interactions are pre-composed and all performance data is generated spontaneously in real time. The rules are written, the parameters are set and whatever events happen after that point are the system's own creation. Structures and transitions are generated with meaning drawn from the narrative and in relation to what has previously happened in the system, rather than being decided arbitrarily by algorithms or temporal triggers. *The Stream* is a group improvisation between computer-based agents, although they do not realise they are making music. What they are doing is interacting and creating their own sequences of events based on the roles they have been given and exploring them over time. I believe that this approach has given rise to a more believable model for music making than programming software to understand

traditional musical rules. Group improvisation stems from our social intelligence, the way that we model personal relationships and the roles that we play within them. *The Stream* seeks to create a virtual environment where those social interactions and mutual dependencies can occur, and lead to complex narratives and structures comparable to that of our own musical creations.

A blog documenting the development of the project can be found at http://edperkins.tumblr.com/.

fig 3.10 Operating the system at the premiere in London 2013 with live narration by Jason Dixon

Conclusion

In this commentary, I have conducted an auto-ethnographic study of my own work, created by my own practice, acknowledging that such individual work is mutated and influenced by those with whom I have collaborated. On reflection, I have found that as an artist, I most value the moment of the creation of new material, and that this material must be brought into being in communication with others. For the benefit of such collaborations, I must know the performers socially as well as professionally, and the communication and consequent music produced requires an established social relationship to be present between all group members to successfully function and create.

This commentary presents an analysis of long-term group collaborations with an account of any repeatable techniques I have learnt which have improved the success of both the ensemble as a social group and the music produced. The techniques discovered have been applied to shorter-term projects and commissions and their efficacy is then evaluated. The value of this research lies in the longevity of the projects covered, and its consideration of the social bonding that occurred outside of the musical domain. *FHTA* rehearsed, performed and socialised together over a core period of five years, with over forty performances across the UK and Europe of pieces that were improvised, and then discussed after the matter so that they might be refined in line with our emerging values. *TRATC* have played together for over eight years with around thirty performances of significantly longer form works, further developed by discussion than those of *FHTA*.

Both *FHTA* and *TRATC* were the only regular ensembles for all group members at the time, although I was simultaneously playing in both groups as *FHTA* waned and *TRATC* began to perform more regularly. *The Stick* was developed over a period of ten years and was used as my main interface for all performances I was involved in during its development.

In the first chapter I found that *The Stick* was partly influenced by my early musical experiences, and I sought to design and develop an interface that could be used to control my own software. Being employed mainly for live ensemble work, the excitation method and consequent control of the sound needed to be visible to other members of the ensemble. I suggested that due to our historical relationship with physical tools and our relationship to them, the physicality of the interface required detailed consideration, informed by the qualities of acoustic instruments whilst benefitting from the sonic possibilities afforded by digital technology. Whilst the design and execution of the physical interface and its mappings require significant consideration, it is of greater importance to develop ones own practice on the instrument and to test its abilities in real performance situations to determine its authenticity as an instrument.

The second chapter analyses my experiences of working in ensembles from a socio-psychological perspective. I disputed studies of group interaction that focused on fabricated conditions and purported that research needed a more holistic approach, encompassing real performances and considering social group dynamics and interpersonal relationships within established ensembles. I suggested that the lessons learned from this type of research could be applied to shorter-term ensembles to improve the success of the collaboration including building groups with pre-established social or professional connections, or by fostering those connections outside of the musical environment. Applying archetypes and pre-determined roles can accelerate group cohesion, particularly when roles are assigned both to take advantage of existing strengths and skill sets, and with sensitivity to the types of roles that individuals are comfortable in from previous ensembles.

Chapter three mainly deals with *The Stream*, a socio-economic model for generative composition. As the complexity of the system shows, modelling societal relationships is no simple matter. My earlier work *The Four Zoas* focussed more on personal communications,

but lacked the coherence of a system that would form the type of emergent structures and group behaviours that I was looking to generate for live composition. *The Stream* was an attempt at creating a system that had no pre-existing understanding of music, but instead was formed by interdependencies between agents to generate behaviours over time. These behaviours composed a narrative of data, which were mapped onto musical outcomes based on my own musical experiences of both harmonic and sound based practices. Moreover, I developed coherent archetypes so that the agents were recognisable, and their actions and relationships could be deepened in terms of tangibility and complexity. The resultant success of the pieces in terms of their similarity to human composed musical structures suggests that perhaps these natural relationships that form emergent cooperative or discordant structures are what we as composers are drawing on unconsciously when composing fixed works.

The focus on group cohesion outside of the musical environment, discovered through the observation of interpersonal relationships is key to the understanding of musical collaboration in this field. The opportunity for self-organisation and the development of roles is uniquely interesting in the field of new experimental electronic music, as there need be no musical traditions, pre-established roles or group hierarchies. Group states can constantly fluctuate, even within a single piece or become fixed for a series of works. Further flexibility is made available through instrumental tools, free from the confines of physical pitch and behaviour that apply to acoustic instruments. These new instruments can be created by the individual and tailored to any group, series of works or personal practice as the designer sees fit. One avenue for further exploration might be to develop a group of acoustically influenced instruments that communicate with each other and adapt to the style of both the player and the group as a whole. These instruments might have their own agents as part of their software that develops their behaviour and relationships with each other over time.

This analysis is obviously limited primarily to my own work and as such is confined to my own practice, experiences and collaborative style. The commentary has been written over a substantial period of time, much of this necessarily produced a number of years after the practical work was originally created and performed. The time period of the main body of work documented in the portfolio is around five years, which has yielded a significant amount of material to analyse, and sufficient time for major developments to occur to my

personal practice both technically and aesthetically. Although the analysis is self-focused, the temporal dislocation between the submitted works and commentary has afforded a perspective for reflection with substantial hindsight.

Whilst there is much work to do in this area, it is my hope that this research encourages others to analyse experimental electronic music in terms of those who make it and how they collaborate. Further research should encompass an ethnographic investigation of other established groups, to draw comparisons and reveal new approaches. Both musical and social aspects should be considered, drawing on the work and language of socio-psychology for analysis. This work should avoid quasi-scientific measurements and instead explore and investigate the culture of each group and the roles, relationships and experiences of each participant.

The technique of modelling the practical relationships of *The Stream* could be extended into the social domain, with agents that form interpersonal relationships with each other based on their personality, emotional profile and historical experience. The patterns of interaction could then be used by the agents for musical communication, mimicking how groups of musicians form social bonds, and then organise themselves into ensembles, drawing on their social bonds to play out unexplored roles or to carry through existing aspects of their relationships into the musical domain.

In summary, I have found that when performing and composing ensemble work, the use of technology is most effectively employed when considering and supporting the physical and social aspects that have historically always been part of making music together. The possibilities afforded by technology to extend beyond the physical and social domain are most successfully implemented when they support, rather than inhibit the natural relationships and human physicality of those taking part.

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Appendix A

A Guide to The Stream

What follows is a detailed description of the workings of *The Stream*, as its intricacies, mappings and the reasons for them are too complex to be directly evident through listening. I also wish to show that rather than being a collection of algorithms, the system is a hugely complex web of the interactions of modular elements and hierarchical levels that each have a narrative part to play, and each enhances the possibilities for realistic interactions to spontaneously occur.

The Flock

The system began as a simple population model using an implementation of Elsea's fuzzy logic and the resulting group of creatures is the only source of food and resources in *The Stream*. Time in *The Stream* is decimal, mainly for simplicity, and features an annual cycle of ten months. A variable speed metronome drives the entire system and time generally passes at around sixty beats per minute, where one month is one bar of four beats. The metronome allows for the composer to control time during a live performance, where slowing down time for interesting sections can be a useful control parameter. I managed to gauge the most appropriate base speed through trial and error during the workshop at UEA in 2012. The tempo of 60 bpm provided a good match for both the speed required for variation on the micro level, such as rhythms and melodic patterns, whilst also producing a good pace for macro level structures such as section lengths and financial years. Appropriate sub-division and multiplication of the base tempo was also intrinsic to managing a balance of time scales in the system.

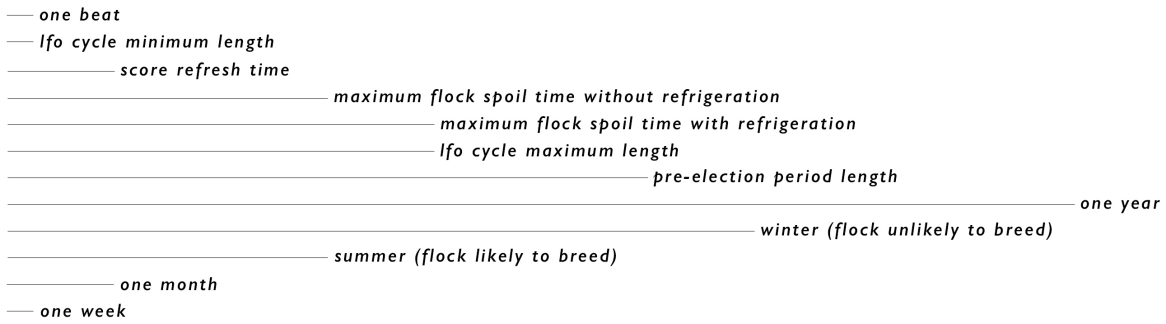

fig d.1 Various cycle lengths of events within the system

The **Flock** takes the form of a closed group of virtual creatures with a seasonal breeding cycle. This cycle is implemented through a proportional increase of numbers each month, depending on a fuzzy 'breeding success factor' that multiplies the current population

amount. Generally in a performance, I will mimic natural cycles by creating a fairly high success factor for a few months around the middle of the year, and very little chance of breeding during the other months. Death is also taken into account and some of the **Flock** will die a natural death each month through age or illness. Population size is also a factor as bigger populations have a higher likelihood of death due to modelled levels of starvation and disease through lack of resources and limitations of space. This prevents an over abundance of food and ensures that the agents within the system experience hunger and lack of resources on occasion for dramatic effect. Illness proved to be a useful limiting factor in the system as discussed later on, preventing the stagnation that can occur when the agents have everything that they need for too long.

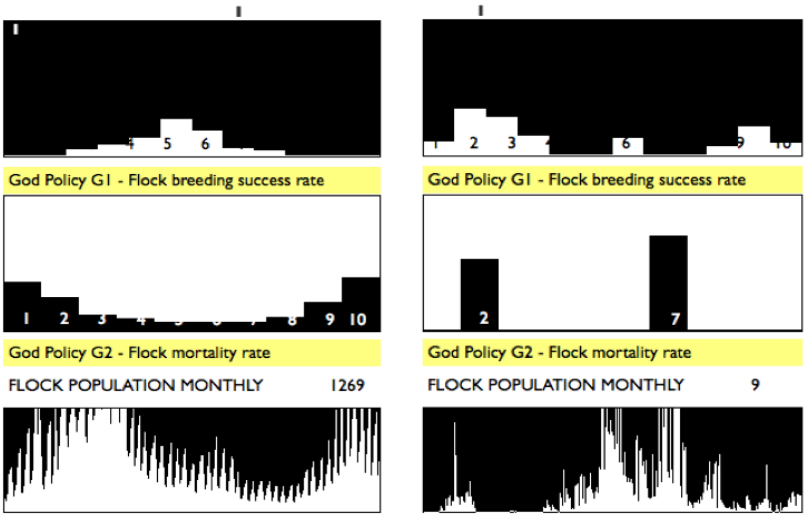

fig d.2 - Two varying annual birth/death cycle sequences and their resultant population variations over time (each individual white line on the population graph represents one month)

The composer can alter the annual birth and death patterns at any stage during a live performance and this serves as a macro level parameter with a major impact on the overall structure of the piece. The most useful technique that I discovered was to find settings that prevented stagnation whilst creating emergent cycles of varying population size.

When acting autonomously without intervention, the model settles into fairly predictable patterns, which although varied over the course of the year, generally create fairly regular sinusoidal cycles. Acting alone, the population model will not create data that describes dramatic change within the narrative, and consequently this data is unfit for use as interesting compositional material. In order to create a force for change within the ecosystem, I introduced a specific agent to impact periodically on the **Flock** population by

modelling the hunting of a wild herd in the same way that fishermen catch wild fish in the sea.

fig d.3 Rehearsing 'The Stream', Strode Room, UEA 2012

Hunting

The first agent I created was the **Hunter**, who periodically harvests a percentage of the **Flock** for food and other resources. Although I have named the process 'hunting', the model is actually more similar to that of fishing, as the hunt is controlled and regulated by a system comprised of two rules to ensure the survival of the **Flock**. It is distinguished from farming by the fact that the agents themselves do not manage the breeding process. The **Flock** is protected by a limitation on hunting where the **Hunter** can only hunt if the population is above a certain minimum level. This avoids extinction, as at critical levels the **Flock** becomes protected and all hunting must stop until the population recovers to a level that can self sustain, whilst being hunted. The other limiting factor is a monthly hunting quota, which is a maximum percentage of the **Flock** that the **Hunter** is allowed to hunt in any given month. The variables are set by the **Alpha,** a term within *The Stream* for the agent currently elected as leader. Their political values shape the narrative by altering government funding, wages, taxes, technological development and environmental preservation. More nuanced factors such as the **Hunter's** physical and emotional state also affect his ability to hunt and consequently his impact on the **Flock** population over time. Feedback loops are

created as the **Hunter** both consumes and gains physical and mental energy during a hunt, with the success of the hunt also impacting on these levels. These regulating features, combined with the **Hunter's** limiting influence on the **Flock** form a complex and fluid relationship that helps to avoid total extinction, overpopulation or stagnation in the data stream. As discussed later, the volume at which the cello that voices the **Hunter** can be heard is directly related to his physical health, and the tone and technique of the cello alters according to his position in society. The breadth of melodic and rhythmic material available to the player is determined by economic and mental health levels, which vary through the course of a performance as the narrative unfolds.

The **Hunter** gains economic profit from the **Flock,** which is the only mechanism in the system for generating revenue. All personal financial gain is either from government funding (**Medic** and **Artist**) raised through taxes on the **Hunter's** and **Worker's** earnings or by receiving a salary (**Worker**) from the **Hunter**, all of which originally stem from the monetisation of the **Flock**. Changes in government policy related to hunting, combined with the variable effectiveness of the **Hunter** to hunt the **Flock** create varied styles of cyclic emergent structures, shaping higher level structures of density, pace and texture within the composition.

When the **Hunter** is the elected **Alpha**, he generally pushes the limits on hunting to allow vast harvests to be reaped from the **Flock**, and consequently enormous profits for himself. The **Hunter** agent is programmed to become greedier as he gains more economic health. His enthusiasm causes him to expend more energy hunting than he usually would, combined with the energy it takes to harvest larger numbers of the **Flock**. This attribute was created to provide a dramatic and tragic element to the character, and ultimately to ensure of his downfall at some point during the piece, allowing for changes in leadership and their associated compositional seasons. The combination of the **Flock** hitting a few bad years and over-hunting by a zealous **Hunter** results in a population too few to hunt until numbers are replenished by breeding. Consequently, this creates problems for all agents in terms of both their food source and their source of wealth. At this point, the **Hunter's** leadership may be called into question and an election will take place to instigate a change of leadership and government policy regarding hunting. This loss of office causes the **Hunter** to moderate his policies for the beginning of his next government, although the longer he maintains his leadership, the more he returns to his original self-serving and population decimating intentions once again.

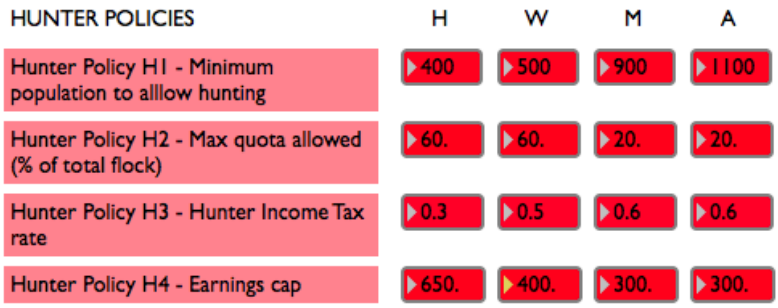

fig d.4 - Policies that affect the Hunter with original values from government styles of the four agents; Hunter, Worker, Medic and Artist

Working for a living

The **Worker** agent is the only character that receives a performance related salary, determined by his efficiency and paid for by the **Hunter**. The relationship between the **Hunter** and the **Worker** is one of co-dependence. The agents cannot use the **Flock** in its raw form. The **Worker** must first process the Flock into resources that feed the agents so that they can regenerate their physical health. Without the **Worker**, the **Hunter** cannot regenerate physical energy or earn any wealth from hunting. Without the **Hunter**, the **Worker** has no income. The **Worker**, like the **Hunter**, can become avaricious and encourages hunting quotas to be increased so that he can earn more commission. Like the **Hunter**, he can become exhausted if the monthly yield is too high and he lacks the foresight to avoid it. The **Worker** will blindly work himself until the ground until he expends all of his physical energy, leaving him unable to work at all. Due to this close interdependent relationship, the two are often strong or weak at the same time and can often be heard to have similar levels of volume or variation in notes.

Although the **Hunter** and **Worker** have similar intentions and political views around continuous economic expansion, class divides them. The **Worker** will never be able to create wealth independently from the **Hunter** and is unable to accrue the levels of wealth available to the **Hunter**.

Although the **Worker** is financially reliant on the **Hunter**, the **Worker** at least has good financial security. As long as the **Hunter** has wealth, the **Worker** will always earn a minimum wage, even if there is no hunt due to low **Flock** population. This minimum wage level is decided by the current **Alpha**.

The **Hunter** is essentially running his own business, with a monopoly on the resources needed to generate wealth and support the economic system of *The Stream*. Consequently he holds a great deal of power over the other agents. His ability to earn is however dependant on the health of the **Worker**, and it is in the **Hunter's** interest to support government funded health care and leisure to sustain the health of his work force.

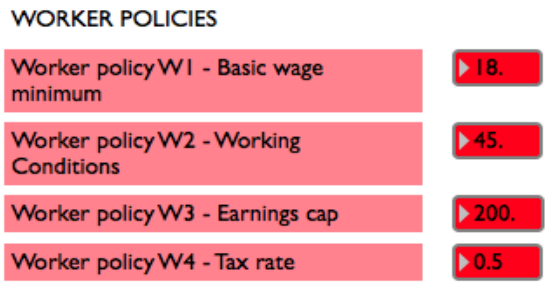

fig d.5 - Policies affecting the Worker with values formed by his own government

Economics

Due to the presence of wealth, tax and earnings within *The Stream*, an economy emerges and its health affects the individual economic stability of the agents. Each agent requires good **economic health** to sustain its own activities by purchasing **resources** from the **Hunter**, processed by the **Worker**. In turn this sustains agent **physical** and **mental** health levels. As previously mentioned, the **Hunter** is the only agent who brings wealth into the system at the expense of reducing **Flock** numbers. This wealth is distributed amongst the agents both as government funding, gleaned through income tax or in the case of the **Worker** agent, as a performance related salary. The amount of money the Hunter can make from a hunt depends on the current **price index**, determined by the amount of the **Flock** in the system. This mechanism models real world economics and ensures a realistic and regulated notion of the value of resources.

Needs

The agents have specific needs that they need to be met, and each of them has a particular balance of these that they require. In *The Stream* there are four basic **Needs**; **Wealth, Resources, Health** and **Culture.** Each **Need** is represented by a unique sonic theme that rises and falls in amplitude and intensity throughout the piece. The **Needs** themes were designed to be a kind of sonic scenery that would be present most of the time, but would rarely dominate the foreground in the way that the agent themes do. The **needs** that are most in demand at any given moment, and consequently the most 'newsworthy' are

broadcast most loudly, communicating subtext narrative to the audience. As with news coverage in the real world, no news is good news and the quieter these elements are, the less problems there are with them. Interestingly, these periods of social harmony generally happen when the **Artist** operates as leader, although mainly because society is doing well enough in terms of wealth, health care and resources to prioritise culture, rather than because of the **Artist's** policies. During the aforementioned excerpt, there is little contribution heard from the instruments due to the live data mixer I implemented for this performance, discussed later in the chapter. Although the data is being created all the time, sonically this can become overwhelming, and interesting relationships can be lost under a blanket of sound. The data mixer allowed me to focus in on particular relationships in the piece, highlighting areas of interest and cutting off or limiting data streams to the performers at will.

Sounding the narrative

The underlying **Needs** of the society are voiced by synthesisers in both MaxMSP and Ableton, with their parameters determined by the current state of that **Need**. This is executed using Max For Live within Ableton Live 9 to receive data from the social model, which is then passed on to the synthesisers. Sonification of the themes provides context to the instrumental material by sonically representing more of the state of the model as a whole system. Combinations of behaviours in the synthesiser themes create contrasting moods and scenes, and underscore the foreground provided by the instruments themselves. I wanted the system to be able to clearly communicate the current state of the society through sound. These thematic elements of the narrative are mapped to musical ranges of pitch, volume and internal modulation to create texture, development and melody. The sounds used for the themes are related to the agent responsible for them and the choice of sound echoes both the sonic character of the theme, and the associated agent's instrument:

Agent	Theme	Sound	Imagery	Low needs	High needs
Hunter	Wealth	Reedy and horn like	Hunting horn	Rumbling Bass territory	Raucous Domineering
Worker	Resources	Filtered noise	Mechanical production/steam engines	Subtle Wave-like	Crashing like waves Distorted
Medic	Health	Sine tones	Sterility, cleanliness	Static High pitched	Glissandi Lower and more varied in pitch
Artist	Culture	String section/comb filtered noise	Spectrally softer and pretty	Harmonically static Subtle	Melodic Foreground

fig d.6 – Table showing the sonic properties of the 'Needs' themes in 'The Stream'

The ranges of behaviour vary from loud and chaotic when resources are low to steady and integrated within the soundscape when resources are healthy. This creates dramatic moments when a society is failing, and conversely subtly supports the ordered and balanced counterpoint of a productive utopia. Compositionally, this gives rise to sections where the instruments dominate when society is doing well and equally the synthesisers take the lead at times of hardship. This was partly intentional as when there is harmony between the agents, the resulting instrumental parts of the music are most harmonious and traditional in terms of melodic, harmonic and rhythmic relationships. At these points, I wanted to showcase the possibilities for synchronicity and the potential for interesting transitions to occur emergently as the moments come and go throughout the piece. The use of live scores allows these transitions to be both fluid through the interpretations of the musicians, but also coordinated by the emergent patterns that occur within the system. Examples of the live video scores can be found in Appendix D.

Fail-safes and wildcards

After some experimentation with the stability of the economic model, I found that because the **Hunter's** ability to hunt is affected by his physical health, he would often spiral downward and become too poor to buy food and therefore too weak to hunt effectively. I designed one of a number of fail-safe devices within the system to prevent this happening. Over the course of the piece, the **Hunter** can save money in a secret tax haven that he can use once to boost his economic health, and thus breathe life back into a fading society when necessary. The building of wealth over time is only available to the **Hunter** and also gives him another class-based advantage over his fellow agents. It is important that the **Hunter** can bail himself out of trouble when he needs to, as within the system all other agents depend on him for their own income. If this happens too often however, the money runs out and the **Hunter** becomes too weak to hunt, which is one of the ways that the system can end the piece.

These fail-safe devices create compositional elements that are unlike any other within the system, as they do not naturally form part of the evolving contours. These fail-safes reset the system into a new mode of behaviour, and can often result in changes of government and consequently entirely new hierarchical relationships between the agents. The **Medic** agent mentioned later is the main fail-safe rescue device for the system as a whole.

Wild cards are like fail-safes in that they do not form part of the regular interaction between agents and are able to create dramatic elements or situations that would not happen as a result of standard interactions. The **Artist's** penchant for drug taking is one of the main wildcards in the system and has both positive and negative consequences for the artist and the other agents. On one hand, he may suddenly produce brilliant work massively enriching culture and emotional well-being, or equally he may fail to produce anything through long bouts of **mental health** problems, starving society of art and causing a longer term dip in **mental health** levels, which in turn impacts on productivity.

Wealth & Pitch

The characters use their **economic health** to buy the ability to speak, the more **economic health** the agent has, the more diverse the pool of possible pitches he can draw from, and the more often he is able to play them. This mapping is analogous to political power, where the rich and influential are allowed more opportunities to get their voices heard.

Fortunately, it is not only wealth that is valued in this society; otherwise the Hunter would consistently take the role of soloist, limiting the possibility for individual musical roles to change during the performance. An agent may have the financial means to purchase up to four notes, however, if the agent lacks the physical health to speak, or the mental health to be outgoing, the options for melodic diversity will be limited. The result of this mapping is that strong, well-balanced and well-resourced agents are heard most clearly and are able to most directly communicate their own melodic themes.

In the two earlier performances from the workshop at UEA and the premiere in London, when an agent couldn't afford a note, he would play an unpitched sound using extended techniques which were closely related to their pitched technique for the section. This approach tended to create busy structures that lacked space and also reduced the amount of contrast present across the entire performance in terms of contour and density of textures. For the last performance at the Undercroft in Norwich, this was altered to score silence if the agent was too poor to buy notes, with the possibility for more noisy timbres included within the harmonic content. The Undercroft performance is by far the most successful composition in my opinion, as it best emulates the variation and cohesion of a studio work. This was primarily because after reflecting on the recording of the premiere at Canada Water Culture space, I realised that the density of the piece need to be varied. There was way too much happening simultaneously and interesting elements were becoming lost amongst the background. For the Undercroft performance I developed a live data mixer to edit and refine the performance in real time. Like an audio mixer, this could fade instruments up and down, or mute them altogether allowing me to bring out smaller groups or solo sections. In contrast to an audio mixer it worked by removing data or by lowering the volume level instructions from the live scores.

Health

The presence of **Health** within the system adds two essential streams of data to the model in the form of mental and physical health levels. These levels fluctuate throughout the piece in patterns defined by the actions and relationships of the agents. The agents require **resources** to sustain the physical energy needed for them to carry out their activities successfully. The agents also have a mental health level which is sustained or depleted through various interactions with the other agents, alongside their own sense of personal success. The success level to which the agents can carry out their role in society varies depending on their innate robustness in conjunction with the environmental and social

aspects that impact on their satisfaction with their work. For example, **Hunter** can only hunt successfully when his **physica**l and **mental health** levels are high, and when the **Flock** is large enough to provide the yields he needs to be satisfied with his work. A bad year for the Flock combined with restrictive hunting quotas can send the **Hunter** spiralling into depression. Conversely, he can physically exhaust himself by hunting too much in periods when the **Flock** is healthy and become too weak to hunt at all, which is catastrophic for the system as a whole. Similarly, the Artist requires high levels of **Culture** to sustain his mental health, or he is unable to work and consequently to feed and look after himself.

At times when they can no longer sustain themselves, the **Medic** agent will administer short bursts of health that can kick-start an agent back into self-sustaining operation. The **Medic** functions as a rescue agent, adding a new style of behaviour to the system. Rather than regularly contributing over time, the **Medic's** input is applied topically, with his effectiveness dependent on environmental and personal factors. This mutable relationship creates mutations in the more regular feeding/working cycles of the system, perpetuating the possibilities for interesting emergent system behaviour that can be mapped to compositional elements.

The human performer plays at a volume indicated by the width of the indicator bar on their score e.g. the wider the bar, the louder the note. This width is determined by the **physical health** attribute, meaning that physically stronger agents can produce louder sounds. The indicator moves across the score in a pattern denoted by the agent's LFO shape, and the amount of the score it covers is determined by the agent's **mental health** level. This means that if the agent's mental health level is poor, the material that the human player can use is limited, even if they have the **economic health** to provide access to the full range of four notes across the score. Consequently, agents with low health become lacklustre and tired a good example of which can be seen and heard at between 29m and 30m of the Undercroft performance (50). All agents are gradually getting lower on health as I reduce the **Flock** population in order to starve them and end the performance. Harmonic material becomes very limited and you can hear the flugelhorn playing with such low energy that there is barely enough air to sound the note at times. The visual projection shows barely any particles emanating from the players due to their low energy, and darkness begins to fall as their energy dwindles to nothing.

The ability of the **Medic** agent to perform his role is based on how well he is funded by the government and his own current health levels. Most styles of government include adequate health care funding due to its basic necessity in avoiding total death within the system. The **Medic** holds the ability to sustain the system until more economically favourable times, and in periods of generous healthcare funding, can even provide enough of a boost in energy to kick start a positive transformation to the society as a whole.

Policy styles have the ability to vary between physical and mental health funding, with the **Hunter** and **Worker** favouring physical over mental health funding. Agents with enough economic health can also subscribe to private healthcare, which is more effective and provides a more significant and long lasting boost to health levels when needed. This is another aspect that develops upon the idea of a class system and creates a hierarchy that favours the wealth generating **Hunter** and **Worker**. The **Medic** favours a more balanced funding approach and the **Artist** requires better mental healthcare, partly due to the negative impact of regular drug use on his mental health.

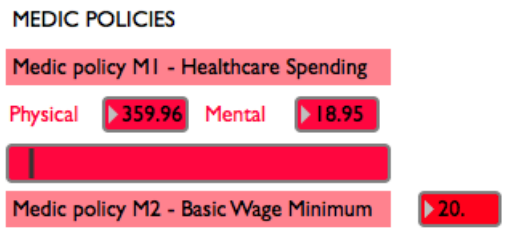

fig d.5 - Healthcare funding under the reign of the Hunter.

Illness

Agents are pre-set with an initial value of **robustness** in relation to their mental and physical health. The opportunity for health problems arise sporadically around times of hardship, but the **robustness** value of the agent determines whether or not he will succumb to an illness and further depleted health. Illnesses can vary in terms of acuteness and recovery time and not only have an effect on the characters' health levels, but also more directly affect the video scores of the performers. Physical illness causes the score contrast to deteriorate so that the notation is hard to distinguish from the background. Mental illness reduces the score refresh rate so that blurring and smearing occurs, debilitating the performer in terms of their synchronicity with the group. This is disorienting to the player and disrupts their flow and connection to the group. I created this system to model the disconnection and confusion that health problems can cause, and to show how the suffering agent has a negative effect on all those who are dependent on

them to perform. I also wanted to highlight how important adequately funded mental healthcare is to the system. Even though it does not have an effect as obvious or direct as that of economic or physical health, it impacts in many smaller ways that influence the health of the system as a whole.

Nutrition and Storage

The physical and mental health levels of the agents are co-dependent and have an impact on each other both directly and through other feedback loops. Agents must maintain a good balance of both to operate effectively. Each agent possesses a stomach that varies in its ability to gain nutrition from food. The efficiency of the agent's stomach is linked to their innate physical **robustness,** but also varies dependent on mental health levels. Poor mental health reduces appetite and nutrition extraction, intensifying the need for the characters to preserve their own mental health levels.

Initially, agents cannot store food and consequently there is a large amount of wastage within the system. Health levels can fluctuate wildly from month to month dependent on supply. As time passes, the technology level of the society increases and as a result, resource production becomes more stable, allowing for the storage of food in months when money or resources are scarce. This aspect of the system that continues to develop over the course of the piece, results in a form of progress that increases and encourages the society to develop in a positive way. For me, the harmonic and synchronous patterns created by a utopia are one of the most rewarding aspects of the system. There are usually one or two brief sections where this is evident and they often occur towards the end of a performance. One example of a utopia can be heard emerging during the premiere at around 24m 20s and continues until around 26m 51s (51) where the **Medic** begins to protest and unsettle the harmony and rhythm of the section. By 28m (52) we are back into more familiar dystopian territory with short bursts of breath from the flute and muted squealing from the flugelhorn of the **Worker**. During the utopian section the instruments are playing alone without the electronically produced sounds of the **Needs** synthesisers.

Art

The fourth and final agent within *The Stream* is the **Artist.** The **Artist** is funded by the government, which takes the form of a regular income for a period of time or a single more substantial fee for commissions, dependent on policy. The resulting artwork manifests as a boost in mental health for all agents and is the main way of sustaining good mental health in the system, particularly in times when resources are low. The maintenance of high levels of mental health fundamentally transforms the productivity and operation of the entire system, and poor global mental health can be just as destructive as poor physical health.

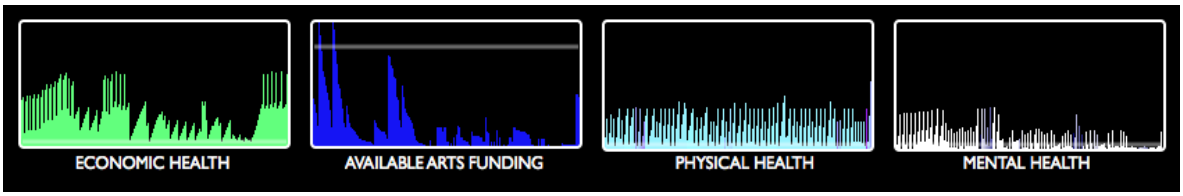

fig d.6 - The Artist's health level charts

The ability of the **Artist** to work, gain commissions and produce effective work is drastically affected by his own mental and physical health. This is dependent on his economic health for resources and his engagement with his work through the availability of regular commissions. Government funding for commissions is made available in times of good global economic health and the funding pot can increase over time up to a maximum level. The **Artist** applies for a commission when his health levels are high enough, and his success of being awarded a commission is based on the quality of his recent work. The more commissions he acquires, the better his work gets but conversely, if commissions are not available for some time, the quality decreases. Right-angled triangles in the economic health chart above are indicative of the **Artist's** earning style where sums of money are received and lived off until his next commission. Spikes present to the left of the chart show that the **Artist** is now also receiving a subsidy due to a change of government. When the **Artist** is working, any emotional health benefits he experiences are doubled.

Unlike the other agents, the **Artist** develops consistently over time through two parameters; skill and drug dependency. Skill gradually improves as time passes, ensuring that his ability to support himself also increases over time, which in turn causes the mental health of all agents to gradually improve as the **Artist** becomes more effective. The **Artist's** use of drugs can happen at any time but will most likely happen at times of poor mental health. Initially, his drug usage can improve the emotional impact of his work and makes

him more productive, although each time the **artist** uses drugs there is a reduction in his long-term ability to experience mental and physical health benefits from the satisfaction of working.

Unpredictable events and mutations are vital to creating a valid system, and one that composes pieces that include elements of sudden change in mood and direction. Without them, the system would carry on along a steady line, and ultimately stagnate at some point in either direction towards utopia or dystopia. The more erratic elements in the system keep the data alive, and ensure that sonic and structural variations in group behaviours and the resultant changes in musical mood arise throughout a performance at regular intervals. In *The Stream*, there are two main forces of change brought about without outside intervention; the change of government that arises through voting, and the **Artist** agent, whose highly emotional character leads him to unstable behaviours and spontaneous changes of energy and direction. The **Artist** serves not only as a force for unpredictable events within *The Stream* through his sporadic earning and influence on general mental health, he is also the only character with the capacity for permanent behavioural change. Although the other characters will become generally more content over time due to the economic and health benefits of improved technology, their fundamental ways of responding to each other remain fairly static and show no continuous development in any direction over the course of the piece. During a performance, I will generally add my own unpredictable events by manipulating the breeding patterns of the **Flock** or by forcing spontaneous elections to take place. These interventions are primarily to create drama, or to upset Utopian incarnations of the society. A content society has no reason to elect a new leader, and as such, the instrumental techniques remain unchanged for long periods of time. As a simulation, long periods of contentedness are fine, however, during a twenty minute performance, I would prefer an audience to have a more varied experience of what *The Stream* can achieve sonically and structurally.

Politics

Leadership within *The Stream* is decided by a democratic voting system. Elections are called once there is sufficient dissatisfaction with the current leader and votes are cast six months hence. Each agent will vote for the agent that they believe best fulfils their current needs.

	resources	wealth	health	culture
hunter	30	40	20	5
worker	25	20	20	15
medic	5	15	30	20
artist	20	10	20	50

fig d.7 - Minimum values of satisfaction required to meet the needs of each agent (measured against agent health levels)

These basic need levels are further influenced by the agents' current **physical** and **mental health** levels. Poor health makes the characters more needy and consequently, more unhappy with the current leader. Specific **needs** are weighted so that they are considered more vital the closer they get to their minimum requirements. **Needs** and current political leanings are reported visually to the composer live from the main patch:

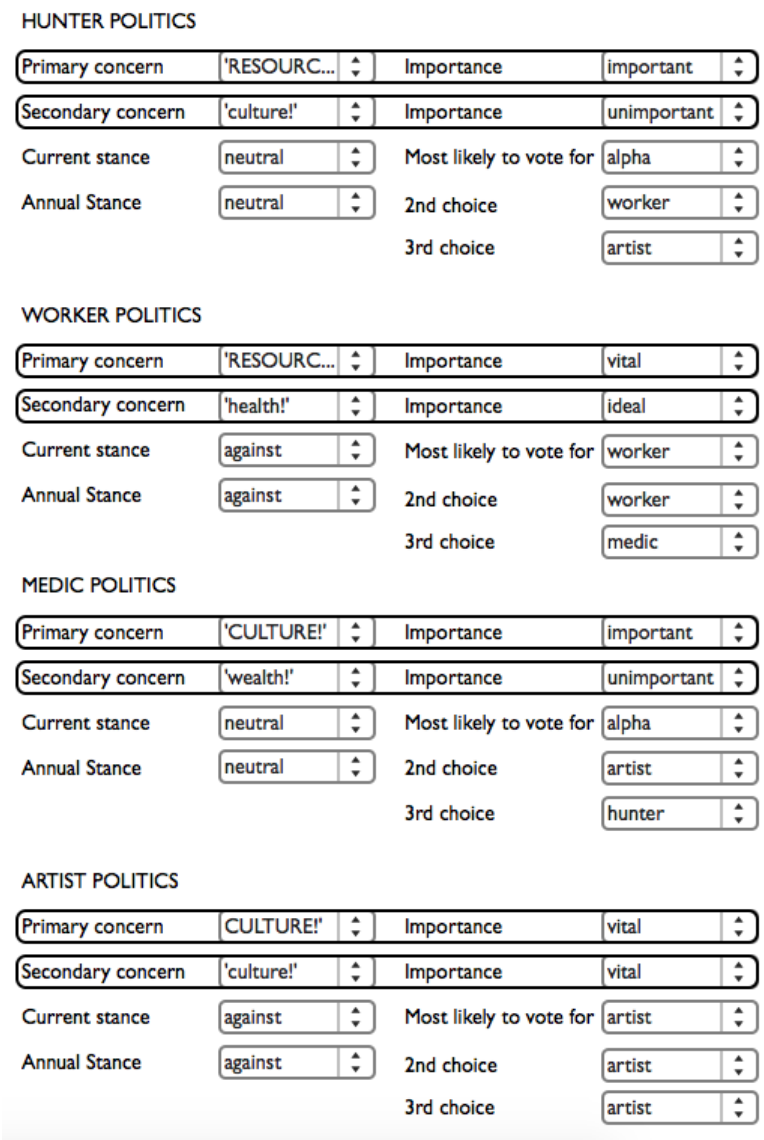

fig d.8 - Political concerns and their resulting choice of leader during the reign of the Hunter in fairly stable economic times

Harmony & Discord

I had previously implemented some generative harmonic systems as part of other projects including *The Stick* interface and *The Raw and The Cooked*. These earlier systems had been implemented by fuzzy logic chord progressions with pre-composed harmonic possibilities that the software was taught to navigate through. As Miranda (Miranda, 2008: p.321) had previously found, this approach offered a fairly closed set of possibilities and would at best generate a pastiche of traditional harmony and at worst, fail to produce any consistent harmonic or structural coherence. For *The Stream* I wanted to try a new approach where harmonic structure was assembled note by note in relation to a root generated by the **Alpha**. The **Alpha's** own choices are selected from a genetic pool of harmonies individual to each agent. The Alpha provides a harmonic base, with the other agents forming their

harmonic intervals around it. The metaphorical possibilities between a harmonic system and a political system were too ripe with opportunity to ignore, and political power relationships form the intervals that comprise the harmonic elements.

I began by assigning two melodic themes to each agent, forming their genetic harmonic choices whenever they were **alpha**. These were simple sequences of notes, composed to be as different from each other and as recognisable as possible. One theme uses major scale intervals and is heard when the majority supports the agent who is **alpha**, the other theme is minor and is heard when the majority opposes the leader. If the opinion polls register neutrality, that leader cannot move forward in their melodic theme but can choose to play any notes currently on the score relative to the root. The duration of each note varies, depending on the LFO speed of the **alpha** in combination with their level of political support.

I wanted the audience to have some awareness of whether the society was in support of their leader or not and this seemed the most unambiguous way to communicate this element. The melodic themes of each character give identity to the sectional variations, evident when a change of government occurs. Generally a mix of both melodies is heard and forms the harmonic content for the current **alpha**. Other notes from the score often obfuscate these melodies, but generally each agent has a semblance of harmonic colour that underscores his time in power. The final section from the Undercroft performance between 25m 10s and 30m 05s (53) contains elements from **Hunter's** minor theme where the second to seventh intervals can be heard in sequence played in G by the flugelhorn. The **Worker** continues to support **Hunter's** leadership as shown by the echoing of his theme, however the presence of the minor theme shows that he is strongly opposed by both **Medic** and **Artist**.

The melodies were designed to support the agents' personalities and relationships to each other; for example, the **Medic's** theme is formed of two binary groups, echoing the shape of his square wave LFO.

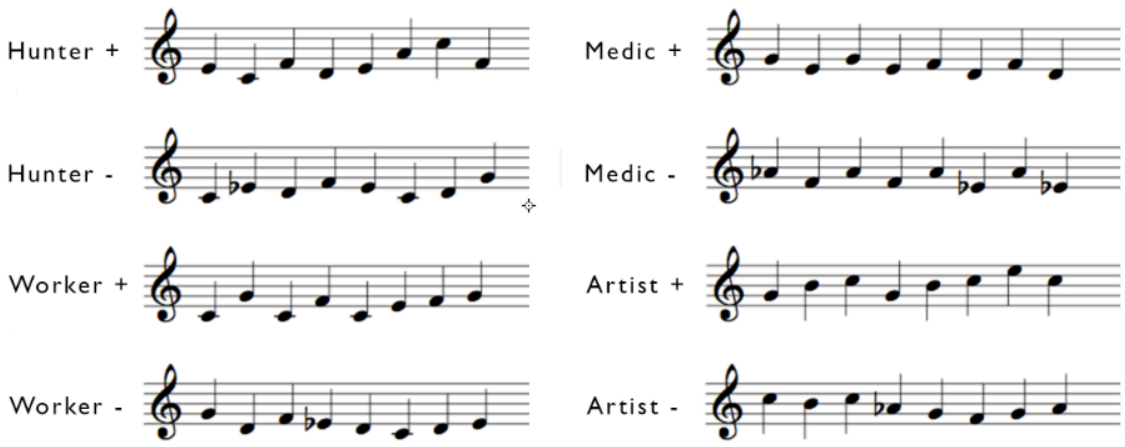

fig d.9 Agents' melodic themes relative to a root of C.
'+' = support of the majority and '-' = opposed by the majority

Hunter and **Worker** are both formed of one binary group and one sequence of notes to represent their alliance. The **Artist** melody is more varied, analogous to his noise based LFO, with the second group of four notes similar in shape to his counterpart and foil, the **Hunter.** The agents form their own harmonic choices around the central anchor of the **alpha**. Their relationship to the current root note of the leader is determined by three criteria; their opinion of the leader (stance), their wealth and their influence. The system is based on a series of intervals and associated weightings to create a unique system of pitch relationships.

Interval	Proximity	Stance	Influence
Root	0	1	16
Minor 2nd	1	-1	14
Sub-Major 7th	-1	-1	15
Major 2nd	2	0	14
Sub-Minor 7th	-2	-1	15
Minor 3rd	3	1	13
Sub-Major 6th	-3	-1	14
Major 3rd	4	1	13
Sub-Minor 6th	-4	-1	14
Perfect 4th	5	1	14
Sub-Perfect 5th	-5	1	13
Augmented 4th	6	-1	12

Interval	Proximity	Stance	Influence
O+Minor Second	13	-1	8
SubSub-Major 7th	-13	-1	9
O+Major 2nd	14	0	8
SubSub-Minor 7th	-14	1	9
O+minor 3rd	15	1	7
SubSub-Major 6th	-15	1	8
O+Major 3rd	16	1	7
SubSub-Minor 6th	-16	1	8
O+Perfect 4th	17	1	9
SubSub-Perfect 5th	-17	0	10
O+Augmented 4th	18	-1	6
SubSub-augmented 4th	-18	-1	7

fig d.10 Database of pitch choices

Interval	Proximity	Stance	Influence
Sub-Augmented 4th	-6	-1	13
Perfect 5th	7	1	15
Sub-Perfect 4th	-7	0	12
Minor 6th	8	1	11
Sub-Major 3rd	-8	0	12
Major 6th	9	1	10
Sub-Minor 3rd	-9	-1	11
Minor 7th	10	1	10
Sub-Major 2nd	-10	-1	11
Major 7th	11	-1	9
Sub-Minor 2nd	-11	-1	10
Octave	12	1	14

Interval	Proximity	Stance	Influence
O+Perfect 5th	19	1	5
SubSub-Perfect 4th	-19	1	6
O+Minor 6th	20	1	5
SubSub-Major 3rd	-20	0	6
O+Major 6th	21	1	4
SubSub-Minor 3rd	-21	-1	5
O+Minor 7th	22	1	4
SubSub-Major 2nd	-22	0	5
O+Major 7th	23	-1	3
SubSub-Minor 2nd	-23	-1	4
O+Octave	24	1	10
SubSub Octave	-24	1	11

fig d.10 (continued) - Database of pitch choices

The agents' physical and mental health combines with wealth to give a political influence value. This influence value is cross-referenced with their current political stance of 'for', 'against' or 'neutral' to make a choice about the interval that they will play in relation to the current alpha note. Their choice of note can either support that of the leader (stance=1), or purposely subvert the harmony so that the leader's melody is less pronounced (stance=-1). Neutrality is somewhere between the two, favouring 'traditional' but more obscure harmonic relationships to the root. The amount of wealth the player has decides how many different notes appear on the score, from none up to four at a time. Although all possible notes are displayed on the live score, the active note is chosen by a vertical line that moves across the score in a pattern designated by the agent's waveform.

The interval relationships were designed to harmonically describe the current political situation in terms of the agents' support for one another. Based on my mimetic interpretation of harmony and previous experience of tonal composition, I designed the system so that agents support their leader's harmonic choices by harmonising with strong intervals such as fifths and octaves. I drew on common assumptions that major harmony represents positive moods, moving towards negativity through minor and eventually on to more discordant intervals as the agent opposes their leader. Agents who politically oppose the **alpha** choose intervals below the leader's pitch. At low levels of political influence, this choice can produce an obscure interval relationship that is too far below the root note to be harmonically unsettling, given that other agents may be supporting the root note of their

leader. As the opposing agent in question increases his influence, the lower notes become closer to the root and as a result may subvert the harmony and therefore the melodic clarity of the voice of the leader.

Similarly, agents in support of the leader will make choices above the root, building chord structures on the leader's melodic foundations. The more influence they have, the more they will reinforce their leader's melody and choose to play octaves or fifths above the root. This system gives rise to the emergent property of a more global pitch relationship structure, where a healthy and prosperous society favours strong major tonality, and a failing government will be accompanied by discordant intervals and ambiguous tonality.

Due to the cyclic nature of the system, both can be heard in various incarnations within a performance. The global harmonic result was designed to underscore the narrative and to make clear to the audience when the society was functioning well and when less peaceful events were occurring. Generally, agents who are not having their needs met or oppose the current style of government are unhappy and unsupportive of their leader. If the leader is doing a particularly bad job, the harmony soon gravitates towards discord until another agent is voted in.

An example of a recurring narrative theme that the system gives rise to is a prolonged period of leadership for the **Hunter,** who is able to generate large amounts of wealth for society. His propensity to pocket some of this wealth into a secret offshore account allows him to sustain himself, and indirectly the rest of society through difficult periods. When their needs are met, the agents turn their attention towards political ideals and become complacent about the **Hunter's** stance on topics such as mental health funding and environmental responsibility.

At this point they may vote in the more idealistic **Artist** agent and society enjoys a brief but beautiful period of traditional major harmony and counterpoint, before funds begin to run out and society begins to fall apart once more. One example of the **Artist's** leadership can be heard beginning from 24m 20s (52) during the Canada Water performance and has become more established by around 26m 40s (52) but is over by 28m 0s (52) as noisier material begins to enter, indicative of agents without the **economic health** to afford notes. Another recurring narrative event is a prolonged period of government for the firm but fair **Worker**, whose government style is consistent in maintaining health levels but becomes

uninteresting after a period of time, and this becomes evident in the music. I eventually developed my control system so that I could focus on musical interactions between agent duos during the more politically dull Worker led moments, shedding light on the macro level of synchronised interactions between the LFOs that denote the rhythmic patterns, voiced by the instruments. I implemented this through a data-mixing desk, which allows me to 'turn down' some of the other agents' data streams and to limit their ability to voice their own current state. Compositionally, I did not want any section to dominate the majority of a performance. If I felt that any behaviour has gone past the point of being interesting, I allowed myself to intervene by utilising my 'god-like powers' to either trigger a general election or to decimate the **Flock** population through some terrible natural disaster, a particularly harsh winter or a sudden dip in fertility.

Waveforms & behaviour

In addition to harmonic choices, the political model also has an effect on when and how the notes are played. Each agent has a signature simple waveform, used as a kind of low frequency oscillator, similar in approach to the LFO modulation matrix I used for the *FHTA* network system. The waveform oscillations move a visual indicator that tells the players what part of the score to play at the current moment, or can be sent directly to a digital instrument over a network as control data. The waveform moves back and forth across the score in a pattern determined by the modulated agent waveforms.

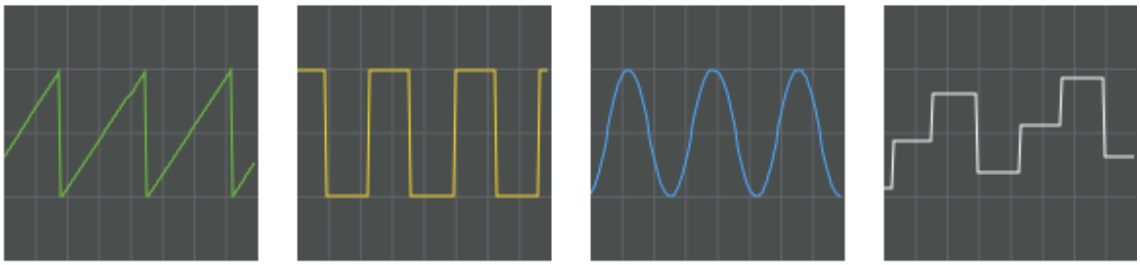

fig d.11 - Waveform types of agents from left to right Hunter, Worker, Medic & Artist

The LFO pattern is influenced by the political system, in that agents who support the current government have their own waveforms modulated by the **alpha's** waveform. Those who are neutral use their own waveform and those against the **alpha** are modulated by whichever agent they are backing to be the next leader. For example, if the **Worker** is supporting the **Hunter**, his square wave will be modulated by the **Hunter's** saw-tooth and as his support for the **Hunter** grows, his own waveform will become more and more like a saw-tooth wave. This aspect was designed to reinforce the idea of the leader controlling the

section of the composition, and to sonify the political aspects of the system to the listener. The personal melodies and waveforms were composed to allow the agents' to adapt to each other over the course of a performance. The prevalence of any particular agent's identity signifies both success and political influence. Each variable that makes up the agent's personalities have been carefully chosen for the sake of continuity and the development of a unique identity for each agent.

Creating agent identity

The character traits documented in the following table are comprised of my own exaggerations and social assumptions for dramatic effect, but this hyperbole also helps to define them clearly as distinctive archetypes. These definitions determine not only their personal behaviour, but also the compositional makeup of the entire piece when the different agents are appointed as leader.

	Hunter	Worker	Medic	Artist
Instrument	Cello	Flugelhorn	Alto flute	Violin
Symbol	Stag	Anvil	Shield	Lyre
Visual Particle Shape	Triangle	Square	Circle	Hollow diamond
Waveform LFO	Sawtooth	Square	Sine	Noise
Source Of Wealth	Private	Performance based salary	Government funded	Government funded
Genetic Physical Health	60%	40%	60%	50%
Genetic Mental Health	70%	50%	40%	30%
Needs (Order Of Importance)	Wealth Resources Health Culture	Resources Wealth Health Culture	Health Culture Wealth Resources	Culture Health Resources Wealth
Responsibilities	Wealth creation Resource gathering	Resource processing & distribution	Healthcare	Art/Culture Emotional wellbeing

fig d.12 Role and style differentiations between agents

Government Style	Generate wealth without environmental responsibility Prioritise physical over mental health Underfund the arts Privileges for the elite No cap on earnings	Support workers' rights Lower taxes on salary Support working conditions Prioritise physical over mental health	Balance physical and mental healthcare spending Preserve natural resources Higher tax on savings Fund technological development	Prioritise mental over physical healthcare Fund the arts Improve working conditions Increase government spending Protect the environment at the expense of resource yields

fig d.12 (continued) Role and style differentiations between agents

The first four entries in the table define how the agent is seen and heard; it is important that the characterisation is strong and coherent here as this is the main way in which personality is communicated. The characters' waveform LFO is the main source of their personal behaviour in how they voice and modulate their own data streams. I have tried to select coherent themes of shapes, sounds, behaviours, names and colours to create a simple visual and auditory identity for each character. Instruments were selected for their similarity in timbre where possible to those created by their waveform.

For example, the **Hunter** is coloured green, both to symbolise camouflage for the natural world in which he spends much of his time hunting, and to create the suggestion of paper money. Economic wealth within *The Stream* is also represented visually by the colour green. His emblem, the Stag, relates to his profession and is drawn to contain triangular elements, complementing the triangular particles that visually represent his health levels. The Cello echoes the timbre of a sawtooth wave, which in itself is triangular and spiky, suggesting spears, arrowheads and teeth. In practice, the sawtooth LFO gives rise to soaring glissandi and harsh attacks. Voiced by the Cello, the **Hunter** is an overbearing and large predator capable of both grace and violence.

His employee, the **Worker,** is coloured a yellowy gold, suggestive of brass instruments, the pistons of the early industrial revolution and coins, as a smaller denomination of currency to the paper money of the **Hunter**. His symbol is a hammer, indicative of the tools and processing work that he carries out, and the symbol also alludes to socialism and

communism. The square wave gives a regular mechanical behaviour to the **Worker** and at higher frequencies has similarity in timbre to the Flugelhorn that voices him, which is indicative of brass colliery bands, mining and trade unions. The **Worker** is a dependable figure and is perhaps the most popular leader of the group due to his ability to balance the generation of wealth and government spending, ensuring good conditions for all.

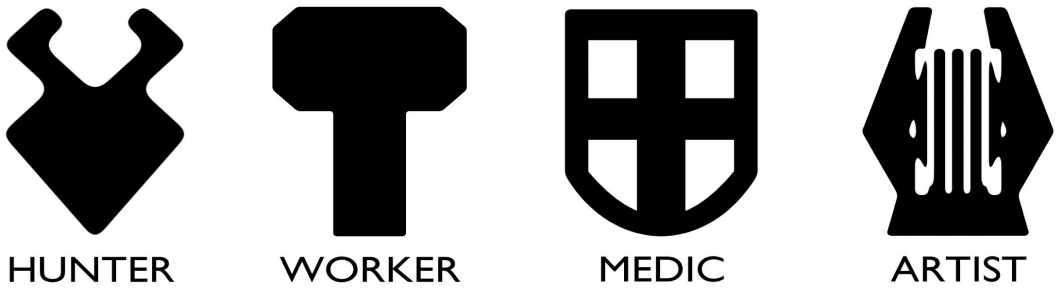

fig d.13 - Agent symbols featured within the live animation and on the front of each player's score

Looking after the health of his fellow agents, the **Medic** is voiced by the alto flute, which as an object gleams with the sterility of a surgical implement. The gentle nature of the **Medic** is revealed sonically in the curves of his sine wave LFO that ensures his utterances are always smooth and subtle. This shape carries through to the circular particles that represent his health levels as part of the generative animation. To me, his pastel blue hue is evocative of calmness and cleanliness. Adding blue dye to white washing powder through the use of fine iron dust makes it seem cleaner, and pastel blues are used in hospitals to provide a calm atmosphere. The **Medic's** shield emblem was chosen for its protective imagery, and consequently because it features in many of the healthcare emblems from across the world, and the cross was added to exaggerate this further. His character is heard in the piercing sine tones of the **Health** theme, which are similar in timbre to the flute itself at higher ranges.

The **Artist** brings disorder through a randomised waveform created with a sample and hold process on a white noise generator. The **Artist** is coloured white, and as the combination of all colours of light, indicates complexity and a special or privileged position in society different to that of the other agents. The **Artist** stands for unpredictability and beauty in the system, and is slightly more complex than the other agents in terms of symbol, LFO and visual particle shape. All the symbols were drawn on the same grid, giving them uniformity in their appearance through limitation within the same dimensions. The only

exception is the **Artist** whose design arose by accident from a quirk in the smoothing algorithm in Adobe Photoshop, allowing me to create the thinner strings and bridge of the lyre by altering the structure derived from the **Hunter's** stag symbol. In some ways due to their more extreme politics, the **Hunter** is the shadow of the artist, or vice versa, and to a lesser extent, the **Worker** is the shadow of the **Medic**, although I would not wish to imply positive and negative roles too heavily.

The quartet itself was chosen as a whole for its balance of timbre, excitation behaviour and frequency ranges. **Hunter, Worker** and **Medic** were chosen from three distinct instrumental families, with the **Artist** added as an undecided wildcard. I considered a percussion instrument to enhance the noise theme of the artist, but in the end I opted for the virtuosity and flair of the violin and its familial relationship to the **Hunter**. Utopian forms of the system and periods of success often trigger **Artist** led harmonic sections, requiring a melodic instrument to lead the harmonic development. This quartet gave me a huge range to play with in terms of combinations of sounds, particularly when matched with specific instrumental techniques to further extend the possibilities to sonically describe and colour the narrative.

Realising the system: Performance, evaluation and development

I was fortunate enough to perform *The Stream* in public twice with *Apartment House* and also had one workshop session previous to the performances, which was my first opportunity to hear the system live. Hearing the piece, getting feedback from the players and experimenting with pacing and control in a real situation was an incredibly valuable experience. One cannot fully know how the system will operate until it gets deployed in a live performance situation. Here are some of the ways in which the workshop and live performances impacted on my development of the system:

Scores

I had developed a system for instantaneous transposition of the scores to allow for any instrument to be used for any agent. Although I had already used the system to transpose for the alto flute and flugelhorn, I included a calibration routine to ensure that my transposition was correct which displayed a note on all the scores that would sound as a

concert C. I also included a prefabricated animation that displayed extremes of range on the score to calibrate with the players what their loudest volume or most extreme use of a technique would be. All other possibilities thrown up by the scores such as the effects of illness and use of multiple notes could also be activated at will in order for me to discuss the types of behaviours and sounds I was looking for in response to these events. The first hour of the workshop at UEA was really useful in getting feedback from the players as to what they could do well in certain ranges on their instruments, and also how they felt about the material they were given. Tempo was also important due to the live nature of the score, and it became clearer that faster speeds were difficult to execute accurately. I overcame this by slowing down the tempo and using pulsed techniques like variable speed tremolo to achieve shorter and more frequent rhythmic patterns. I also added a tempo indicator in the top left corner of the score featuring two circles which pulse at the players' own tempo divisions to make it clearer what the tempo was when they needed to play rhythmic staccato or pizzicato notes. This was for clarity, as at times the tempo would be hard to distinguish for the players as the rhythmic movement of the score indicator would become modulated by complex combinations of LFO patterns. There were previously two types of note heads, a standard for tonal content and the word 'noise' written as text for un-pitched content. By the second performance at the Undercroft in Norwich, I had removed the noise note function entirely as there was enough disruption and distortion already present in the pitched material. I was able to view all the scores simultaneously by using Apple Remote Desktop over the Ethernet network, which gave me an overview of the players' laptop screens. This enables me to monitor the visual information they would receive and helped me to identify poignant material to bring out. I found that often I could visually identify inter-agent behaviour patterns before they evolved sonically into a more perceivable relationship as the players began to feel the emergent rhythmic and harmonic links between their materials. The data for the scores was sent via OSC over the Ethernet network to four Apple Macbooks resting on orchestral music stands. The score patches were local to each machine using Max Runtime, with the score software coded entirely in Jitter using openGL graphics and a notation font. The video score software was generic and all agent specific data was sent over the network allowing easy installation on any laptop for robustness. Fortunately I had four Macbooks at my disposal, but the flexibility of the score software meant that the execution of the work would be more simple and financially viable for anyone wishing to play the piece using their own computers.

Below is the email I sent to the players on 20th June 2013 before the premiere at the Canada Water Culture Space. It contains a refresher on how to interpret the scores, and details the modifications I made after the initial workshop.

Dear Inhabitants of The Stream,

Really looking forward to seeing you all on Saturday and actually making the piece heard by an audience! I wondered if you would all be so kind as to dress in black for the performance, with an accessory or two of your choice in your character's colour:

Anton/Hunter/Green Jonathan/Worker/Yellow Gavin/Medic/Blue Angharad/Artist/White

This could be a scarf, tie or whatever you like that you feel comfortable to play in. I've done a short video for each of you of your personal score of around 6 minutes. I thought it might be helpful as a refresher and possibly to have a quick run through with if you wanted to.

The videos are available on youtube here:

Hunter	http://bit.ly/29g1uAa
Worker	http://bit.ly/29jkjo4
Medic	http://bit.ly/29qwSid
Artist	http://bit.ly/29l3HuX

Instructions for the score are as follows:

The thicker the line, the louder you play.
The video shows a few cycles of the line going from nothing to its thickest at the beginning so you can get some idea of the range.

If there is no line, you don't play anything.

The horizontal position of the line denotes the level of each technique used.
Techniques and their associated parameters are displayed below the staff in the centre. The line moves between two parameters below your technique name. As the line moves horizontally, apply the technique according to how close it is to each of the two parameters e.g. the line being in the middle would be a blend of the two parameters. The video shows a few cycles of the line moving left to right so you can get a feel for it.

Your technique and its associated parameters change as your line colour changes. This signifies a change in leadership. If it changes to red, you are the leader. Green = hunter, yellow = worker, blue = medic, white = artist. Please make technique changes gradually as the line colour transforms.

There is now a rhythmic indicator in the top left of the screen
This shows the current 'pulse' of your character and can be used to get a sense the timeline or even be used to denote rhythm when playing pulses etc. The rhythmic indicator will speed up and slow down throughout depending on energy levels of your character. The blue dot represents physical

health and the white is mental health. Slow = less energy, fast = more.

Sometimes your score will go white/opaque or the notes and lines will leave ghosts of themselves, which make the score difficult to read
The whiteness indicates a physical illness, the illness will start to be healed and gradually the score will become clearer. Do your best in this situation; it is meant to make reading the score harder. Your character will naturally weaken but you can interpret illness in your playing if you do so wish. The ghosting of the line or notes (sometimes looks like multiple notes) is mental illness; interpret the score as best you can. Play all notes displayed if you wish in any order you choose.

If the score gives you something you can't physically do, please interpret as best you can.
I trust you all in interpreting something on your instrument better than the score or instructions have told you to do, as long as it is fairly close to the score. The material is computer generated so sometimes it requires human intervention to make it communicate better.

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fig d.14 – Email message to Apartment House before 'The Stream' premiere in London, June 2013

Appendix B

The Stream legend

Chapter I: Birth

1 In the beginning there was The Stream and through The Stream flowed time, and after some time had passed, The Flock were born. The Flock were simple and beautiful creatures that both nurtured and lived on The Stream, and for a time, The Stream was at peace.
2 But all things must pass and as The Flock grew strong, Hunter stepped out from the mists of The Stream.
3 Hunter was of the stream, yet he was different from the flock. Around and out of his body there flowed three energies. Physical, Mental and Economic. As Hunter explored his new surroundings, he yearned for more than to be taken by the flow of the Stream.
4 Hunter longed for the power to control his own destiny, and so began to hunt and consume The Flock. He grew, and as he grew, he hunted more, and as he hunted more, he grew hungry, until he had hunted so many of The Flock that the burden of his work grew too heavy for him to manage. Hunter needed an ally, to help him store and distribute the products of The Flock as Resources so that he could satisfy his hunger.
5 Hunter needed to attract an ally to work for him. From out of The Stream, Hunter created the promise of Wealth. And soon enough, Worker entered The Stream.
6 Hunter taught Worker to turn The Flock into food, and the Worker created vast and powerful machinery using the Wealth of the Hunter to do so. In turn Hunter granted the economic health that allowed Worker to grow.
7 Worker processed the flock, which fed and sustained both Hunter and Worker and gave them other valuable resources.
8 They both fed and grew on what they had achieved, but after some time, they began to stagnate and sicken physically and mentally, and as a result, economically.

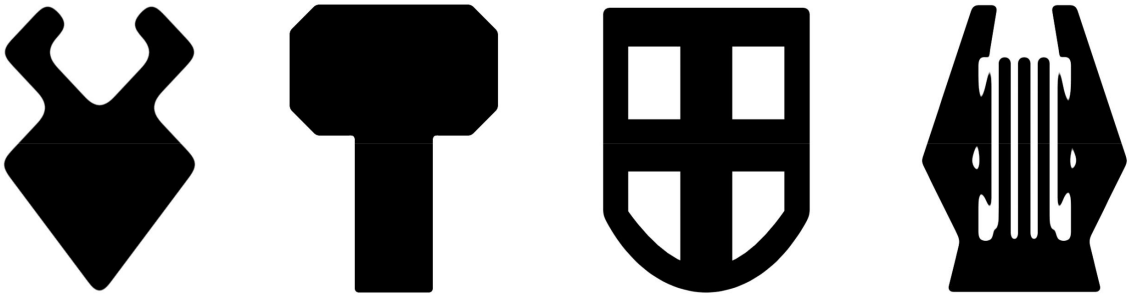
Chapter II: Life

1 Although they were powerful and they could generate Wealth and Resources, they needed support to keep Hunting and Working, and more importantly, to continue developing.
2 The Stream sent them Medic who would heal them whenever they were in need. The Hunter and Worker agreed to pay the Medic a portion of what they had, so that he might support himself and be willing to help them to heal. All was well in the stream as the Medic gave them Health.
3 The inhabitants of The Stream grew, and as they began to overcome some of the hardships their world had bestowed on them, they learned things about life. As they learned, they grew complex, and as they grew more complex, they created stories of their lives in The Stream and reflections of themselves so that they could understand and learn about themselves outside of The Stream.
4 From out of the flow of The Stream, grew Culture. With the

creation of stories came imagination, and the promise of breaking free from Hunting, Working and Healing.
5 The final inhabitant was soon to arrive, the one who would inspire through imagination and give pleasure through knowing themselves amongst the beauty of The Stream.
6 Out of the flow of The Stream came Artist. Hunter, Worker and Medic agreed to provide Artist with Health, Wealth and Resources, and Artist agreed to occupy himself with and growing and amplifying the Culture that flowed in The Stream.
7 The four soon found themselves craving change in how the decisions of their lives were made. Each one wanted the power to rule society by his own values and create his perfect vision for The Stream.
8 With the invention of structure and simple laws, each began to need each other more to grow. They decreed that one of them should lead the others, but all should be eligible take up the leadership when most needed.
9 Elections would be held, and whoever was most needed by The Stream would lead their society, and his beliefs and ideals would determine the mechanics of their government. And they called their leader Alpha. And with each change of Alpha came a change in ideology and direction for The Stream.
10 Hunter can reap great benefits from hunting intensively, but in killing too many of the flock, numbers would soon diminish and Wealth and Resources would eventually become scarce.
11 Without Wealth to support Worker, Hunter could not process The Flock into Wealth generating Resources, causing imbalance and possible negative flow to The Stream.
12 If Hunter did not fund Medic through taxes, he would not be healed from the strains of Hunting and would be left unable to hunt, and society would be left without Resources. Without the Artist, their world would become bleak and unpleasant and he would lack the motivation to hunt well.
13 This is The Song of The Stream

Chapter III: Death

1 But all things must pass, and the flock began to grow smaller and weaker as more demands were made on their numbers.
2 And Hunter and Worker began to increase the numbers of the flock through unnatural procedures and the flock grew sick and night began to fall on the Stream.



Appendix C

Catalogue of Performances

Catalogue of Performances

Selected performances: September 2008 – February 2014

2014

The Stream (Performed by Ed Perkins and Apartment House), The Undercroft, Norwich, February 2014

2013

The Stream (Performed by Ed Perkins and Apartment House), Canada Water Culture Space, London, July 2013

Conductable, Sonic Arts 74, University of East Anglia, April 2013

The Raw and The Cooked, The Lamb, BBC Radio Norfolk introducing, Norwich, March 2013

From Honey to Ashes, Tall Trees/Maesteren/She Moved Through the Fair, SARC, Queen's University, Belfast, Feb 2013

From Honey to Ashes, Tall Trees/Maesteren, Blood Relations, EMS Concert, Goldsmiths, London, January 2013

2012

Conductable, ExWo , Snape Maltings, Aldburgh Music, July - September 2012

The Stick, Improvisation, 'A John Cage Musiccircus' with Exaudi, Aldburgh Festival, Snape Maltings, June 2012

From Honey to Ashes, Evening Concert, EMS, Goldsmiths, London, January 2012

2011

The Raw and The Cooked, The Dream, Music and Transendance Conference, Cambridge University, November 2011

The Raw and The Cooked, The Dream, Norfolk & Norwich Festival, The Puppet Theatre, Norwich, May 2011

The Raw and The Cooked, The Dream, Norwich Playhouse, Norwich, April 2011

The Raw and The Cooked, The Dream, Spectro, Norwich Arts Centre, March 2011

John Cage Songbooks with ExAudi and Bill Thompson, King's Place, London, March 2011

Wayang Listrik, The Vortex, London, January 2011

2010

John Cage Songbooks with ExAudi and Bill Thompson, Aldeburgh Music LAB, Snape Maltings, Aldeburgh, November 2010

Wayang Listrik , Sonic Intermedia 2010, Ars Electronica, Austria, October 2010

From Honey to Ashes, Improvisation, EMS at The Shunt, The Shunt Lounge, London, June 2010

The Raw and The Cooked, Improvisation, Howlback Hum, Norwich Arts Centre, Norwich, January 2010

2009

The Raw and The Cooked, Improvisation, Howlback Hum, Norwich Arts Centre, Norwich, December 2009

Wayang Listrik, Sonic Arts 56, Strode Room, University of East Anglia, November 2009

The Raw and The Cooked, The Rhime of the Ancient Mariner, The Crypt, St Giles Church, London, October 2009

From Honey to Ashes , Tall Trees/A Kind of Logic, Baby Birds, Sound and Perception, Café Scientifique, The Horse Hospital, London, October 2009

From Honey to Ashes, Sonic arts Expo, Holy Trinity Church, Leeds, September 2009

The Raw and The Cooked, The Rhime of the Ancient Mariner, Olive's Café & Bar, Norwich, September 2009

The Stick, The Quiet Joys of Heathcote Street, as part of Mr Shordy, Shoreditch Festival, London, July – August 2009

From Honey to Ashes, Film for Hannah Marshall, screened at Birds Eye Film Festival, ICA, London, March 2009

Prinzen Achmed, Re:Chord Air with Laura Cannell, Norwich Arts Centre, March 2009

The Raw and The Cooked, Improvisation, Howlback Hum, Wesum Lodge, Norwich, January 2009

2008

From Honey to Ashes, Live at EMS, EMS Concert, Goldsmiths, London, January 2008

The Raw and The Cooked, Improvisation, Howlback Hum, Norwich Arts Centre, Norwich, December 2008

The Raw and The Cooked, Cu Chullain, Sonic Arts Series 50, Peter Mancroft Church, Norwich, November 2008

From Honey to Ashes, Littlest Birds Get Loud Sponsored by The Wire, The Whitechapel Gallery, London, November 2008

BD4D London, By Designers for Designers - Piano and Electronics
ICA, London, November 2008 with Jim Perkins

From Honey to Ashes, Collision Festival, London, September 2008

Appendix D

Additional materials

Additional materials

All works indexed here are mentioned in the text but are not part of the official submitted works.

They can be found on the accompanying media within the appendix D folder

Live at the EMS I 3′ 37″ & II 3′ 13″, FHTA, (2008)

Collaboratively composed and performed by FHTA:
Ed Perkins, Jeremy Keenan & Matt Lewis
Recorded in the Great Hall, Goldsmiths College, London

Baby Birds 3′28″ (2008)

Collaboratively composed and performed by FHTA:
Ed Perkins, Jeremy Keenan & Matt Lewis
Recorded at the EMS, Goldsmiths College, London
From the album Meme (2010)

States Vaporise 3′29″ (2008)

Collaboratively composed and performed by FHTA:
Ed Perkins, Jeremy Keenan & Matt Lewis
Recorded at the EMS, Goldsmiths College, London
From the album Meme (2010)

Extremely Acatalectic Eschatological Musings 20′ (2008)

Free Improvisation by TRATC:
Ed Perkins & Jason Dixon
Recorded in the electronic music studios at UEA, Norwich

Cú Chullain13′44″ (2008)

Collaboratively composed and performed by TRATC:

Ed Perkins & Jason Dixon

Recorded at St. Peter Mancroft Church, Norwich

Tall Trees 3′29″ (2009)

Collaboratively composed and performed by FHTA:

Ed Perkins, Jeremy Keenan & Matt Lewis

Recorded at Havelock Road, Norwich

From the album Meme (2010)

Housemaster or Stranger 4′43″ (2009)

Collaboratively composed and performed by FHTA:

Ed Perkins, Jeremy Keenan & Matt Lewis

Recorded in London, EMS, Goldsmiths College

From the album Meme (2010)

A Kind of Logic 4′05″ (2010)

Collaboratively composed and performed by FHTA:

Ed Perkins, Jeremy Keenan & Matt Lewis

Recorded in the electronic music studios at UEA, Norwich

From the album Meme (2010)

Blood Relations 5′13″ (2010)

Collaboratively composed and performed by FHTA:

Ed Perkins, Jeremy Keenan & Matt Lewis

Recorded in the electronic music studios at UEA, Norwich

From the album Meme (2010)

The Rhime of the Ancient Mariner, Act III 19′ 50″ (2010)

Collaboratively composed and performed by TRATC:

Ed Perkins & Jason Dixon

Recorded in the electronic music studios at UEA, Norwich

Momentum 12′ 36″ (2010)

Free Improvisation performed by:

Se-Lien Chuang , Anton Lukoszevieze, Ed Perkins, William Vine, Simon Waters & Andreas Weixler

Recorded in the Deep Space, Ars Electronica, Linsz, Austria

The Dream 19′ 35″ (2011)

Collaboratively composed and performed by TRATC:

Ed Perkins & Jason Dixon

Recorded in the Lecture Theatre, Music Centre, UEA, Norwich

Improvisation at LLEAP 8′ 24″ (2012)

Collaboratively composed and performed by:

Adam Jansch, Christos Mikalos, Ed Perkins and Claire M Singer

Recorded in the bar, Norwich Arts Centre, Norwich.

The Stream, test performance 10′58″ (2012)

Composed by Ed Perkins

Composed and directed by Ed Perkins

Software developed by Ed Perkins

Performed by Apartment House:

Anton Lukoszevieze (Cello), Jonathan Impett (Flugelhorn) Angharad Daves (Violin) and Gavin Morrsion (Alto Flute)

Recorded in the Strode, Room, UEA, Norwich

She Moved Through The Fair 10′23″ (2013)

Traditional

Arranged by Ed Perkins

Performed by FHTA:

Ed Perkins, Jeremy Keenan & Matt Lewis

Recorded at SARC, Queens University, Belfast

The Stream, trailer video 6′ 23″ (2013)

Directed by Darren Michael

Recorded in the Strode, Room, UEA, Norwich

The Stream, Premiere 33′54″ (2013)

Composed by Ed Perkins

Composed and directed by Ed Perkins

Software developed by Ed Perkins

Performed by Apartment House:

Anton Lukoszevieze (Cello), Jonathan Impett (Flugelhorn) Angharad Daves (Violin) and Gavin Morrsion (Alto Flute)

Narrated by Jason Dixon

Recorded at Canada Water Culture Space

Edun 11′ 45″ (2014)

Directed and Composed by Ed Perkins

Performed on Conductable by

Sherry Armstrong, Pablo Cook, Jason Dixon, Lilith Perkins & Ed Perkins

Recorded at Sonic Arts 74, Strode Room, UEA