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Portfolio of Compositions Using Causality as a Musical Parameter

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A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of Master of Arts by Research

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Abstract

The main body of this thesis consists of three drone pieces, all with a special concern with causality as a crucial musical parameter, within semi-improvised mixed music settings.

This accompanying commentary gives a theoretical background to the pieces, as well as documenting the pragmatic considerations of their technical implementation, with a special emphasis on real-time audio mosaicking.

This accompanying commentary anchors the pieces within an aesthetic and theoretical background.

The coding and implementation of digital and hybrid instruments, as well as their practical implementation was at the core of the compositional work, as well as mixed-music concerns of integrating the loudspeaker sound with that of the acoustic instrument.

The text will then position mixed-music more generally within current technological trends, and how this position extends the music presented here.

Contents

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Introduction

This introduction will define the core ideas considered when producing the music presented here, providing a context to their use within the music, and how they have been discussed in preceding literature.

Causality underlies the presentation of any music considered live.

The once almost certain causality of music from acoustic instrumentation, and the majority of sound in a listener's life, meant that all sound could be heard and identified as probably being an effect of a single, physical cause.

This certainty was undermined through "three great 'acousmatic dislocations' established in the half century to 1910" (Emmerson 2007, pg. 91): Recording technology removed sound from a defined position in time, Telephony removed sound from a defined space, and synthesis removed sound from a defined "mechanical causality".

Each piece within this thesis uses a different causal dislocation as its main area of musical discourse, creating and removing its causality to different degrees.

Drones

The use of drones in the work augments the temporal dislocation described by Emmerson through an extension of the length of gesture, imposing "a kind of sensory deprivation through effacing the variation we take for granted, the ebb and flow of acoustic data that occur not only in music but in daily life as well", (Demers 2010, pg. 93). The use of long gestures allows the causality to be stretched or removed over a long period, without the listener necessarily noticing the transition between textures.

Mixed music

Establishing causality depends on a physical object being present to attach the sonic result to. The use of a live performer within the piece allows the instrumental source of the music to be present for the performance, giving a presupposed base causality, defined by the perceived "affordances and constraints" (Magnusson 2010, pg. 63) of the physical instrument.

This is in contrast to many new digital instruments which use the computer as the sole audio generator. This results in a mainly arbitrary mapping of action to sound, not allowing for expected sound affordances within the physical instrument to be present. "There is no longer a perceivable causal link between the gestures required to play the instrument and the mechanism that produces its sound" (O'Modhrain 2011, pg. 32).

Sound reinforcement

The physical position of the audio being presented also allows causality to be manipulated, moving the audio source from the "local" of the physical instrument, to the "field" of the "wider location" (Emmerson 2007, pg. 92). Sound diffusion allows this transition to be performed, adding spatial dislocation as an available parameter within a piece.

The music for this research project applies several mixed music specific loudspeaker techniques developed by Tremblay and McLaughlin (2009, pg. 379) in *Thinking inside the box*. This paper and the associated series of performances aims to "[optimise] the integration of live instruments and electroacoustic sound in the concert hall environment" and "[bring] the concert hall acoustic environment into the studio composition process". These techniques aim to allow the composer to "conceive of their works as destined for the live environment, and live performers from the outset" (Tremblay and McLaughlin 2009, pg. 385).

Bounded Improvisation

The use of improvisation allows a further interaction with the causality of the sounds, as well as a "loosening of the stranglehold" that notation can place on music (Bailey 1980, pg. 60).

As the presence of the performer and the instrument allow the physical cause of the sound to be perceived, the presence of an improviser allows the mental source of the sound to also be implied. Even if the piece is in part pre-composed, the audience are able to perceive the performance as the completion of the compositional process. The concretisation of the piece in performance is potentially more of its time and place, through the freedom granted to the performer in its execution.

Bounded improvisation gives a work a freedom of interpretation not allowed for in strictly notated music, while still allowing the piece to retain an identity through either

defining structural or textural material for the piece. Bailey (1980, pg. 60)) mentions an interview, where the composer (Earle Brown) describes "…a piece of music which would have a basic character always, but by virtue of aspects of improvisation or notational flexibility, the piece could take on subtly different kinds of character."

Augmented Reality

Mixed music has parallels to the wider field of augmented reality. The use of technology to change how an environment is perceived can be seen in research such as Google's Glass and Microsoft's Illumiroom, This concept can be seen in the music presented here, with the electronics acting as an augmentation to the instrumental performance.

Overview of Submitted Pieces

Three pieces have been submitted in this portfolio, each utilising a separate technique for creating and removing causal links.

Bell is a piece for clarinet plus fixed electronic sound. This piece consists of a staff based score written for Bb clarinet and a stereo fixed media file.

Wells is a piece for electric bass guitar and live electronics. This piece consists of a text score plus a live electronics implementation written in Max/MSP.

Centrist is a piece written for any 2 instruments plus live electronics. The piece consists of a graphic score with a live electronics implementation written in Max/MSP

1 Causality as a musical parameter

The three pieces presented in this research project extensively use causality as a musical parameter. This section will look at the technological developments which allow for the ease of modification of apparent causality within electronic works. Techniques for modifying causality within past musical pieces from non-electronic music, acousmatic music and mixed music will then be identified. Major concepts currently used in developing digital and hybrid musical instruments will be discussed and their influence on the pieces and systems created for this portfolio will be shown.

1.1 Dislocating causality

Emmerson (2007, pg. 91) gives a technological history of the removal of fixed causality for sound in general:

> …there were three great 'acousmatic dislocations' established in the half century to 1910: Time (recording); Space (telecommunications (telephone, radio), recording); Mechanical causality (electronic synthesis, telecommunications, recording).

This section of the commentary will show how these dislocations have been used in different types of music and how they have been implemented in the works presented here. Three types of works will be investigated: non-electronic music, acousmatic music and mixed music.

1.1.1 Non-Electronic Music

Non-electronic music refers to that which can produced live without an electronic component. This generally means music performed only on acoustic instruments, with the voice or through physical interaction with any sound creating object.

Non-electronic music's causality is generally physically obvious. Instruments and performers on stage allow the listener to ascribe the physical causality to the performer reliably, and to see the individual action which brings about a sound event.

However, some performance techniques allow this to be subverted, such as the offstage trumpet solo used in the Leonore overture in Fidelio (Beethoven 2000). The trumpet cannot be visibly attributed to the sound by the listener, yet is still obviously acoustically generated. The listener calls upon their learned properties of sounding objects to understand that the instrument is not in the standard performance space. This subversion of the concert hall allows the location of the causal object to be

brought into question. The causal ambiguity developed in this and similar acoustic techniques became easier to implement with the acousmatic dislocations mentioned earlier, and the removal of the entire "audiovisual complex" surrounding a "sounding object" (Chion 1983).

1.1.2 Acousmatic Music

Acousmatic music is presented with no on-stage performer. The music is performed solely through loudspeakers, and asks the listener to ignore the physical cause of the sound (the sounding object) and concentrate on the properties of the sound itself (the sound object).

> The acousmatic situation changes the way we hear. By isolating the sound from the "audiovisual complex" to which it initially belonged, it creates favourable conditions for reduced listening which concentrates on the sound for its own sake, as sound object, independently of its causes or its meaning. (Chion 1983, pg. 11).

By removing identifying characteristics of the original sound, such as the attack from a bell sound (Chion 1983, pg. 13), the causal perception can be removed to such a point that the sound appears to have no definitively identifiable source. As well as removing the identifying characteristics from a sound to create an abstract sound object, two or more similar sound objects derived from differing sounding objects may be used to create ambiguity as to the aggregate sound's causality. This is seen in Trevor Wishart's *Red Bird* (1992)*,* where animal sounds and human vocal sounds are interpolated, the sounds being transformed through electronic manipulation, exploring their shared characteristics. The metamorphosis generates ambiguity regarding the source of the sonic event. The sonic similarity of two sounds is used to draw more abstract similarities between the two sounding objects. Wishart (1996, pg 166) describes this enforcement through reference to Red Bird, linking the sound transformation of human voice to bird sound with "the concept 'imagination'", suggesting the "voice 'takes flight'" through the transformation.

Ambiguous causality within acousmatic music is powerful due to its ability to use any sound without the need for a physical counterpart. However, without the physical anchor of a performer, the listener has no fixed causal reference or human agent to attach the sounding result to. The lack of a performer can be mitigated to some extent through live diffusion of an acousmatic work. This allows a tailoring of the

sound to the sound system and environment within the hall, yet the music still retains a mostly fixed nature, leading to a lack of new interpretation in a work:

> …the work is fixed in so many of its attributes that it is not possible to provide a significant new interpretation. One could therefore come to consider electroacoustic music as the ultimate "museumification" of musical art. (Garnett 2001, pg. 29)

The use of a performer within a piece of electronic music avoids this semi-concretisation of a work, requiring a performer to interpret the notation of the piece at performance time.

1.1.3 Mixed Music

Mixed music is music containing both a live acoustic instrument and electronic sounds generated through loudspeakers. The original use of the term "musique mixte" refers to a piece for acoustic instrument and a fixed electroacoustic tape recording. However, it has grown to include music incorporating electronics generated in the real-time performance of the piece.

Mixed music allows the physical reality of the instrument to be combined with the acousmatic ability to subvert causal perception. Emmerson (2007, pg. 105) identifies "extending the acousmatic into the instrumental" as a method of incorporating acoustic instruments and computer based sound into a coherent piece. "Extending the acousmatic into the instrumental" involves attempting to concretise the instrumental sounds into acousmatic "sound objects", which complement the acousmatic sound from the electronics. Emmerson sees this as the instrument "[aspiring] to the acousmatic" however, and points out the tendency of the listener to question the source of the sound, and the "strong tendency for the instrument to reestablish its presence separated from the electroacoustic soundworld" through performer movement and a mismatch of amplification between the instrument and electronic sources.

The treatment of the instrument as "aspiring to the acousmatic" can be seen in the first piece presented in this portfolio, *Bell*. The piece begins with a quiet, noise based sound on the tape part. The clarinet enters the piece with an obviously instrumental texture, contrasting the noisy texture of the tape. This instrumental texture is then augmented through sine tones matching the frequency of the clarinet sound. The second half of the tape slowly transforms the clarinet sound into a

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broadband noise-based sound through distortion and granular synthesis. This removes the obvious instrumental causality of the sound, enabling the instrument to "[disappear] into the ongoing flux" (Emmerson 2007, pg. 105) of the tape part.

Emmerson (2007) also gives precedent for the use of differing causality as a musical parameter in mixed music, stating that recent researches aim to "establish 'perceptible and realistic' gesture-to-sound production mapping". This realistic mapping can also be contrasted by:

> …a more ambiguous relationship, mixing some directly perceivable cause-effect chains with (a) relationships of performer gesture to result which the performer may understand but the audience does not or (b) relationships of a more 'experimental' nature the outcomes of which may not be fully predictable. (Emmerson 2007, pg. 91)

These ambiguous relationships can be seen in Uoon I (2002) by Alva Noto and Ryuichi Sakamoto. The minimal electronics and piano maintain a separation through avoiding shared acoustic material for the majority of the piece. There are however, points in the piece where piano chords are reversed in the electronic processing, after being played by the piano. These moments act as points of togetherness and a resolution of musical tension generated by the seemingly separate instruments, in an otherwise sparse and dualistic soundworld. The reversed piano chords also act as a temporally linked cause of the sine tones which follow immediately after. By occupying the same spectral space as the chords, these tones attain a causality which can be attributed to the piano for the first few moments of their appearance, and subsequently become obviously electronic through their long sustain period. Extending the sonic qualities of an acoustic instrument allows the piece to maintain causal links whilst forming a coherent and complex soundworld. The piece is performed by a pianist and a laptop performer. The audience have no direct knowledge of how the laptop affects the sound, yet its effects can be heard, and these abstract causal relationships developed.

Hewitt (2013) identifies the difference between the traditional "limits of an instrument" (Croft, 2007 cited in Hewitt, 2013, pg. 18) and the "infinite sonority" (Hewitt 2013, pg. 18) afforded by the laptop computer. The use of the computer within mixed music however, allows for this concept to be implemented around the limited sonority of an

acoustic instrument, stretching and redefining its perceived constraints and affordances towards the "infinite". The computer can be used to extend instrumental gesture and redefine the limits of an instrument, through potentially invisible sonic augmentation. This repositions the aesthetic concerns of such pieces into the area between definite and indefinite causality, between the acousmatic and the coherent audiovisual complex.

1.2 Humanising the computer

1.2.1 Laptop as instrument

Human-computer interaction research aims to avoid the physical constraints defined by the "subversive re-appropriation of the ASCII interface for musical instrument use" (Hewitt 2013, pg. 13) found in live coding. Utilising the laptop as a performance instrument allows a "re-emphasis on human performance and human cognition that comes from working with a live performer" (Garnett 2001, pg. 25). The proliferation of the laptop as a performance instrument in its own right has led to the issue of a physical causality being absent from much computer music, even if it is performed live. This can be seen in the projection of code behind the performer in many live coding performances. The live coding language *ixi lang* constrains the performer from the "underlying power" (Magnusson 2010, pg. 69) of the music programming language SuperCollider, on which it is built. The high-level nature of the language allows patterns to be easily seen by the performer and the audience in the code. Through exposing the thought patterns and decisions of the performer, physically non-descript typing on a keyboard gains a causal relationship with the sound production techniques used.

Through creating new physical controllers for real-time computer music, the obviousness of physical gesture found in acoustic music is brought to control the "infinite sonority" found in computer music. Garnett (2001, pg. 26) identifies these physical and cognitive constraints on computer music as "constraining music to what is cognitively graspable, without confining it to what is already cognitively grasped." This focus on constraints in computer music is continued in more recent research (Magnusson 2010, pg. 62), with specific regard to digital instrument construction. Magnusson approaches digital instrument design as a relationship between

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"*affordances*, *constraints* and *mapping*". *Affordances* represent the "potential applications derived from the agent's embodied relationship with the object", *constraints* refers to the "expressive limitations that face the thinking, creative, performing human", and *mapping* is the designing of the constraints of the instrument. Digital instruments' sound engines are typically constraints placed on a lower level programming language.

Examples of this include the SHNTH, a combined controller and audio synthesis system. The musician is free to program the device with assembly language and to receive data from the controller on an external device, however a higher level visual programming language is also made available. This allows the musician creating music with the SHNTH to create their own setup for the instrument from a range of audio synthesis modules. Combined with the physical constraints of the controller (four pressure sensitive bars, eight buttons, two antennae and a microphone), these modules confine the performance ability of the instrument whilst allowing simple extension and personalisation of the instrument at the mapping level.

Learning a digital instrument according to Magnusson involves "building a habituated mental model of its constraints (2010, pg. 71). Developing virtuosity on an instrument therefore, requires practice with a static set of constraints, simulating that of learning an acoustic instrument. These constraints however, would not be immediately obvious to the audience unless they were familiar with the instrument.

1.2.2 Hybrid Musical Instruments

Hybrid acoustic-digital instruments couple the performer of an existing acoustic instrument to a digital sound engine. The instrumentalist retains their performance ability from previous experience with the instrument. The constraints of the instrument are modified through the use of a digital extension to the sound. This may be as drastic or as subtle as the musician requires, and will be based on the pre-existing causal relationship of the performer and instrument.

The "Hypercello" used in Tod Machover's *Begin Again Again…* (2003) is an early example of a hybrid instrument. This instrument receives data from the player through sensors placed on the performer and instrument to modify audio samples of the instrument and generate synthesised audio. The use of sensor data to modify the sound allows the extension of gesture into any parameter. The performer is able to

generate audio which is matched to the audio being played by the cello, allowing a coherent soundworld to be generated from the performance.

Sandbox#3 (Tremblay and Schwarz, 2010) allows the interfacing of an electric bass with a sample bank hosted on the performer's computer. The mapping of the instrument to the collection of samples is done using corpus-based concatenative synthesis. This method uses MPEG7 audio descriptors (Manjunath, Salembier, Sikora, 2002) to describe the sample bank or "corpus". The same descriptors are then used to describe the input from the electric bass. The input signal is then matched to the closest sample available using the same descriptors, creating an "audio mosaicing" synthesis method.

Causality in Sandbox#3 is physically apparent. The performer can use their knowledge of the instrument to "navigate" the corpus, translating the audio from the bass into a more varied audio generator. This "recycling the virtuosity" (Tremblay and Schwarz 2010, pg. 447) offers a source of instrumental extension which allows scope for performance and sonic development, whilst maintaining an easily manipulable causal relationship.

1.3   Developing a Performance System

1.3.1   Self-Referential Corpus Based Concatenative Synthesis

Each piece in this portfolio utilises an audio mosaicing system, developed in conjunction with the pieces. The basis of the system involves recording the incoming audio signal from the performing instrument. This signal is then described in real time by selected MPEG-7 audio descriptors, and split into grains, averaging the value for each descriptor over the length of the grain. The input signal is then used to play back from the recorded material the grains which most closely match the signal. The system is implemented in MaxMSP, and uses Alex Harker's objects for implementing concatenative synthesis. Using custom objects within MaxMSP allows the system to be built and modified more easily than repurposing CataRT, which is built for a static corpus.

Bell uses the first incarnation of the system. This is a simple proof of concept system, built for use within a studio setting. It uses a mouse interface to control external

processing of the sound through distortion and filtering, as well as taking an input either from a soundcard or from a different application. The system was used in this piece to generate audio files from pre-recorded clarinet samples by playing the samples through the system. These audio files were then assembled in a DAW with synthesised material to create a fixed media part, to be played alongside a live clarinet part. Through the use of the descriptor-matched material, an apparent causality can be heard with the live clarinet seemingly initiating the samples. The simple matching system means that only one matched grain of sound is played back at a time, and playback cannot be stopped whilst recording. This results in grains being selected which may not closely match the clarinet sound being currently played, due to a break in playing or a previously unperformed gesture being used by the clarinet. This semi-unpredictability in performance is increased through the use of a distortion effect on the system generated sound. Through the increase in spectral energy created through distorting the sound, the piece is developed into a more enveloping object, and the noise from distant grain matches is incorporated into the noise-based soundworld of the piece.

Wells develops the system as a live performance tool. An electric bass guitar is used as the performance instrument, along with a foot controller with multiple switches and a foot pedal controller. The instrument signal is recorded as in the first piece, however each grain is recorded with a layer tag, enabling the performer to create individual corpora which can be selected and matched to the input signal as required. When a layer is being played back by matching the input signal, the grains being played can be stored, and played through again randomly. This random playback enables up to three independent textures to be played without constant intervention by the performer. The use of the bass's own audio as source material for the corpus allows the piece to retain a physical causality, as performance gestures are extended through the most similar audio grains available. The semi-random playback abilities of the system allow the piece to use a temporal dislocation, with material performed earlier in the piece being collected into pools and played back using a small foot-switch gesture.

Constraints within this system are defined by the sonic constraints of the instrument being used, and are extended through the use of playback of the recorded sound. The causal relationship of the instrument and computer sound remains strongly

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linked, as the sound created by the computer is generated with the instrumental sound as ultimate source. By playing back their own performance, the sound must have been created by that performer. This strong causal link is subverted in the final piece in the portfolio, through the use of two instruments and corpora, linking the physical sound sources of sonically diverse instruments.

1.3.2   Concatenative Cross Synthesis

Centrist extends the self-referential performance system used in the second piece to allow use with two corpora. In the piece, each corpus is filled from the live performance audio and data from a different instrument. Each instrument can play back matching grains from its own corpus, the other instrument's corpus or from both. The use of multiple instrument sources allows the physical causality of the instrument to become ambiguous. When one instrument performs a gesture, sound from both instruments can be heard. The matching of grains to the input signal however, means that the audio being played will be matched to the performing instrument's gesture. This creates a causal link between the two instruments, giving the ability to attribute causality for both sources of sound to an instrument in isolation.

Constraints within this system are defined by the instruments selected for performance. In choosing instruments to perform, the musician is selecting the range of constraints they wish to work with. Instruments which have more coincident descriptor spaces (Tremblay and Schwartz 2010, pg. 449), such as similarly pitched instruments will create more matching grains, and allow more flexibility in performance.

Rehearsals for the realisation of this piece were originally performed on bass guitar and drums. After several recording sessions, this instrumentation proved to be unreliable in generating coincident descriptor information. This did not allow for the causal ambiguity required for the piece, and it was decided to change instruments for the realisation. The instruments used in the realisation presented here are tenor saxophone and electric guitar. These instruments share much of the same pitch space, and allow a range of techniques to be used in performance, especially on the electric guitar, which also allows modification through amplification and distortion.

The use of concatenative synthesis as a causal link between instrument and computer enables a natural sounding extension to the sound, and one which

requires little extra effort to manipulate by the performer due to the automatic nature of descriptor-based matching. Combined with multiple loudspeakers, concatenative synthesis offers a method for utilising all three of the dislocations mentioned by Emmerson. The sound is dislocated from its time and space by the use of pre-existing (and pre-heard in the pieces presented) material, allowing an audio fragment whose apparent source is that of a physical instrument currently on stage to appear behind or next to the listener at any point during the piece, whilst retaining a link to the acoustic performance. The physical source of a sound may also be dislocated through concatenative synthesis, by allowing the sound of one instrument to be matched to the signal of another, whilst both instruments are on stage. The use of loudspeakers is integral to the success of this technique, enabling the "infinite sonority" of the computer to be physically integrated with an acoustic instrument's sound.

2   Composing for the concert hall

2.1 Sound Reinforcement

Speaker placement within mixed music has several effects on both the composer-listener dynamic and the composer-performer dynamic. One concern, addressed by Tremblay and McLaughlin (2009, pg. 379) is that of:

> …optimising the integration of live instruments and electroacoustic sound in the concert hall environment for both the performers and the public, by carefully choosing loudspeaker types and placement at commission time, and by avoiding sound reinforcement…

By placing radiating loudspeakers close to the performer, the loudspeaker imitates the position and sound generation of a traditional instrument. This allows the performer to hear both themselves and the electronic sound, reducing the need for extra monitoring systems for the performer. This allows the performer to react to the electronic part of the piece more naturally, and able to estimate the most suitable volume level to mix with the electronics.

2.2 Local and Field

The application of radiating loudspeakers enables the "Local/Field Distinction" (Emmerson 2007, pg. 92) to be subverted. Emmerson defines local and field as:

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> Local controls and functions seek to extend (but not to break) the perceived relation of human performer action to sounding result. Field functions create a context, a landscape or an environment within which local activity may be found.

Bell utilises this idea of local and field to extend the clarinet sound from the locality of the stage and into the field of the concert hall. The piece begins by extending the sound of the clarinet through quiet noisy textures and similarly pitched sine tones, with the diffusion performer maintaining these on stage. The sound is then slowly extended, both in the amount of sonic spectrum occupied by the piece and in the use of standard surround stereo pairs to extend the spatial characteristics of the sound. Through blending the local and field operations, the spatial dislocation mentioned earlier is used to extend the clarinet's causality, making the resultant sound mass causally related to the clarinet's performance.

Wells utilises two stereo pairs of speakers, one placed next to the performer, and the other pair placed slightly closer to the audience and wider apart. This allows the system to assign spatial placement for each layer of the piece, allowing the layers to be more distinct, and slightly straining the causal relationship with the instrument. This adds to the idea in *Bell* of extending the local into the field, yet this time existing on the periphery of the local/field boundary.

Centrist avoids extending the audio into the field any more than natural reverberation allows for, by simply using local radiating loudspeakers. This is to approximate the use of unamplified instruments, and maintain a physical presence at the location of each instrument in the duet. The main focus of this piece is on maintaining a causality over sound coming from the location of the instrument, and overly extending the sound into the field would disrupt the spatialisation of that sound.

Speaker positioning and specification allows a blending of the sonic possibilities afforded by the integration of the computer into live performance and the physical causality intrinsic to the constraints of the acoustic instrument. By choosing speakers with radiating properties, the locality of the instrument can be augmented by the computer audio, rather than simply offering a studio-centric stereo listening environment. This local-field dichotomy can then be used to aid in the dislocation of

the instruments fixed spatial causality through the use of field based, more directional speakers.

3 Form

3.1 Bounded Improvisation

The pieces within this portfolio utilise different levels of improvisation, bounding the performer in different ways.

In *Bell*, the performer is given timings, pitches and levels, yet is also given less determinate instructions, in order to facilitate the blending of the piece in different spaces and performances. The full form of the piece is essentially fixed, due to the fixed electronic part.

Wells uses a micro-defined form, where general instructions are given on the forming of the different textures within the piece and the textures used to create them, yet the performer is free to determine the exact lengths the sections of the piece are played for, as well as the exact dynamics, pitches and gestures used in the piece. This allows the performer to react to the performance system in a more fluid way, as well as being able to react to the space and audience of the performance. The exact length of the full piece and the sections of the piece, as well as the relative volumes will differ for every performance. The piece retains its identity through the use of the same limited range of techniques used to create the textures being used. The identity of the piece will also be solidified through performance in several situations, or with different performers. The similarities within several performances allow its identity to become more obvious.

Centrist has a macro-defined form. This defines different electronic processing presets for each section, and therefore the source of the playback grains for each instrument's input signal. The sound production methods of the instruments are not fixed, and neither are the instruments to be used for the performance. Each section of the piece should last about the same amount of time, but is not fixed, to allow different performance strategies to utilise the form of the piece. The realisation recorded in this portfolio utilises a 5 minute section length, allowing the use of a short

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form drone soundworld, which draws the three pieces presented into a coherent aesthetic.

Bounded improvisation avoids the singular event of a completely free performance, whilst removing the full burden of deciding the entire substance of the performance. Two of the pieces presented aim to bound the improvising performer in different ways. The micro-defined structure of *Wells* allows the performer to concentrate on the overall form and temporal relationships of the performance, whilst the macro-defined structure of *Centrist* allows the performers to develop the material contained within each section and its relationship to the other performer without having to decide the long-term form of the piece.

3.2 Drones

The use of drones in these pieces enable a focus on the causality of the sounds, by providing a temporal extension of the gestures within the piece. The sonic detail of the gesture changes slowly, associating the instrument within the piece with a small set of constrained performance techniques, leaving the listener time to establish the causal relationship between the instrument and electronics. The concatenative synthesis system used in the pieces allows a focus on similar material, recalling technique used in other longer form drone works, "refocusing the listener's attention on the subtle fluctuations in timbre or pitch that accrue greater importance against an otherwise static background" (Demers 2010, pg. 93)

The system allows many versions of the same gesture to be played at once, by matching the current input signal with previous grains in the system. This enables the "refocusing" on "subtle fluctuations" described by Demers.

The pieces however, do not stay static for the entire length, and in fact change drastically within a few seconds at points. This is not without precedent in earlier drone pieces, such as *Kyema* by Eliane Radigue (1988).This piece is described by Demers (2010, pg. 95) as: "sectional and episodic with a climax of sorts occurring approximately two-thirds of the way through the piece". Using teleological drones allows multiple instrumental techniques to be used within a piece, whilst still enabling the focus on small movements and variations.

Orthodox Caveman by Sunn O))) (2005) uses both short form drones (ten minutes total duration) and a similar instrumentation to that of *Wells.* Repeated melodic

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figures played on a downtuned, heavily distorted guitar provide the base material for the piece. The repetition of these riffs places a focus on the differences audible between iterations. These can be caused by an obvious decision of the performer, or by an unconscious change in performance technique between repetitions. Repetition in *Wells* uses these differences in a similar way to that of *Orthodox Caveman*, but with the addition of computer playback of sounds to introduce almost exact repetitions of previous material, alongside the instrumental source sound. This allows an almost exact comparison of the material to be made.

Drones in mixed music allow time for the listener to associate the electronic manipulation of sound with the instrumental performance. This enables the consolidation of an apparent causal relationship with the sound. *Centrist* illustrates this consolidation through the introduction of sounds from the saxophone being played by the speaker local to the guitar. This establishes an ambiguous causality to the electronic sound, with the spatial source and the descriptor values of the sound being close to that of the guitar, yet the sound character matches that of the saxophone. Drones are used in this case to give time to the listener question the causality of the sound, as more dynamically altering sounds would draw away the listener's attention from the similarities in the sound.

4 Wider Research

4.1 Augmented Reality

The use of augmentative digital technologies is not limited to use in music. Augmented reality is a research concern in many forms of media and art. Buechner (2011, pg. 55) describes augmented reality as being: "any change in the totality of our sensory and cognitive experiences (at any given moment) that is produced by some form of technology." This relates to music as a whole, through the technology of musical instruments, but more specifically to mixed music as it augments the physical sound with a digitally derived extension. Augmented reality is used as a basis of research for video game development in the Illumiroom concept (Jones et al, 2013), this extends the game from its traditional locality of the frame of the television screen into the field of the room containing it using projection mapping techniques on

the surrounding area. This mirrors the use of local and field techniques in mixed music, with the projection mapping taking the place of the field speakers used in mixed music, and the television taking the place of the acoustic instrument and any local radiating speakers used as augmentation.

Buechner's (2011, pg. 55) description of augmented reality gives the three ways in which changes to a user's "total experiential field" are implemented, as "additions, modifications and deletions". Both additions and modifications can be seen in Illumiroom and in the self-referential concatenative synthesis used here. In Illumiroom, modifications consist of changing the physical room so that its environment matches and extends that of the on-screen virtual environment. Additions are seen in the use of projected objects rolling "around the physical environment". In self-referential concatenative synthesis, modifications involve the re-organising of the performed sound into grains of set length, the temporal delay of the playback and the physical manipulation of their location in space. Additions involve the reintroduction of this electronically modified material.

5   Conclusions

This portfolio utilises the attribution and removal of causality to instruments as a form of musical performance. Acousmatic causal dislocations enable causality to be subverted with much more ease than in pre-electronic music. The systems built for use in this portfolio allow the augmentation of several acoustic instruments with the "infinite sonority" provided by the use of a computer. The systems allow for a wide range of sonic outcomes, which can be manipulated through the use of different instrumentation and performance techniques. Bounded improvisation allows the performer to exploit the flexibility of the system, whilst keeping an identity to the piece. Drones, along with considered speaker placement are used within the pieces to enable the association of causally disparate audio with a single extended performative gesture, allowing the musical manipulation of causal dislocation.

The use of digital technology as a mediator for the augmentation of instrumental performance reflects the current use of augmented reality as a way to augment physical environments. The use of Illumiroom to extend virtual environments into the

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real world through projection mapping shows how this is used in interactive visual arts, and may offer a direction for further research, extending the use of grains to visual mosaicking, linked to the performance. This would enable a further augmentation of the performative aspect of the work, and would be simple to implement through a link to an interactive visual performance software.

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Appendix A: Score for *Bell*

Bell

Score and Performance Notes

Ashley Green

Score notes

Timing
The timings in the score are from the beginning of the fixed audio. Each bar lasts for the timings shown above the bar. The piece ends when the fixed media fades to silence at 14:10.

Clarinet
The clarinet should play for the time specified, following instructions above the bar. A rest indicates the clarinet should not play for the time indicated.
The pitches in the score are played pitches for a Bb clarinet.
The clarinet is not to be amplified, unless necessary.

Diffusion
The diffusion starts at the beginning of the fixed media playback.

A crescendo marking in the diffusion part indicates a movement of the fixed media sound away from the stage, into the main auditorium speakers.
A decrescendo marking indicates a move back to the stage.
The movement in the sound should be achieved through a smooth change in speaker volumes using a mixing desk.

"Stage" in the score indicates the use of the stage speakers only.
"Auditorium" indicates the use of speakers within the main auditorium only.
"Half auditorium" indicates the use of stage speakers and the front stereo pair of auditorium speakers.
"Behind stage" indicates the use of speakers place behind the stage.

Speaker Setup
The stereo fixed media is to be reproduced on a loudspeaker system consisting of:
  * Mixing desk with the stereo input file routed to four stereo pairs
  * On Stage radiating speakers stereo pair (e.g., Bose L1) placed just behind the clarinettist.
  * Auditorium front stereo pair
  * Auditorium rear stereo pair
  * Behind stage stereo pair

Bell

Appendix B: Score for *Wells*

Wells

Score and Performance Notes

Ashley Green

Notes:

Technical setup:

The setup consists of:

- Fretless 4-string bass guitar – Tuned to standard EABG, with the E string tuned down an octave.
- Distortion pedal.
- Digital pitch-shift pedal.
- Volume pedal.
- Computer with audio interface and supplied Max/MSP patch.

Control:
The patch used for performance of this piece is designed to be controlled by a SoftStep footswitch, with an expression pedal connected.

The SoftStep controls the patch in the following way:

Key 1: Record the input signal to layer 1.
Key 2: Record the input signal to layer 2.
Key 3: Record the input signal to layer 3.
Key 6: Turn on or off playback of layer 1 grains which match the input signal.
Key 7: Turn on or off playback of layer 2 grains which match the input signal.
Key 8: Turn on or off playback of layer 3 grains which match the input signal.
Key 9: Toggle through record, playback, off of grains output from layer 1.
Key 4: Toggle through record, playback, off of grains output from layer 2.
Key 5: Toggle through record, playback, off of grains output from layer 3.
MIDI Pedal: control the mix of source signal with that of a band pass filtered signal.

Timings
Timings in the score are approximate. If the performance requires longer to be spent on each section, this is fine.

Key:
Rx - Record on layer x.
RRx - Record automatic playback on layer x.
Px-ON - Play on layer x.
Px-OFF - Turn off play on layer x.
PPx-ON – Turn on automatic playback on layer x.
PPx-OFF – Turn off automatic playback on layer x.

Section 1

Layer 1
0:00
R1

Allow e-bow to resonate slide by placing the slide within the e-bow, far enough away from the pickups to not be amplified.

Slowly move the e-bow and slide closer to the pickups of the bass, bending the slide within the e-bow to change the pitch, occasionally allowing the resonance to stop, through twisting the slide past resonance range.

1:00
P1-ON

Continue with resonating and pitch bending the slide.
Move the filter slowly to fully on.

1:30
Continuously tap behind the headstock of the bass, allowing the strings to resonate.
Back off the filter a little so lower frequencies are heard.

1:40
RR1-ON

2:00
PP1-ON

Remove filter completely.

2:30
Stop tapping headstock.
Remove e-bow from slide, bring e-bow to E String, close to bridge pickup, resonate string quietly and slowly increase volume.

2:45
P1-OFF
PP1-OFF

Section 2

3:00

R2

Create swelling gestures by moving the ebow closer to the string and the pickup, increasing the gestures in length and volume to around 15 seconds each.

3:15

P2-ON

Continue with swells, bring the slide to the string at the neck whilst the string is resonating to produce a rattle.

Allow e-bow to touch string occasionally.
switching off the layer 1 automatic playback.

4:00

RR2-ON

4:15

PP2-ON

Bring e-bow very close to bridge pick up on the e-string, with the most distortion to the sound as possible. Use slide at 12th fret on e-string, pulling the slide so it barely makes contact with the string. Find the point at which the sting begins to rattle. Move between this point, a fully voiced note at the 12th fret and an open e-string.

6:00

P2-OFF
PP2-OFF

Continue with the previous gesture, allowing more periods of silence. Touch the string with the e-bow to resonate the string at a high pitch.

Section 3
6:30
R3

Switch e-bow to octave mode, and play g-string between 15th and 17th fret, moving slowly between pitches.

6:45
Add pitch shift, moving between fully on and fully off.

7:20
P3-ON

Move filter to on until next timing.

8:00
P1-ON

9:00
Allow e-bow to resonate slide, with pitch shift.

9:20
P1-OFF

9:30
P3-OFF

Move e-bow and slide away from pickups slowly, until no longer audible.

10:00
End

Appendix C: Score for Centrist

Centrist

Score and Performance Notes

Ashley Green

Notes:

Technical setup:

The performance setup requires:

- Two musical instruments.
- Two radiating speakers (e.g., Bose L1, one per instrument), placed as close to the instrument as possible.
- Two cardioid microphones, one per instrument.
- Computer with audio interface and the performance patch.

The performers should be at opposite ends of the stage, with the speaker on the far side of the other performer.

Instrument:

The piece is for any two instruments. The instruments should ideally have a coincident pitch range.

Length:

The performance can be of any total length.

Each section should be around the same length, though they may vary slightly if the performance requires it.

The section length should be chosen before the performance begins.

Reading the score:

The score is read left to right. The top horizontal row represents the first instrument, the middle row represents the computer patch, and the bottom row represents the second instrument.

The words in the top and bottom row of rectangles represent the source of the grains created by the patch, matched to the relevant instrument's input signal. "Own" means the grains are derived from the instrument's own recording. "Both" means the grains are derived from both instruments' recording.

The numbers in the middle row of rectangles represent the preset number to be selected in the performance patch. The colour of the middle row of rectangles represents the recording and playback destination of the patch. Dark grey means the signal will be recorded to, and grains played back from, the first layer. Light grey means the signal will be recorded to, and grains played back from the second layer.

Content:

The first two sections should be formed of stable sonic material, and the final two of unstable material.

The makeup of the sonic material is determined by the performers, through the co-incident audio data found between the two instruments.

The performance patch:

The patch is controlled by selecting the preset number designated by the score at the start of each section, through a SoftStep USB controller.

Own	Both	Both	Own
1	2	3	4
Own	Both	Own	Both

Appendix D: Enclosed DVD.

Containing:

- Recordings of the three pieces presented here.

- The software patches required for the performance of the presented pieces.

- Electronic copy of this thesis.