Portfolio of Compositions and Written Commentary

Integration of acoustic and computer-generated sounds in mixed-media contemporary concert music through sonic interaction using serial and microsonic techniques

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Abstract

This thesis examines the integration of acoustic and computer-generated sounds in contemporary concert music through a portfolio of eight musical compositions and a written commentary. Through the development of the creative work, idiosyncratic compositional strategies for sonic interaction integrating diverse sources are developed. These strategies expand on existing work on sonic interaction and provide distinctive approaches using serial, indeterministic and microsonic techniques as methods for integration. The written commentary outlines the research narrative of the creative work, outlining its background, research questions, aims, objectives, methodology, and contributions. The commentary adopts the methodology of annotated portfolios with the aim of clarifying the research narrative in the creative work, at the same time capturing its multifaceted nature and the interrelations between the pieces in the portfolio. The eight compositions are analysed through five annotation topics: pitch to noise continuum, sonic gesture, sound mass, juxtaposition and superimposition of sound, and spatialisation. The annotations give key insights about the compositional strategies and play a significant role in addressing the research questions. This thesis aims to contribute to the field of mixed-media composition by producing a body of work with idiosyncratic compositional thinking, identity and perspectives, and providing individual perspectives into how compositional strategies may be developed for the integration of acoustic and computer-generated sounds.

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List of Works

This portfolio consists of eight scores, one data DVD (which contains the audio recordings and files for the electronics), and this written commentary.

Title	**Dates (in chronological order)**	**Duration**
Synthesis? – For One Loudspeaker	September 2016 – January 2017	11 min
A Study for String Quartet	January 2017 – March 2017	5 min
String Quartet	April 2017 – December 2017	9 min
Solo for Bb Clarinet	January 2018 – April 2018	13 min
A Study for Violin and Electronics	March 2018 – April 2018	9 min 30 s
Trio- for Eb, Bass Clarinets and Electronics	April 2018 – July 2018	7 min
Is There an If? – For Flute and Electronics	June 2018 – May 2020	20 min (duration depends on the performer's choice of movement sequence)
Requiem for Beauty – For Soprano, Ensemble and Electronics	August 2018 – December 2019	19 min

Total Duration: approx. 93 min 30 s

Recordings

1. *Synthesis?* – performed by Shu-Yu Lin at the Rymer Auditorium at the Department of Music as part of the White Rose Electroacoustic Network concert (2017)
2. *A Study for String Quartet* – read during the Ligeti String Quartet workshop at the Department of Music (2017)
3. *String Quartet* – 2 min 30 s of the piece was read at the Autumn postgraduate forum at the Sir Jack Lyons Concert Hall by Emily Jones (violin), Catherine Robson (violin), Bella Clifford (viola), and Sarah Kegerreis (cello) (2017)

   The recording corresponds to mm 1–7 and mm 105–123 on the score.
4. *Solo for Bb Clarinet* – recorded by Chiung-Yu Ku at the Trevor Jones Studio at the Department of Music (2018)
5. *Trio for Eb, Bass clarinets and Electronics* – recorded by Saori Kurimoto (Eb clarinet), Jun Ishii (bass clarinet), and Shu-Yu Lin (electronics) at Lin's residence in Puteaux, France (2021)
6. *A Study for Violin and Electronics* – recorded by Ping-Jie Wang (violin) and Shu-Yu Lin (electronics) at Lin's residence in Puteaux, France and Wang's residences in Paris and Malakoff, France (2021)
7. *Requiem for Beauty* – Terry Holmes Composer & Performer Award concert performed by Clare Lesser (soprano), the Chimera Ensemble, Shu-Yu Lin (electronics), and conducted by Dr John Stringer at the Sir Jack Lyons Concert Hall (2019)
8. *Is There an If?* – stereo version of movement sequence II III I II III I II recorded by Serina Kondo (flute) and Shu-Yu Lin (electronics) at Lin's residence in Puteaux, France (2021)

Acknowledgements

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I am also grateful to the clarinettists Saori Kurimoto and Jun Ishii for rehearsing and recording *Trio for Eb and Bass Clarinets and Electronics*, the violinist Ping-Jie Wang for discussing violin techniques and recording *A Study for Violin and Electronics*, and the flautist Serina Kondo for recording *Is There an If?*. Thanks to Chiung-Yu Ku for the discussions on the clarinet techniques, rehearsals, performance, and recording of the *Solo for Bb Clarinet*. My thanks to Wen Lee for her performance of *A Study for Flute and Electronics* at the 2018 Autumn postgraduate forum. Many thanks to Ben Eyes and Lynette Quek for their technical support for the rehearsal and performance of the *Synthesis?*, and their aid in the setup of the electronics and the recording of pieces. Thanks to many others who have helped me throughout my research, given me feedback on my work, and provided support in one form or another.

Lastly, I would like to express my gratitude to my father, my mother, and my husband for their unconditional support during these years of research, as well as for providing me with financial aid and resources.

Author's Declaration

I declare that I am the only author of this portfolio. Sources and quotations by others are cited. The recordings are provided with the performers' names and the locations where the pieces were performed, workshopped, or recorded.

This portfolio has not been accepted. Corrections will be made for final submission.

Commentary

Chapter 1 – Introduction

This portfolio of compositions consists of eight musical works and a written commentary, and aims to develop and examine idiosyncratic strategies that effectively integrate acoustic and computer-generated sounds in contemporary concert music.

The acoustic sounds used in the musical works include sounds from acoustic instruments, vocals, and field recordings. Computer-generated sounds are those which are digitally manipulated through digital signal processing or generated through digital synthesis. In the portfolio of works submitted, integration between acoustic and computer-generated sounds is achieved through serial and microsonic techniques adopted in the generation of sonic interaction, a joint process of sound generation between live acoustic instruments and digital electronics. Sonic interactions are demonstrated through idiosyncratic compositional strategies, which were developed through the practical work and discussed in detail in this written commentary. Additionally, each piece has a set of individual compositional objectives and concerns depending on their instrumentation, performance and aesthetic contexts, and technological specifications. However, all of the portfolio's compositions, in one way or another, aim to answer specific research questions about how integration between acoustic and computer-generated sounds may be achieved. This commentary maps, examines, and contextualises these strategies and gives insights into how they contribute to the formation of idiosyncratic compositional thinking, identity and perspectives. It also identifies where these strategies may be observed within the pieces, as well as clarifies the connections and interrelationships between the compositions.

1.1 – Background and research questions

Schachter and Menezes use the term *interaction* to refer to the joint process of sound generation involving live acoustic instruments and electronic resources through particular compositional methods.[1,2] Within this approach, both authors are concerned with the perceptual coherence between acoustically- and electrically-produced sounds when combined, which Schachter refers to as *integration* and Menezes as *fusion*.

Fusion relates to the process of spectromorphological interaction, where sounds' inherent structure may be transformed, or move between the extremes of contrast and fusion when combined with others. Menezes provides a taxonomy of interactions of contrast, fusion, and the transitional stages to describe the interactions between acoustic instrumental and electronic sounds, highlighting the importance of the perception, spatialisation, and transformation of sounds in integration. In *Atlas Folisipelis* (1996–7) for oboe, percussion, and electronics, fusion can be specifically attained through 'textual similarity' (oboe and electronics reciprocally play sounds of similar sonic properties) and 'virtualisation' (electronics project and spatialise the oboe sounds through a 'rotating trajectory' via an electronics system).[3] Perceptually, the listeners would be in a state of doubt in the interaction of 'textural similarity', where they are required to consider whether the sound is coming from the oboe or the electronics, as well as in 'virtualisation',

[1] Daniel Schachter, 'Towards New Models for the Construction of Interactive Electroacoustic Music Discourse,' *Organised Sound*, Cambridge University Press 12, no. 2 (2007): 67-78.
[2] Flo Menezes, 'For a Morphology of Interaction,' *Organised Sound*, Cambridge University Press 7, no. 3 (2002): 305-311.
[3] Ibid.

where no visual reference of the oboe in the trajectory of spatial movements is provided.[4] Menezes also provides an extensive taxonomy on the interaction through contrast, including 'textural distinction' and 'structural silence' (silences with instrumental sounds),[5] and transitional stages, including 'non-reflexive transfer' (the imperceptible 'transmutation' of one sound to another), 'convergent interference' (the merging of one sound into another of a contrasting characteristic), 'reflexive transfer' (perceptible 'transmutation'), 'directional contamination' (one sound's interference with another to gradually transmute it), 'potentialising interference' (a sound is heard differently in the context of another, neither in fusion nor contrast), and 'non-convergent interference' (one sound accentuates another without transmuting it).[6] For Menezes, compositional stage is essential in creating and managing interactions while also taking into account the perception in listeners, spatialisation, and collaborative sonic transformation.

Further to Menezes' theory on the interaction of sound primarily from the perspective of composition, Schachter proposes the notion of integration linked to the live quality of electronic music and the physical co-actions of performers.[7] *FlaX* (2002) for real-time processed flute and electronics, pinpoints the aspect of gesture, perception, open structure, and interactive system design for interaction in particular. The composer details the interaction during the composition processes in four steps. The first two highlight the importance of the flute gesture at the compositional and recording stages: writing the flute part (consisting of 32 short fragments of sound with characteristic gestures) and recording these flute segments as recorded material for the electronics part.[8] During a performance,

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[4] Menezes, 'For a Morphology of Interaction,' 305-311.
[5] Ibid.
[6] Ibid., 309-311.
[7] Schachter, 'Towards New Models for the Construction of Interactive Electroacoustic Music Discourse,' 71.
[8] Ibid., 72-73.

a flautist interacts with the recorded flute sound by responding to it based on scored instruction.[9] The third step relates to the perceptual aspect where 32 recorded flute sounds are grouped in a series of categories of how a specific sound may possibly be perceived: ‘frullati’, ‘impulses’, ‘crescendo’, ‘iteration’, ‘long notes’, ‘phrases’, and ‘rough sounds’.[10] These categorised sounds are played back so as to interact with the live flute sounds.[11] The fourth step involves creating an interactive system that can play back the recorded flute sound, conduct live processing on instrumental sounds, and interactively change the ordering of sounds to highlight the ‘controlled randomness’.[12] Schachter notes that the structure of this piece is ‘episodic’, where flautist and electronics performers both simultaneously choose modules to play as a method of interaction (sections within the modules are unchanged).[13] In short, Schachter proposes integrating sounds through simultaneous gestural co-actions and decisions on the materials to play, which thus affects the structure of the live interaction.

Menezes’ spectromorphological approach to fusion and Schachter’s approach to integration through performers’ co-action are examples of effective frameworks for sonic interaction that may serve to achieve the integration of acoustic and computer-generated sounds. Extending these two approaches, this portfolio develops idiosyncratic compositional strategies for sonic interaction that use serial organisation and microsonic techniques for integration.

The compositions presented in the portfolio, as well as the insights and discussions within this written commentary, seek to address the following research questions:

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[9] Schachter, 'Towards New Models for the Construction of Interactive Electroacoustic Music Discourse,' 73.
[10] Ibid.
[11] Ibid., 73-74.
[12] Ibid., 73, 76.
[13] Ibid., 76.

1. To what extent can idiosyncratic compositional strategies be developed with the purpose of integrating acoustic (instrumental, vocal and field recordings) and computer-generated (digital effects and synthesis) sounds in contemporary concert music?

2. How can digital interactive systems be used to integrate acoustic and electronic sounds by algorithmically generating musical structures through serial methods, generating both synthesised sounds and note information for musical notation?

3. How can micromontage and granulation techniques be applied to generate sonic interactions between acoustic and computer-generated sounds using pre-recorded and live inputs?

1.2- Aims and objectives

This research has three underlying aims: first, to develop idiosyncratic compositional strategies with the purpose of integrating acoustic and computer-generated sounds implementing serial methods and the use of micromontage and granulation techniques. These strategies are developed through pure instrumental and electronics works, as well as via pieces for a mix of instruments and electronic media. Second, serial strategies are examined and evaluated in relation to the resulting sonic interactions, as well as how effectively they integrate computer-generated sounds and acoustic instruments. Finally, this research examines micromontage and granulation techniques implemented using digital interactive systems in order to determine their efficacy in integrating diverse sound sources, including live, pre-recorded, instrumental, vocal, and synthesised sounds.

These aims are achieved through the following objectives:

1. Compose fixed-media, instrumental, and mixed-media works in order to show a diverse use of techniques for sonic interaction and integration of acoustic and computer-generated sounds.
2. Create a fixed-media electronic work by juxtaposing and superimposing synthesised sounds generated from the ChucK programming language and pre-recorded sounds from acoustic sources (clavichord, bird calls, and waterfalls) in a digital workstation.
3. Compose a study for string quartet, creating sound masses with contrasting characteristics using extended techniques and evaluating the extent to which their juxtaposition may be suitable as an interaction method with computer-generated sounds in subsequent pieces.
4. Compose another string quartet that uses a pitch-based serial matrix to create sound masses and juxtapose them with non-serial sounds to observe contrast and fusion in sonic interaction, examining the possibility of using pitch as mediator between instrumental and computer-generated sounds.
5. Compose a solo Bb clarinet piece that uses the same pitch-based serial matrix of the string quartet in order to examine further operations on the matrix, with the idea of implementing these serial procedures into a generative algorithm to produce material in subsequent mixed-media pieces.
6. Create a program in the SuperCollider programming language to calculate pitch intervals from the three dimensional pitch matrix used in the string quartet that can be applied to both acoustic instrumental composition and digital interactive systems.
7. Develop an interactive system that generates synthesised pitched sounds using the three dimensional matrix, introducing stochastic processes to generate and manipulate new series.
8. Compose a mixed-media piece for violin and electronics in which pitch-based synthesised sounds are derived from the three dimensional matrix, and examine the effectiveness of the integration between acoustic and synthesised sounds.
9. Compose a mixed-media piece for Eb clarinet, bass clarinet, and electronics using the serial matrix to generate pitches for sound synthesis, exploring the interaction between different registers of the clarinet and the synthesised sounds.

10. Develop an interactive system in the SuperCollider programming language for granular synthesis using live- and pre-recorded sounds, and real-time spatialisation, as a tool for integrating acoustic and computer-generated sounds.
11. Compose a mixed-media piece for soprano, 13 orchestral instruments (flute, clarinet, bass clarinet, bassoon, contrabassoon, horn, trumpet, trombone, tuba, violin, viola, cello, and piano), and electronics that uses a granular interactive system to mediate between acoustic instrumental and real-time spatialised computer-generated sounds, which include recorded clarinet sounds, granular sounds using a recorded reading of a text by the soprano, and field recordings, as inputs for granulation.
12. Compose a mixed-media piece for flute and electronics that uses a granular interactive system to manage flute and real-time spatialised computer-generated sounds (which uses live and field recordings as granulation inputs).
13. Review the existing literature and compositional practices related to sonic interaction and integration of acoustic and computer-generated sounds to identify concepts and techniques that may be expanded through compositional practice.
14. Discuss idiosyncratic compositional strategies for integration developed in the portfolio and identify them in the form of annotations in this written commentary.

1.3 – Methodology

This research applies the concept of annotated portfolios, first introduced by Gaver and Bowers,[14,15] to practise research in composition. The idea of an annotated portfolio was originally developed in the context of interaction design and Human Computer Interaction (HCI) research. Such a portfolio 'highlights, formulates, and collates interaction design issues', and communicates design thinking efficiently without being constrained by

[14] Bill Gaver and John Bowers, 'Annotated Portfolios,' *Interactions* 19, no. 4 (2012): 40-49.
[15] John Bowers, 'The Logic of Annotated Portfolios: Communicating the Value of "Research Through Design",' *DIS '12: Proceedings of the Designing Interactive Systems Conference*. (Association for Computing Machinery, 2012): 68-77.

theory,[16] while also respecting the multidimensionality of works.[17] The portfolio is indexical, wherein each index points to features of a design work and connects them to particular areas of research or concern.[18,19] The purpose of the indexing is to extract useful information that may not be evident if viewed purely from theoretical perspectives.[20] Additionally, a portfolio's annotations may bring individual pieces into a systematic body of work, capture similarities and differences between them, and be mutually informative – pieces may be further understood by annotations, and annotations may be illustrated by the pieces.[21]

Following the methodological scheme of the annotated portfolio, this research extracts information from the practical works and relates them to their research narrative. Concretely, this commentary discusses the portfolio's eight works in the form of annotations. Annotation topics include pitch to noise continuum, sonic gesture, sound mass, juxtaposition and superimposition of sound, and spatialisation. These topics were selected due to their commonality across works, as well as their capacity to reveal different insights about the idiosyncratic strategies developed in the portfolio in relation to sonic interaction and the integration of acoustic and computer-generated sounds.

1.4 – Contribution

This research contributes to the field of mixed-media composition – which combines live instrumental, vocal, and computer-generated sounds – through the development of a body of original work and idiosyncratic strategies that aim to provide novel approaches to sonic

[16] Ibid., 68
[17] Gaver and Bowers, 'Annotated Portfolios,' 43.
[18] Ibid.
[19] Bowers, 'The Logic of Annotated Portfolios: Communicating the Value of "Research Through Design",' 70.
[20] Ibid.
[21] Gaver and Bowers, 'Annotated Portfolios,' 40-49.

interaction. These strategies expand on existing sonic interaction methods by providing distinctive approaches to serial and microsonic techniques, as they are applied as processes for integration. Sonic interaction mediated through pitch organisation in serial techniques and structuring process in micromontage and granulation techniques were found to be particularly effective in the practical work. Furthermore, the approaches to notation and digital interactive systems developed in this portfolio were key in establishing a dynamic interplay between acoustic instrumental, vocal, and computer-generated electronics – particularly evident in the works consisting of complex interactions involving microsounds. Specific strategies for sonic interaction are discussed as annotations in Chapter 3, giving different perspectives of the contexts in which they can be observed within the portfolio.

Instead of developing completely new methods for the integration of acoustic and computer-generated sounds, this research examines existing approaches and applies techniques in distinctive ways in order to create a portfolio that adds to the repertoire of compositions focusing on sonic interaction. The compositional work applies existing techniques, but repurposed as integration strategies and recontextualised to specific musical and technical contexts. Through the portfolio's development, strategies for sonic interaction have been formulated to produce a body of work with idiosyncratic compositional thinking, identity and perspectives. Furthermore, these strategies may be applied by other composers as techniques for mixed-media compositions and as design considerations for interactive systems. This written commentary contributes by applying methodologies in interaction design and HCI to practise research, adopting practices used in annotated portfolios to: 1) capture the multi-faceted nature of compositional work, 2) provide insights into the interrelations between pieces in the portfolio, and 3) make evident the research narrative embedded in the compositions.

1.5 – Content overview

This portfolio consists of eight compositions and a commentary. The order of presentation is chronological, showing the gradual and cumulative research and development.

1.5.1 – Electronic and instrumental composition

The following pieces are the portfolio's first works, and are studies examining different techniques that were subsequently refined for sonic interaction in the mixed-media pieces.

Synthesis?

This is a work for fixed-media electronics. It examines the juxtaposition and superimposition of field recordings, clavichord, and digitally-synthesised sounds.

A Study for String Quartet

This piece explores using extended techniques in string instruments to create instrumental sound masses, and the juxtaposition and superimposition of sound masses as a compositional process.

String Quartet

Following the experience of *A Study for String Quartet*, this piece additionally uses a serial method to create sound masses. Serial sound masses are juxtaposed between sections in the piece to contrast with non-serial elements.

Solo for Bb clarinet

Continuing the research using a serial matrix, this piece derives pitch materials by chromatically adding pitches onto the pitches of the matrix. This process is repeated several times to aggregate pitches to form pitch series.

1.5.2 – Mixed-media composition

These pieces focus on building and using interactive systems for sound generation, and demonstrate the move from a pitch-based serial approach to micromontage and granulation techniques.

A Study for Violin and Electronics

This study uses the SuperCollider programming language, continuing the pitch-based serial experiments. The pitch matrix from *String Quartet* is algorithmically enlarged into a three dimensional pitch structure, where, in the third dimension, each plane is the transposition of the original matrix. To generate the electronic sounds, an interactive system was built to randomly select pitches within the structure and synthesise sounds.

Trio for Eb and bass clarinets and electronics

This piece elaborates the three dimensional pitch structure from *A Study for Violin and Electronics*. The electronic sounds are generated by the same random selection and synthesis method. However, the purpose here is to explore the possibilities of using these pitch-based synthesised sounds with two wind instruments and granular sounds.

Requiem for Beauty for soprano, 13 instruments and electronics

This piece uses a granulation approach from an interactive system to synthesise sounds, where sound samples are randomly selected within recorded sound files for synthesis. The system specifically uses a recorded reading of a text by the soprano, recorded instrumental, and natural environmental sounds as input sources for granulation. With spatialisation through a surround sound system of eight loudspeakers and two subwoofers, diverse sonic interaction can be achieved in addition to the fixed-position vocal and instrumental sounds from the concert stage. The instruments used include flute, clarinet, bass clarinet, bassoon, contrabassoon, horn, trumpet, trombone, tuba, violin, viola, cello, and piano.

Is There an If? for flute and electronics

This piece explores sonic interaction between live flute and computer-generated sounds through granulation and spectral processing from an interactive system.

1.5.3 – Commentary

Further to the practical works exploring a series of sound experimentations using acoustic instruments and digital interactive systems for sonic interaction, this commentary frames the discussion of works within the topic of integration and contextualises them within serialism and microsound. Through these two lenses, the commentary discusses the works in the form of annotations to make evident how the compositional strategies developed may be observed in the compositions, how the different pieces in the portfolio link to each other, and how the practical work relates to the research questions, aims and objectives.

The remainder of this thesis is structured as follows. Chapter 2 examines the research and artistic context of this work and previous approaches to serial, indeterministic, micromontage, and granular methods for sonic interaction, and positions the practical works to the specific methods used in prior compositional practice. Chapter 3 presents musical features that were developed in the portfolio relating to sonic interaction (pitch to noise continuum, sonic gesture, sound mass, juxtaposition and superimposition of sound, and spatialisation) and annotates the practical works in these contexts. Idiosyncratic strategies for sonic interaction are examined through the annotations, and common qualities in the different compositions in the portfolio are identified. Chapter 4 summarises the research results, outlines the answers to the research questions, identifies the limitations, and proposes avenues for future research.

Chapter 2 – Research and Artistic Context

Integration of acoustic and computer-generated sounds in mixed-media composition is an area of compositional practice that may be observed through the work of a wide range of contemporary composers. The aim of this chapter is not to provide an exhaustive and systematic review of all practices concerned with this compositional concern, but rather to provide the research and artistic context of works and methods that have directly influenced the compositions in the portfolio. In the previous chapter, two theoretical approaches to sonic interaction were described based on research by Menezes, on integration through morphological interaction, and Schachter, via simultaneous gestural and structural co-actions of performers. This chapter examines works exploring serial, microsonic and indeterministic approaches that may be used for integrating acoustic, synthetic and processed sounds. Additionally, the work surveyed here directly influenced the compositions in the portfolio. This chapter therefore presents different approaches to integration using serial (2.1) and microsonic (2.2) methods, indeterministic processes of random selection for sound generation and formal structuring (2.3), and gives insights into the compositional influences and concerns that shaped the contents of the portfolio.

2.1 – Serial pitch and harmony for interaction

This section examines electronic and mixed-media works by Stockhausen and acoustic instrumental pieces by Boulez and Stravinsky to identify different methods of serial organisation that can be applied to integrate acoustic and computer-generated sounds and used to design digital interactive systems.

In Stockhausen's mixed-media works, serial methods are applied to synthesise and process sounds electronically. Maconie observes that the analogue system is the agent for processing and transforming of serial sounds in *Kontakte* (1959–60) for tape, piano, and percussion.[22] The system employs serial permutation procedures to determine the delay between impulses and their amplitudes.[23] These are recorded to create the tape part of the piece, and played back at various speeds to create sounds that are ‘either discrete rhythmical events or continuous, broad-band textures’.[24] Serial procedures in this piece are the common ground between the interaction between the piano and percussion, and the electronically generated sounds.

Stockhausen’s *Mantra* (1970) for two pianos, analogue ring modulators, and percussion further demonstrates a pitch-based serial process with ring modulators. To derive melodies of the piece, a 13-tone series is repeated to ‘contract’ and ‘expand’ a structural ‘formula’.[25] More specifically, live processing is involved to either slow or accelerate woodblock and piano gestures, to loop gestures with reverberation, and to compress the work through acceleration.[26] Similarly with *Kontakte*, the interest is the treatment of the duration of electronic sounds to diversify the rhythmic aspect, counteracting the physical limitation of the human performer on speed.

The serial method is also involved in the organisation of melodies in Stockahusen’s *Gesang der Jünglinge* (1956), for fixed-media. These melodies are sung and recorded for further processing, which includes the repetition of certain phrases, words, and phonemes.[27] Recorded and treated serial melodies are juxtaposed with synthesised sound

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[22] Robin Maconie, 'Stockhausen at 70. Through the Looking Glass,' *The Musical Times* 139, no. 1863 (1998): 7.
[23] Agostino Di Scipio, 'Micro-time Sonic Design and Timbre Formation,' *Contemporary Music Review* 10, no. 2 (1994): 137.
[24] Ibid.
[25] Jerome Kohl, 'The Evolution of Macro- and Micro-Time Relations in Stockhausen's Recent Music,' *Perspectives of New Music* 22, no. 1/2 (1983 - 1984): 147-185.
[26] Xenia Pestova, Mark T. Marshall, Jacob Sudol, 'Analogue to Digital: Authenticity vs Sustainability in Stockhausen's Mantra (1970).' *34th International Computer Music Conference* (2008)
[27] Roads, *Composing Electronic Music: A New Aesthetic*, 81.

from sine, impulse and filtered, and broadband noise, as well as 'chords' of narrow noise bands.[28] The electronic system in Stockhausen's work is the tool for communication, managing the interaction. This idea is adopted in the digital interactive system design for the mixed-media works in this portfolio.

The intricate serial processes using hexachord in the pre-planning stage of the instrumental serial works of Boulez and Stravinsky could provide further ideas on designing serial interactive systems. In Boulez's *Messagesquisse* (1976), two matrices are used to derive serial melodies. Matrix A consists of the pitches of the interval classes of the 'Sacher' hexachord (Eb, A, C, B, E, D), rotated so that each series begins from Eb, resulting in a matrix with six rows and six columns of pitches, while Matrix B transposes the interval classes of the original hexachord.[29] Another later serial work of Boulez, *Incise* (1994, 2001) for piano, verticalizes the hexachords to create a 'tonic' collection.[30] Stravinsky's *Requiem Canticles* (1966) also demonstrates the verticalization of serial pitches for harmony, predating Boulez's *Incise*. Specifically, the composer derived a pitch matrix from rotating six-note pitch series (A#, G#, A, D, C, B) and transposing them so that each begins from A#.[31] The pitch series from the matrix are superimposed and juxtaposed to form chordal harmony played by the violins I, II, viola, cello, and double bass at the culmination of the Exaudi movement to create a static, serial harmony with half and whole notes.[32] Both composers use hexachords to create melodic or harmonic material. In this portfolio, the serial method of organisation is adopted not only in the instrumental works, but also in creating digital interactive systems for generating pitch-based serial sounds.

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[28] Roads, *Composing Electronic Music: A New Aesthetic*, 236.
[29] Arnold Whittall, *The Cambridge Introduction to Serialism* (Cambridge University Press 2008), 205.
[30] Ibid., 209.
[31] Joseph N. Straus, 'Stravinsky's "Construction of Twelve Verticals": An Aspect of Harmony in the Serial Music,' *Music Theory Spectrum* 21, no. 1 (1999): 45, 47.
[32] Ibid.

2.2 – Microsonic structuring process for integration by micromontage and granulation

The concept of microsound offers an opposing perspective to serialism, whereby sonic operations on sound grains do not involve teasing pitch, timbre, or duration apart, but involve processing on the grain's properties (e.g., duration, density, frequency). Moreover, this approach can also be used as a method for integrating acoustic and computer-generated sounds. This section presents micromontage and granulation approaches from which to generate interaction in the structuring process of sounds that crosses timescales, from micro (a few milliseconds), meso (seconds), to sound object timescale (100ms to several seconds).[33] While many composers have contributed to this area of compositional practice, this section will focus on works by Vaggione, Roads and Meneze, which influenced some of the compositions in the portfolio.

Vaggione uses the micromontage technique to manually operate on sound samples to structure in micro timescale so as to form larger entities of sounds. To create microrhythms in *Points Critiques* (2011), the IRIN program (2005) is specifically used, in which the composer graphically edits and organises sound samples of recorded orchestral instrumental sounds.[34] These microrhythms form intricate and dense sounds that contrast with the free and metrical elements as a way of interaction in the structuring of the work.[35]

In contrast to micromontage, Curtis Roads uses algorithms to create interaction based on scripted instruction. Specifically, Roads uses algorithmic granulation to generate and organise granular sounds with possible effects, such as 'freezing', where a pointer stops at a grain and repeats it, 'random selection' or 'scattering', where points in a sound file are selected randomly, and 'grain size variation', to generate noise, and 'pitch-

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[33] Curtis Roads, *Microsound* (Massachusetts Institute of Technology 2001), 11-21.
[34] Roads, *Composing Electronic Music: A New Aesthetic*, 82, 158-160.
[35] Ibid.

shifting'.[36] In *Tenth Vortex* (2001), sounds begin from a pitch-based texture and transform into a noise texture by contracting the duration of a grain, widening the bandwidth.[37] In this piece, pulsar synthesis is used to generate a recorded source as an input of real-time granulation.[38] *Sculptor* (2001), on the other hand, uses a recorded percussion sound as a granular input to create a continuous 'cloud' and 'flow of undulations, spectral fluctuations, and accents'.[39]

A combination of manual operation on sound samples and generative algorithms can be seen in Vaggione's *Fractal C* (1984). This piece uses the CARL interactive system to select parts from a sound file to create new ones. Furthermore, a DEC VAX-11/780 mainframe computer is used to give UNIX commands to chain a series of musical instructions.[40]

Besides pure electronic works, granular sounds are also used in mixed-media works. Meneze's *Atlas Folisipelis* uses oboe sounds as inputs to create a granular 'cloud' at the beginning of the piece. The interaction occurs when the live oboe sound 'interferes' with the granular 'cloud', and finally converges with it (termed 'convergent interference' interaction).[41] Additionally, this composition uses both fixed electroacoustic sounds and live-electronics *ad libitum*, establishing interactions between recorded acoustic instrumental and synthesised sounds, and live processing (granulation) of the oboe. All of these elements are combined structurally within the composition, creating both coherence

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[36] Roads, *Composing Electronic Music: A New Aesthetic*, 133.
[37] Ibid., 118.
[38] Ibid., 188.
[39] Ibid.
[40] Curtis Roads, 'The Art of Articulation: The Electroacoustic Music of Horacio Vaggione,' *Contemporary Music Review* 24, no. 4-5 (2005): 299.
[41] Menezes, 'For a Morphology of Interaction,' 309.

between granular and instrumental sounds and different structural elements in the composition.

2.3 – Integration through random selection for sound generation and large scale structures

Indeterminacy and stochastic algorithms can be used for sound generation, control structures and musical form. These methods can also be used as strategies for the integration of acoustic and computer-generated sounds.

Indeterminacy may happen at different levels of sonic production and musical structuring. This is evident in Curtis Roads' criticism of John Cage's approach to indeterminacy, suggesting that indeterministic elements are constrained by Cage's formal planning.[42] This statement reflects the multifaceted nature of musical form and sound production, where random processes may occur at different structural and formal levels. Following on Roads' criticism of Cage, open structure, for example, could be an effective alternative for organising indeterministic elements of the macrostructure of a composition. For example, In Schachter's *FlaX*, a flautist and an electronics performer are engaged in the indeterministic macro structuring process of the work by simultaneously choosing composed modules on the score to play live during the performance.[43]

Xenakis' dynamic stochastic synthesis of sound in the GENDYN system, is an example of how indeterminacy may be implemented at the level of sound generation. This digital synthesis system uses indeterminacy to manage the interaction between pitched

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[42] Menezes, 'For a Morphology of Interaction,' 309.
[43] Schachter, 'Towards New Models for the Construction of Interactive Electroacoustic Music Discourse,' 72-73, 76.

sounds and noise through the stochastic organisation of breakpoints in a sound wave.[44] In the system, the interaction occurs between 'low-level automata' (basic sonic entities) to 'acquire complex properties' to create 'unpredictable' sounds.[45] In *Gendy 3* (1991) Xenakis uses the system to create 'unpredictable' sounds, which emerge from 'chaotic noise only to dissolve into chaos, never to be heard again', demonstrating 'emergent behaviour'[46] as a concrete interaction method operated by the system. This composition is also a great example of how stochastic processes can be used at different levels, from micro-sound to macro-structure. Additionally, in this work, order and random behaviours coexist through stochastic procedures, such as weight functions, which are used both to generate sound and to create the overall musical structure. To manage these two polarities, manual control on parameters are used to control the algorithmic synthesis and control structures.[47]

In the compositions in the portfolio, indeterminacy and stochastic methods are used for sonic interaction using control and random processes, whether for selecting samples in granular sound generation, controlling the evolution of sounds, or formally organising interaction. These processes are also used as ways of integrating instrumental and computer-generated sounds - stochastic methods are used as compositional tools to generate notated material for instrumentalists, as well as implemented in the digital interactive systems for the live electronics both for sound generation and manipulations as well as to manipulate control structures.

This chapter examined the research and artistic contexts of works and techniques that have directly influenced the compositions in the portfolio. Building upon theoretical

[44] Roads, *Composing Electronic Music: A New Aesthetic*, 296-297.
[45] Ibid., 296.
[46] Ibid.
[47] Ibid., 350-353.

frameworks from Menezes and Schachter outlined in the previous chapter, this chapter investigated serial, microsonic, and indeterministic approaches to integration of acoustic and computer-generated sounds. Serial methods used in Stockhausen's electronic and mixed-media compositions and techniques employed in instrumental works by Boulez and Stravinsky, may offer insights into how serial techniques may be used to establish integration between acoustic and electronic sources. Microsonic structuring processes, as demonstrated by Vaggione, Roads, and Meneze, also provide avenues for sonic interaction through micromontage and granulation techniques. Lastly, stochastic processes for sound generation and control structures, inspired by the work of Xenakis, Schachter and Roads, may offer further strategies for integration. By considering indeterminacy at all levels of musical structure, from microsonic sound generation to large-scale musical structure, integration may be achieved by implementing stochastic processes both in instrumental writing and the design of interactive systems for live electronics.

Chapter 3 – Annotations

This chapter follows the logic of annotated portfolios, introduced by Gaver and Bowers (1.3 – Methodology), and is applied to examine the compositions within the submitted portfolio. The notion of annotated portfolios involves the deliberate curation of works and their presentation as a coherent whole through suitable media, accompanied by indices pointing to features within the work alongside brief textual annotations. As discussed in Chapter 1, annotations extract useful information that may not be easily discernible solely through theoretical examination. They serve to integrate individual pieces into a coherent body of work, delineate commonalities among them, and compliment each other by adding further knowledge through their juxtaposition. The portfolio of eight works has been analysed for its musical qualities and five common features have been identified as annotation topics. These are: pitch to noise continuum, sonic gesture, sound mass, juxtaposition and superimposition of sound, and spatialisation (3.1 – Annotation topics in context). These topics not only reflect different areas in which integration between acoustic and computer-generated sounds may take place, but also relate to the research and artistic context of applying serial, indeterministic and microsonic approaches to sonic interaction of diverse sound sources. By examining these particular features as annotations and pointing out where these occur in the different compositions, the research narrative and context that binds these pieces together becomes more evident. Moreover, the presentation of annotations for individual index points within the work reveal the idiosyncratic compositional strategies developed in the portfolio for integrating acoustic and computer-generated sounds. Moreover, the annotations contribute to reveal distinct compositional thinking, identity and perspectives that are embedded in the submitted portfolio.

3.1 – Annotation topics in context

After careful consideration of the compositional concerns and close analysis of the musical qualities found in the compositions, the following annotation topics (each annotation topic is represented with an A and is numbered sequentially (A1, A2, A3, etc.)) have been identified as key features that are common across the portfolio. Before examining how these features appear in the compositions, a short definition, examples and background for each annotation topic will be provided.

3.1.1 – Pitch to noise continuum (A1)

Further to viewing pitch as a discrete sonic property (e.g. serial approach), pitch can also be seen as a pole in the pitch-noise continuum, wherein the intermediary states include 'pure pitch' to 'tuned noise' to 'broadband noise'.[48] Xenakis' *Gendy 3* (1991) effectively demonstrates the articulation of the continuum in which melody emerges from noise through the use of dynamic stochastic synthesis in the GENDYN system.[49] It is also possible to create intricate noise textures in a DAW, as in Vaggione's *Points Critiques* (2011), which uses orchestral instrumental recordings as sound sources for graphical micromontage processes in the IRIN program.[50]

3.1.2 – Sonic gesture (A2)

Sonic gestures reflect transformation of energy, beginning from an energy inertia via a physical action into a sound system, such as an instrument, vocal larynx, electronic system,

[48] Roads, *Composing Electronic Music: A New Aesthetic*, 208.
[49] Ibid., 296-297.
[50] Ibid., 158-160.

or a means for sound production to the resulting streaming of sound in space.[51] An example of this can be observed in the interaction induced from physical co-actions of flautists and electronics performers in Schacter's *FlaX* (2002). Furthermore, Menezes' concept of the interaction of sounds through 'convergent interference', where a sound merges into another of contrasting characteristics, and 'non-convergent interference', referring to one sound accentuated without transmuting the other,[52] also relates to the idea of gesture and streaming. Wishart's *Anticredos* for six voices shows continuous streaming and their divergences, in which the seamless transformation between the two can be obtained using extended vocal techniques.[53] Further to instrumental and vocal music, musical interfaces for granulation can use sound streaming and counterpoints as interaction methods, as shown in the design of Creatovox's engine, where the scheduling, overlap, amplitude, and density of sound particles transforms them and evolves granular sound streams.[54]

3.1.3 – Sound mass (A3)

In terms of inherent properties, sound mass relates to sonic interaction. From Stockhausen's statistical view on sound, it entails transformations between sound 'points' and 'groups of points'.[55] Here, the transformation is the inner interaction within a mass. From the perspective of microsound, it is a 'block of sound' that consists of streaming and the formation of granular clouds, wherein masses evolve slowly.[56] A more concrete description is a 'monolith of sound constructed from the superimposition of multiple

[51] Trevor Wishart, *On Sonic Art* (Harwood Academic Publishers 1996), 17 - 18.
[52] Menezes, 'For a Morphology of Interaction,' 309-311.
[53] Wishart, *On Sonic Art*, 115.
[54] Roads, *Microsound*, 194.
[55] Robin Maconie, *Stockhausen on Music* (Marion Boyars Publishers 1991), 41-44.
[56] Roads, *Composing Electronic Music: A New Aesthetic*, 310.

sources',[57] suggesting the possibility of engaging different sound sources in interaction. Hubert S Howe Jr.'s *Clusters* (2010) is an example of sound mass composition where the composer expands a sound of sinusoidal pentachords into a mass consisting of three or four octaves.[58] Risset's *Sud* (1985) serves as another example where the composer processes broadband noises through resonant filters to create harmonic clusters in sound masses.[59]

3.1.4 – Juxtaposition and superimposition of sound (A4)

Juxtaposition is a process of rapidly changing between two sounds at temporal junctions (or abrupt shifts between sounds) with minimum transition,[60] while superimposition refers to the layering process which forms a particular texture within a sound mass.[61] These structural processes can be applied to generating interaction through breaking permutation cycles and patterns,[62] as well as inducing sudden changes to characteristics within slowly-evolving clouds.[63] With the use of intermittent silences, contrasting sonic impressions of distances, 'far' and 'near', can be created, as demonstrated in Roads's granular work *Touche Pas* (2009).[64]

3.1.5 – Spatialisation (A5)

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[57] Roads, *Composing Electronic Music: A New Aesthetic*, 308.
[58] Ibid., 308.
[59] Ibid., 308-310.
[60] Ibid., 315-316.
[61] Ibid., 308.
[62] Ibid., 27.
[63] Ibid., 311.
[64] Ibid.

Sounds can be juxtaposed and superimposed within a space using spatialisation techniques,[65] interactively structuring a piece in live performance with a pluriphonic sound system. These techniques can integrate field recordings of natural environments into a fixed-media work, as seen in Luc Ferraris' *Presque Rien* (1967–1970).[66] Furthermore, interaction through spatialisation can also be seen in Menezes' *Atlas Folisipelis* (1996–7), which uses a quadraphonic speaker system to project recorded oboe, and granular, computer-processed sounds.[67] Spatialisation techniques can also be used to emphasise sonic elements during complex interactions. In Stockhausen's *Gesang de Jünglinge*, particular phrases, such as '*priest den Hernn*' ('Praise the Lord'), have certain words and phonemes emphasised[68] through spatialisation using a multi-speaker system. These systems consist of five groups of loudspeakers,[69] each group with four loudspeakers, with one loudspeaker placed above the audience.[70]

Now that the annotation topics have been defined, and examples and background has been provided to clarify and contextualise them, annotations for individual index points according to identified topics will be provided for each composition in the portfolio.

3.2 – Synthesis?

- A1: *Pitch to noise continuum*

Recording of a waterfall resembling white noise (from 4' 34, crossfade, and ending on 5' 28) versus bird calls with a clearer pitch contour (for example, at 1' 13). Algorithmic

[65] Roads, *Microsound*, 232.
[66] Roads, *Composing Electronic Music: A New Aesthetic*, 248.
[67] Menezes, 'For a Morphology of Interaction,' 309.
[68] Roads, *Composing Electronic Music: A New Aesthetic*, 81.
[69] Ibid., 245.
[70] Ibid., 262.

processes in ChucK involve random selection of sound samples from a sound file of footsteps in a forest. These selections are then combined to create a noise-like sound mass (from 3’ 22, gradually cross fade, and ending at 5’ 03).

- A2: *Sonic gesture*

Gestures are shown in the editing, the positioning of sound sources on the time axis in LogicProX, and tracking control for amplitude and equalisation of sound files (figure 1).

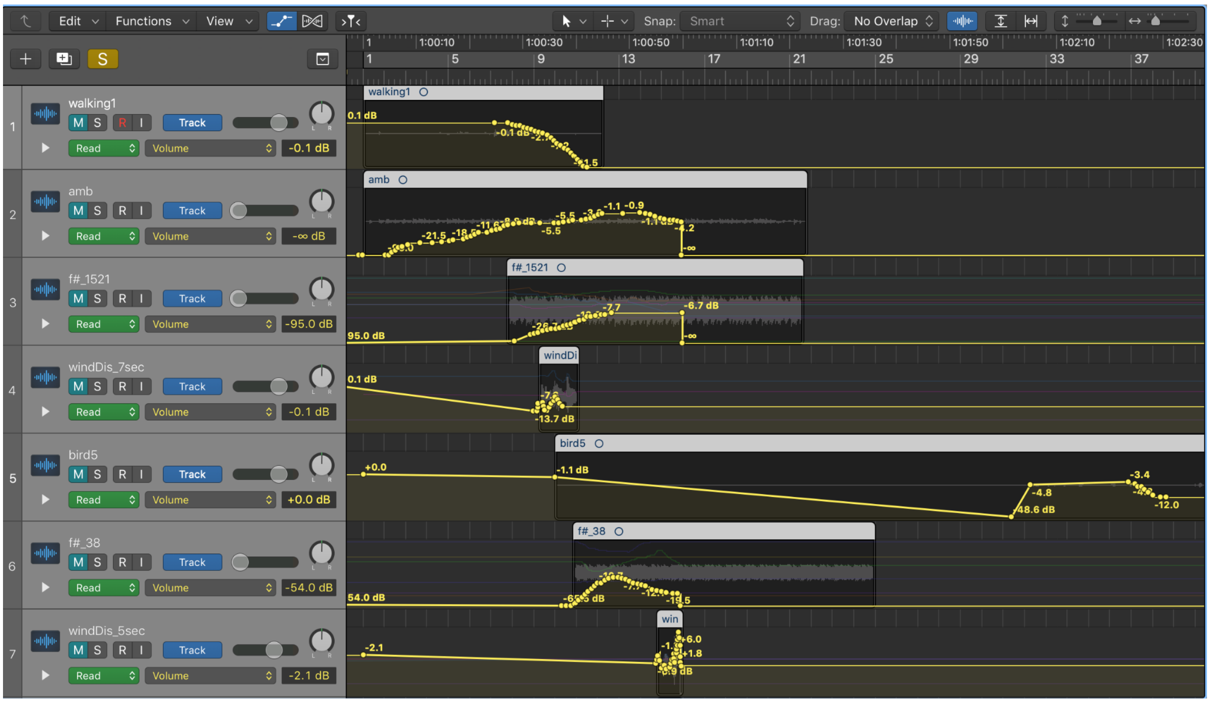

Figure 1 Studio recorded amplitude changes as gestural controls on the first seven sounds in LogicProX in *Synthesis?*

- A3: *Sound mass*

An algorithmically-generated sound mass is evident. It is cross faded to superimpose on the waterfall recording (3’ 22–5’ 03).

The field recordings (bird calls, rivers, and an airplane) can evoke visual mental imagery. Consequently, it would be more appropriate to consider them as individual sounds rather than a sequence of sound masses.

- A4: *Juxtaposition and superimposition of sound*

Recordings of footsteps, treated clavichord sounds, river noises, and bird calls are juxtaposed one after another (0–1’ 15).

3.3 – A Study for String Quartet

- A1: *Pitch to noise continuum*

Different intensities of *pressato* are used to transform a pitched sound to a noise-like sound and back (figure 2).

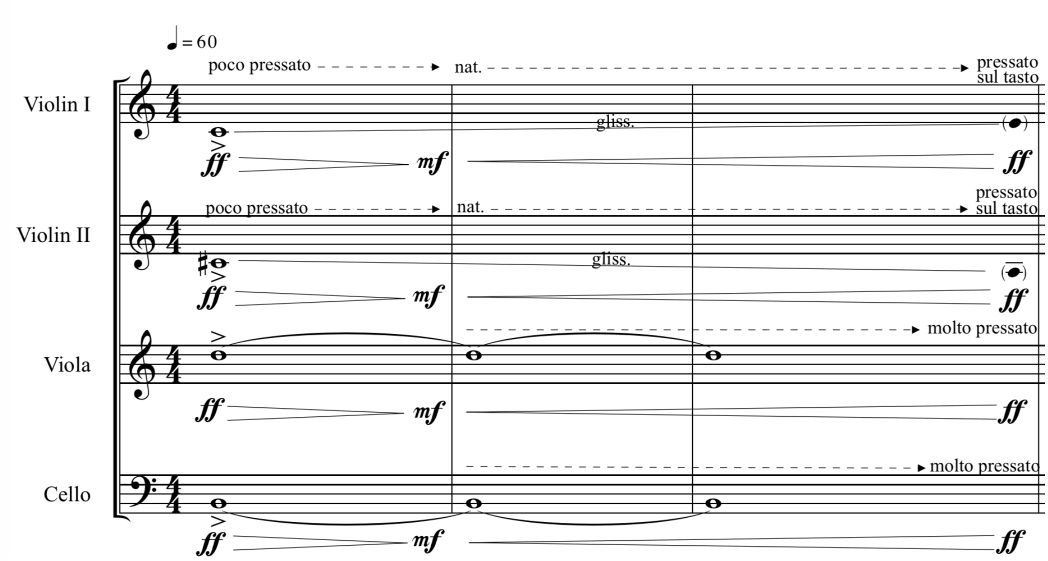

Figure 2 Transformation between pitched sound and noise-like sound using *pressato* techniques in mm 1–3 in *A Study for String Quartet*

- A2: *Sonic gesture*

Extended techniques are used to create evolving sounds one after the other or at the same time with continuous bowing (mm 5–6, figure 3).

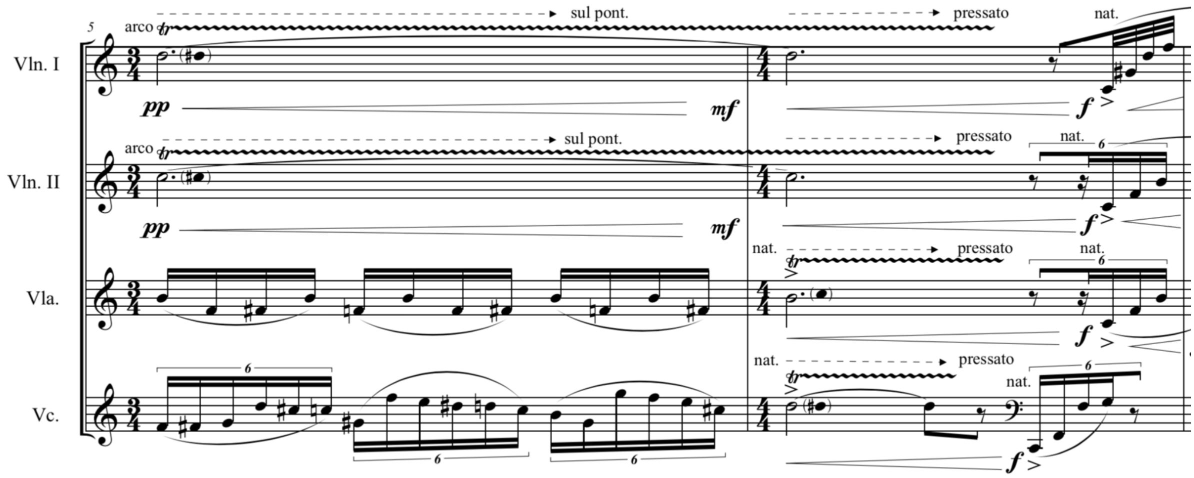

Figure 3 Evolving sounds created by extended techniques and continuous bowing in mm 5–6 in *A Study for String Quartet*

- A3: *Sound mass*

The opening mm 1–3 is an example of sound mass with transformation between pitch and noise-like sound. Another example can be found from mm 5 to the first 3 beats of mm 6 where viola and cello plays against the evolving streaming of sound in the violins.

3.4 – String Quartet

- A1: *Pitch to noise continuum*

The opening noise-like note clusters and its transformation through continuous bowing in *A Study for String Quartet* are reintroduced in this piece (mm 1–4). Additionally, serial-derived sounds are used (mm 73 in viola to mm 83, figure 4) to contrast with non-pitch sounds.

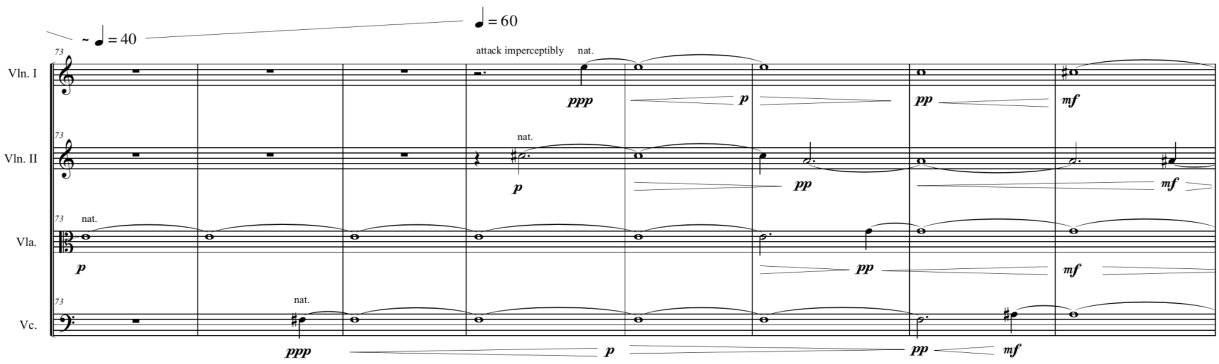

Figure 4 Serial-derived sound mass from mm 73 in *String Quartet*

- A2: *Sonic gesture*

Besides the opening transformation of sound using conventional string techniques, another transformation is shown from mm 119–123 using a bow clef to indicate bowing instruction (figure 5). These contrast with other masses with normal bowing.

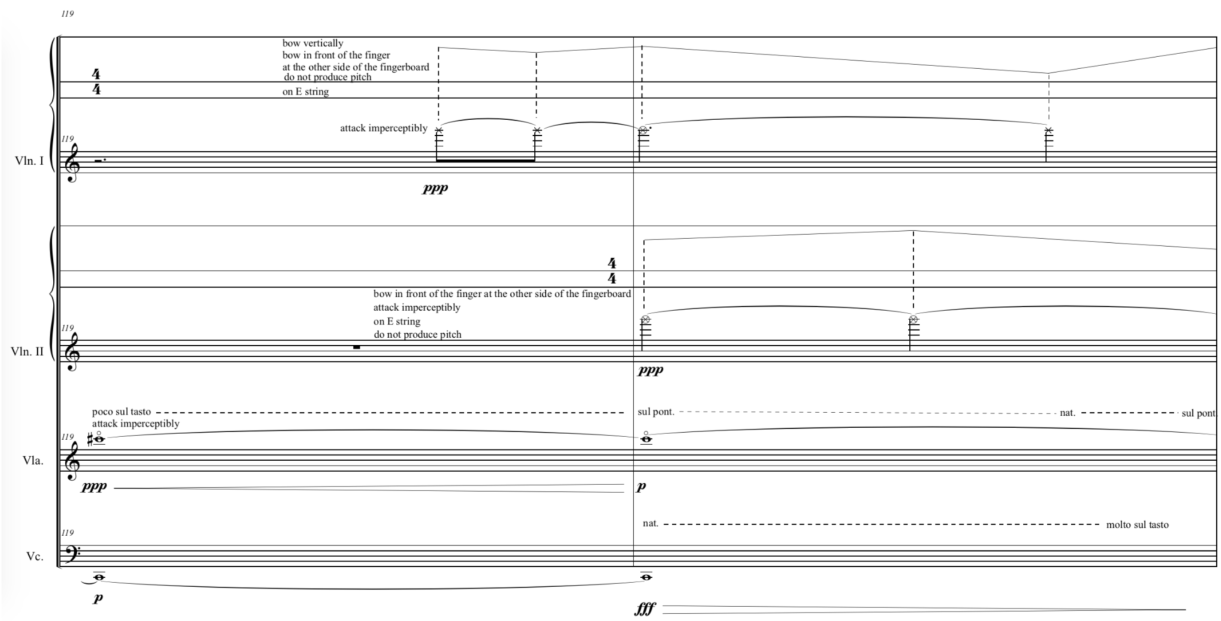

Figure 5 The use of bow clef to indicate bowing instruction in violin I and II from mm 119 in *String Quartet*

- A3: *Sound mass*

Serial sound mass is created using a serial matrix derived from the notes in the opening cluster of tone (mm 1). The notes in the cluster are used as the prime series. Other pitch series – the retrograde, inversion, and retrograde inversion – are derived from the prime. These series are superimposed and juxtaposed to form a serial matrix (figure 6). This matrix is used to create serial sound masses where the first violin plays the first row, the second violin the second row, and so forth, to form a serial harmony (mm 73–83).

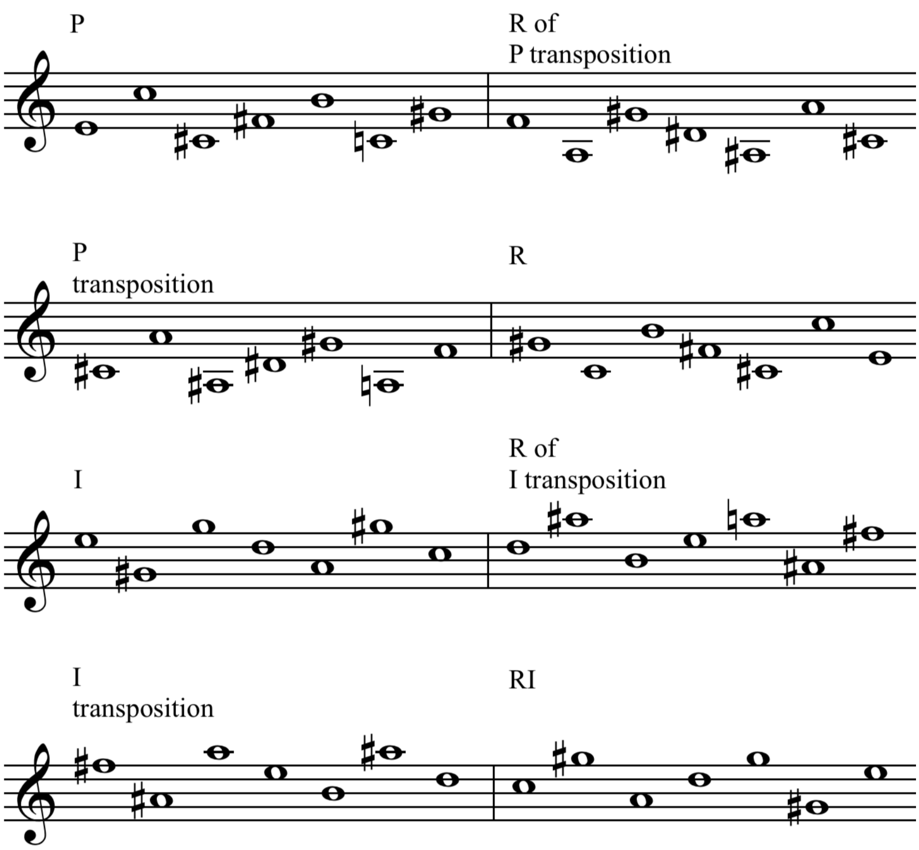

Figure 6 Pitch-based serial matrix used in *String Quartet*

- A4: *Juxtaposition and superimposition of sound*

One example of abrupt change by juxtaposition is evident between mm 16 and 17 (figure 7). Superimpositions for emerging a pitch-based sound mass from a non-serial sound is shown from mm 68 glissando, particularly in the viola, to the beginning of serial material in mm 73.

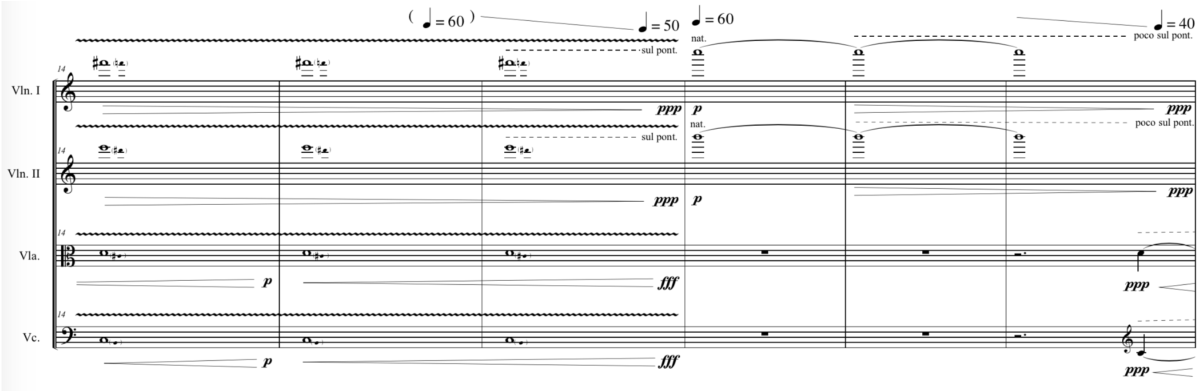

Figure 7 Abrupt change created by juxtaposition of two sounds between mm 16–17 in *String Quartet*

3.5 – Solo for Bb Clarinet

- A1: *Pitch to noise continuum*

Serial notes were aggregated to create serial melodies. The pitches from the serial matrix of *String Quartet* were transposed, with the transposed series being used as signposts to which additional pitches are added chromatically (opening of movement I from F# of the chromatic figure, figure 8). The chromatic pitch series are used to form phrases. These are articulated differently in each movement, thus demonstrating an aggregation of notes.

Figure 8 Chromatic figure in the opening of movement I in *Solo for Bb Clarinet*

3.6 – A Study for Violin and Electronics

- A1: *Pitch to noise continuum*

Pitch-based serial notes are aggregated to create pitched and unpitched sounds using synthetic sounds and violin.

A SuperCollider program is written to expand the prime series of the matrix used in *String Quartet* (figure 6) to a three dimensional pitch structure. This structure consists of four columns, seven rows, and five planes of pitches. The pitch formation in the structure follows the conventional serial processes where, in the first plane, the first row consists of the prime (E, C, C#, F#, B, C, G#), the second row the retrograde, the third inversion, and the fourth the retrograde inversion. This plane is transposed using the intervals from the prime series, E - C# - F# - B - G#, without the C (midi numbers 61, 66, 71, 68), forming four other planes of matrices where the second begin from C#, the third from F#, the fourth from B, and the fifth from G#. These intervallic calculations are made in the SuperCollider script, and the resulting pitch structure is imported into another script for sound synthesis for this piece (figure 9). These pitches are randomly selected and used to synthesise sounds with such aspects as dynamics and timbre (figure 10). The duration of a synthesised sound serves as a variable. A sequence of serial notes with short durations with short intermittent silences may be perceived as an unpitched sound with an overall pitch contour.

```
28     ~midiBlock = [ [ [ 64, 60, 61, 66, 71, 60, 68 ], [ 68, 60, 71, 66, 61, 60, 64 ], [ 64, 68, 67, 62, 69, 68,
60 ], [ 60, 68, 69, 62, 67, 68, 64 ] ], [ [ 61, 69, 70, 63, 68, 69, 65 ], [ 65, 69, 68, 63, 70, 69, 61 ], [ 61,
65, 64, 71, 66, 65, 69 ], [ 69, 65, 66, 71, 64, 65, 61 ] ], [ [ 66, 62, 63, 68, 61, 62, 70 ], [ 70, 62, 61, 68,
63, 62, 66 ], [ 66, 70, 69, 64, 71, 70, 62 ], [ 62, 70, 71, 64, 69, 70, 66 ] ], [ [ 71, 67, 68, 61, 66, 67, 63
], [ 63, 67, 66, 61, 68, 67, 71 ], [ 71, 63, 62, 69, 64, 63, 67 ], [ 67, 63, 64, 69, 62, 63, 71 ] ], [ [ 68, 64,
65, 70, 63, 64, 60 ], [ 60, 64, 63, 70, 65, 64, 68 ], [ 68, 60, 71, 66, 61, 60, 64 ], [ 64, 60, 61, 66, 71, 60,
68 ] ] ];
29
```

Figure 9 Three dimensional pitch structure in line 28 for synthesis in *A Study for Violin and Electronics*

```
326     //// 1
327     ~panArr = Array.series(18, -1, 0.111);
328     ~patIn1 = Pbind(\instrument, Prand(["playRandNotesSawPan"], 18), \midinote, Pfunc({
329         (~filterNote.() ).postln;
330     }), \dur, 0.06, \amp, 0.7, \ctranspose, 12, \pan, Pseq(~panArr, 1));
331
```

Figure 10 Synthesising pointillistic serial sounds using randomly selected pitch, predetermined duration, amplitude, register, panning and timbre (saw wave) in lines 327–330 in *A Study for Violin and Electronics*

The violin plays serial prime series in rapid succession in the opening, followed by the electronics serial sound, as shown in mm 1, where the number 1 in the electronics part denotes the electronics performer triggering the specific sound.

Transformations between pitched sound and noise-like sound in violin are evident in mm 25–26 and mm 27–28 where noise-like sound is produced by *pressato* with *sul pont* (figure 11).

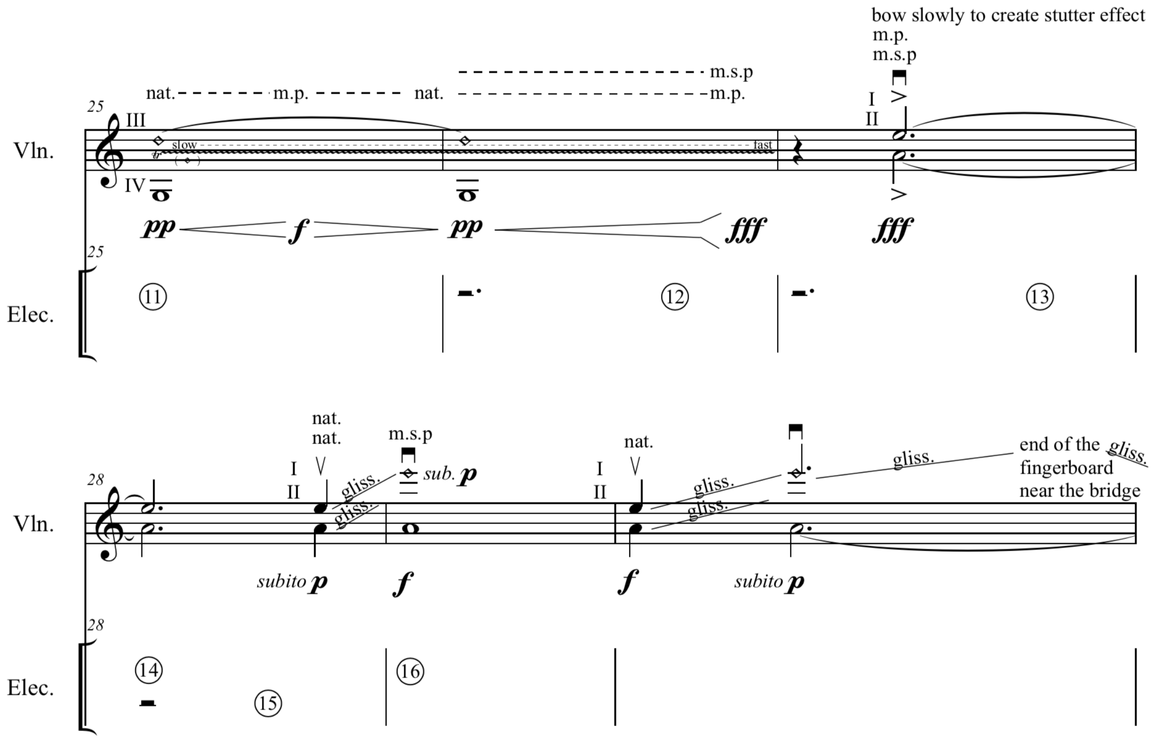

Figure 11 Transformations between pitched sound and noise-like sound in violin in mm 25–26 and mm 27–28 in *String Quartet*

- A2: *Sonic gesture*

The triggering of sound shows gestural control. The electronics part is performed by a performer using a laptop keyboard without any MIDI interface, triggering from the SuperCollider script of particular sounds according to the scored numbers.

- A3: *Sound mass*

Sound masses are formed using algorithmically-aggregated serial notes and violin. The varied duration of algorithmic serial notes (for example, /dur in lines 330 and 335) and sequences for streaming (lines 660–689, figure 12) are parametric controls for the aggregation. Aggregations of algorithmic serial notes are played with the violin part to create masses (mm 25–26, figure 13, mm 27–33).

```
658 //// 5
659 // slow to fast runs; L to R; loud to quiet
660 (
661 Ndef(\5).play;
662 {
663     var tempo = 1;
664     ~panArr = Array.series(120, -1, 0.02);
665     ~ampArr = Array.series(120, 0.8, -0.00534);
666 
667     Ndef(\5).fadeTime = 0.01; // fade in duration; cross this out will have about 1 second of fade in
668     Ndef(\5, Pdef(\pat5) ); // assign \26 to \pattPlay
669     TempoClock.tempo = tempo; // set the current system tempo
670 
671     ~patIn5 = Pbind(\instrument, Prand(["playRandNotesSaw"], inf), \midinote, Pfunc({ (~filterNote.() );
672     }), \dur, 0.06, \amp, Pseq(~ampArr, 1), \ctranspose, 12, \pan, Pseq(~panArr, 1));
673 
674     Pdef(\pat5, ~patIn5);
675 
676     5.yield; //wait for 5 seconds for the above to finish playing and then run the rest of the code to fade out
677     "fadeout".postln;
678 
679     Ndef(\5).fadeTime = 2; // duration of second part of this stream, refer to the fade out part
680     Ndef(\5, {}); // run \pattPlay again for this fade out part
681 
682     10.do { // 10 times of -0.1 to slow down; count down from 1 second and then -0.1 each repetition
683         TempoClock.tempo = tempo.postln; // set a new system tempo by using .tempo; default is beat per second
684         tempo = tempo - 0.1; // increase duration between notes to rit (-0.1); decrease duration between notes
to accel (+0.1 or more)
685         0.1.yield; // give each beat 0.1 second
686     }
687 
688 }.fork; // entire thing as a stream
689 )
690 
```

Figure 12 Sequences of sound streaming in lines 660–689 in *A Study for Violin and Electronics*

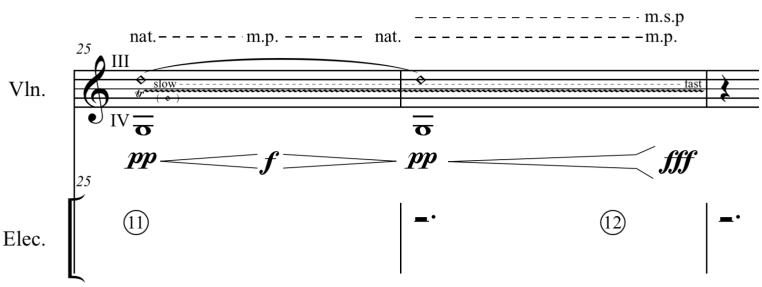

Figure 13 Sound mass created by violin and serial sounds in electronics in mm 25-26 in *A Study for Violin and Electronics*

- A4: *Juxtaposition and superimposition of sound*

Sounds of different characteristics are juxtaposed, creating abrupt changes of violin sounds. The superimposing of sounds with distinct characteristics is employed to create a contrast between the pointillistic serial sounds of electronics and violin sound (mm 72–77, figure 14).

Figure 14 Superimposition of violin sound and electronics' pointillistic sound from mm 72 in *A Study for Violin and Electronics*

- A5: *Spatialisation*

The stereo speakers are placed beside a violinist on stage. The algorithm includes panning instructions for the movements of serial sounds between speakers enveloping the violin sounds.

3.7 – Trio – for Eb clarinet, bass clarinet, and electronics

- A1: *Pitch to noise continuum*

The electronics part continues the research of synthesising pointillistic pitch-based serial sound with acoustic instrumental sounds. Further to the serial sounds, this piece applies granulation on a recorded clarinet recording to generate sound with more noise content (mm 59, recording from 5’ 59).

Subsequent to the implementation of random selection in *A Study for Violin and Electronics*, the pitch selection process in this piece also entails the random selection of pitches from a three-dimensional pitch structure.

- A2: *Sonic gesture*

The triggering of recorded and algorithmically-generated sounds demonstrates gestural control. Specifically, algorithmic serial sounds are recorded in the SuperCollider system and these sound files are triggered using QLab with an MIDI foot pedal by a clarinettist.

- A3: *Sound mass*

Sound masses are formed by algorithmically-aggregating serial notes and granulating recorded clarinet sound. The aggregation of serial notes follows the same procedures in the previous piece, where duration and sequences for streaming are parametric controls. However, as distinct from the last piece, a granular sound is used as an electronic cadenza in the piece (mm 59, figure 15, recording from 5’ 59).

Figure 15 Granular sound as electronic cadenza in mm 59 in *Trio*

- A4: *Juxtaposition and superimposition of sound*

Contrast between sounds is established through the juxtaposition of sounds that exhibit distinct characteristics (mm 58–62 in the electronics part, figure 15, recording 5’ 59–6’ 51).

3.8 – Requiem for Beauty – for soprano, 13 acoustic instruments, and electronics

- A1: *Pitch to noise continuum*

This piece exemplifies the transformations between noise and pitched sounds using vocal extended techniques, brass extended techniques, accumulation of acoustic instrumental sounds, and aggregation and disintegration of granular sounds using recorded readings of text as inputs.

The text used for this piece is taken from lines of Gao Xingjian's filmic poem, *Requiem for Beauty*. This piece uses both the Chinese and English versions as sound sources in the soprano. With such techniques as inhalation and exhalation, words can become a series of phonetic noise (figure 16), with certain phonemes evolving between pitched and unpitched sounds (mm 19 from 'abyss'–mm 23).

The electronics part uses a soprano's recorded reading of a text as a granulation input. Sounds are created in granular real-time in a digital interactive system that transform sounds between noise-like and pitched sounds and intertwined with live soprano (1' 01–1' 21) and piano (2' 08–3' 00).

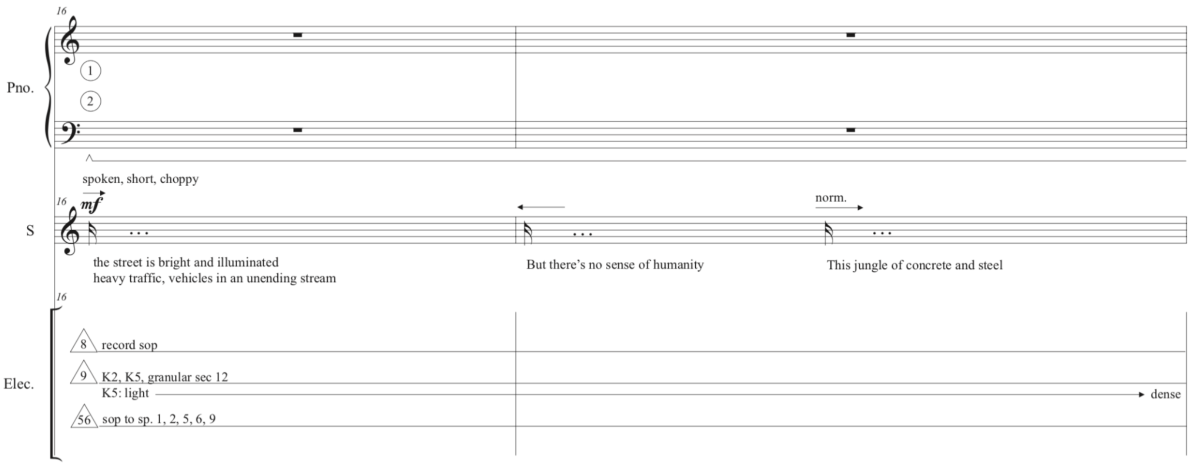

Figure 16 Phonetic noises using inhalation and exhalation techniques on texts in 16–17 in *Requiem for Beauty*

- A2: *Sonic gesture*

Gestural transformation is demonstrated through parametric controls in interactive systems, and vocal and instrumental extended techniques.

Real-time controls, such as knob turning and button pushing on MIDI interfaces, were adopted to interactively change grain properties in order to transform vocal granular sounds. Vocal techniques, such as inhalation and exhalation (mm16–19) and murmuring (mm 79–81), flute techniques, including changing the tunings of the flute's mouthpiece (mm 259–263), and exhaling into the tuba (mm 264–266) are used to induce unexpected sounds from the instruments.

- A3: *Sound mass*

Sound masses are formed by aggregating sound grains in real-time and acoustic sound masses with amplification. One evident example is between 1' 01–1' 21 (mm 16–19, figure 17), where an electronics performer controls grain properties to interact in real-time with the soprano sounds.

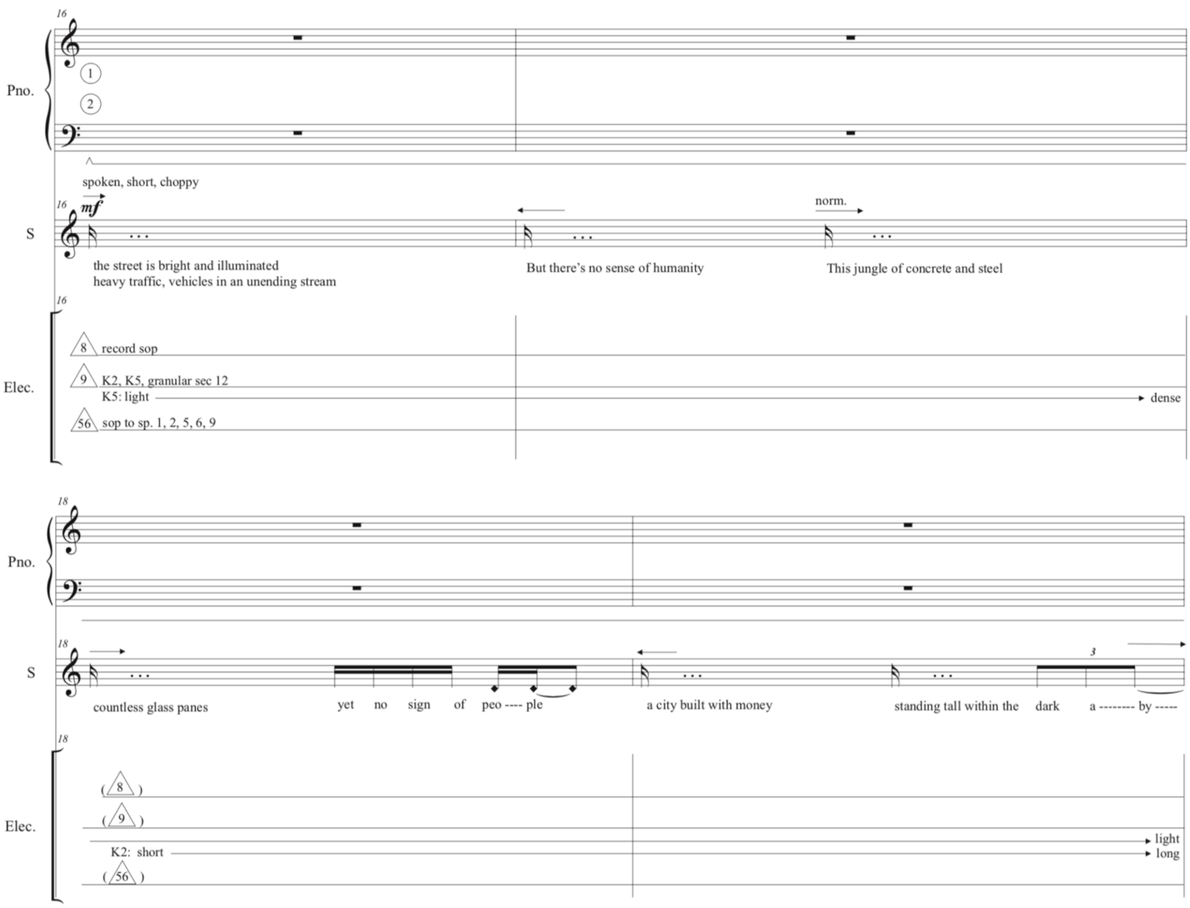

Figure 17 Electronics performer controls grain properties to interact in real-time with the soprano sounds in mm 16–19 in *Requiem for Beauty*

Certain masses are created using acoustic instruments. One example of this can be seen in the last beat of mm 20 to the first beat of mm 24, where a sound mass is formed using a flute, Bb clarinet, bass clarinet, bassoon, contrabassoon, horn, Bb trumpet, trombone, tuba, and an electronic projection of a soprano's voice. The mass from mm 48–51 also uses violin, viola, and cello in addition to the abovementioned instruments, with the soprano projecting a C note (and a recorded clarinet playing on the C note). Furthermore, the dense sound mass from mm 130–134 was composed using verticalized chromatic pitches, with the use of low registers, giving a dark and noisy ambience.

- A4: *Juxtaposition and superimposition of sound*

A flautist's readings are superimposed with a soprano's singing in a clear pitch contour (mm 212, figure 18). This part with instrumentalists' reading is juxtaposed with the next, where the soprano comes in on an Ab note (mm 220).

The flute plays only the head of the instrument from mm 261–263, juxtaposed with the tuba and soprano at mm 264–266.

The tuba is instructed to exhale into the instrument corresponding to the soprano's exhalation and inhalation on the texts (mm 264–266).

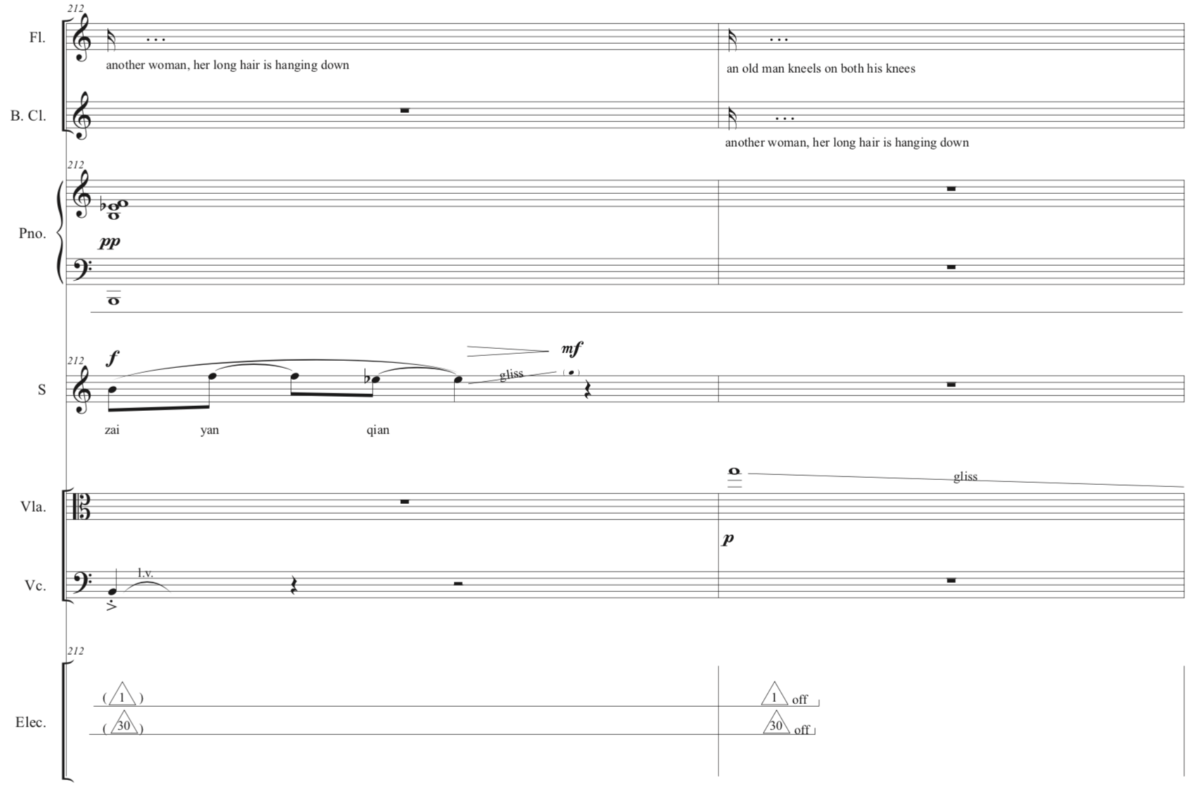

Figure 18 Superimposition of flautist’s readings with soprano’s singing in mm 212 in *Requiem for Beauty*

- A5: *Spatialisation*

Multi-positioned score-based algorithmic spatialisation is demonstrated in this piece. The interactive system is linked to eight loudspeakers placed around the concert hall and two subwoofers on stage beside the instrumental ensemble. The trajectories of granular sounds in space are changed using MIDI controllers according to scored instruction in real-time during a performance. For example, in mm 92–93, electronics performers are instructed to turn knobs k6 (clockwise) and k7 (anticlockwise) to move granular vocal sounds in space (figure 19), while on the stage, the low wind, brass, and string instruments play static notes at low registers.

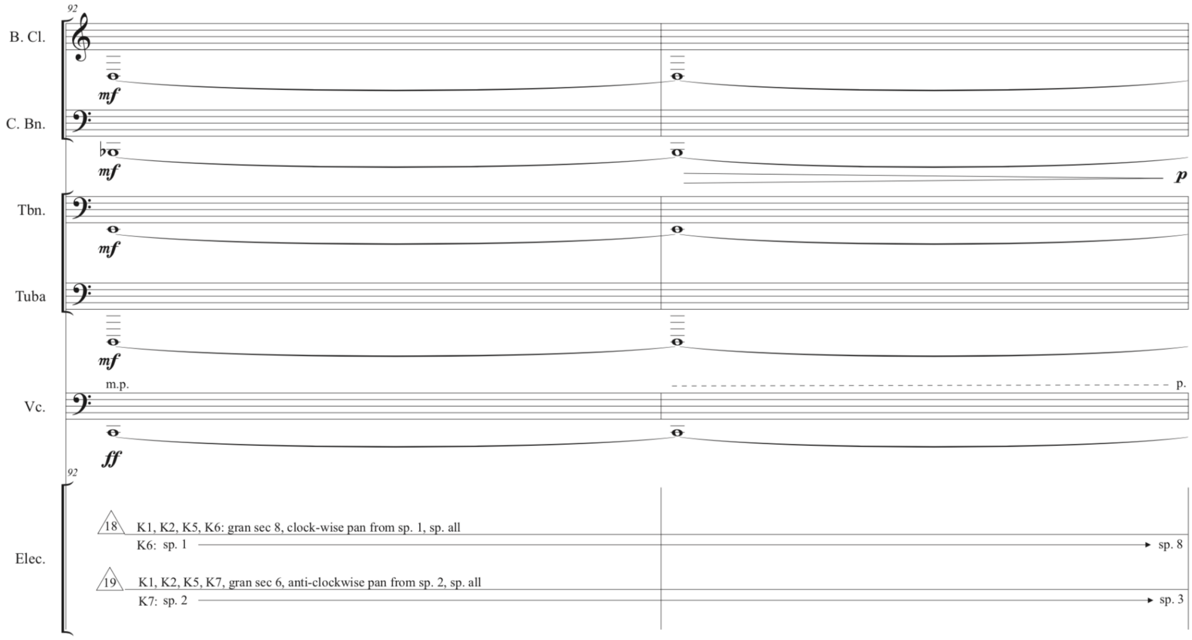

Figure 19 Instructions to turn knobs k6 (clockwise) and k7 (anticlockwise) to move granular vocal sounds in the electronics in mm 92–93 in *Requiem for Beauty*

3.9 – Is There an If? – for flute and electronics

- A1: *Pitch to noise continuum*

Granulation is applied to explore the transitions between noise and pitched sounds. Particular flute parts are recorded live, and are then used as granulation input. Pitch contours, pointillistic phrases, and noises appear in the granular sounds. The flute plays pointillistic pitched sounds and, at times, scale figures (figure 20) and melodic fragments, which contrasts with the granular sounds.

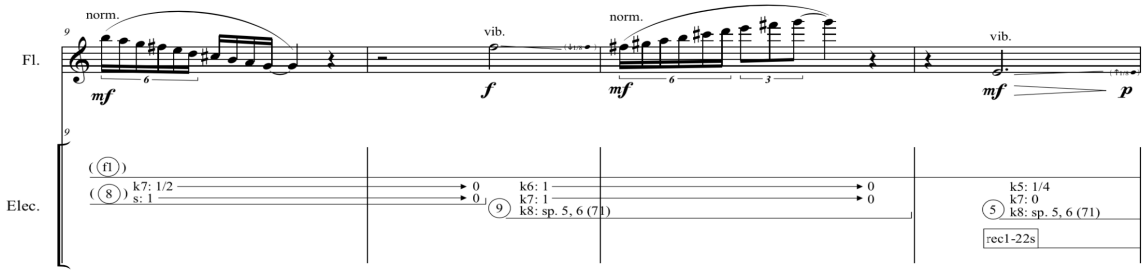

Figure 20 Scale figures in flute mm 9 and mm 11 in *Is There an If?*

- A2: *Sonic gesture*

The action of pushing a button on an MIDI interface commences a series of instructions in the code for granulation and the properties of grains can be changed in real-time by turning knobs.

- A3: *Sound mass*

Sound masses are formed through superimposing different characteristics of sounds – regardless of whether generated algorithmically or played by flute. Masses with scale contours are evident in movement II mm 9–13 and movement III. Furthermore, masses with pointillistic characters can be seen in movements I and II.

It is essential to mention the indeterministic formal process in this piece, particularly concerning sound mass creation. This piece allows the flautist the freedom to choose the sequence of movements to play before a performance. This formal procedure consequently leads to a change in the sequence of sound masses, incorporating an indeterministic element.

- A4: *Juxtaposition and superimposition of sound*

The juxtaposition process changes one texture to another, such as a pointillistic texture with silences (movement II mm 1–8, figure 21) to polyphonic texture with melodic contours (movement II mm 9–12, figure 20).

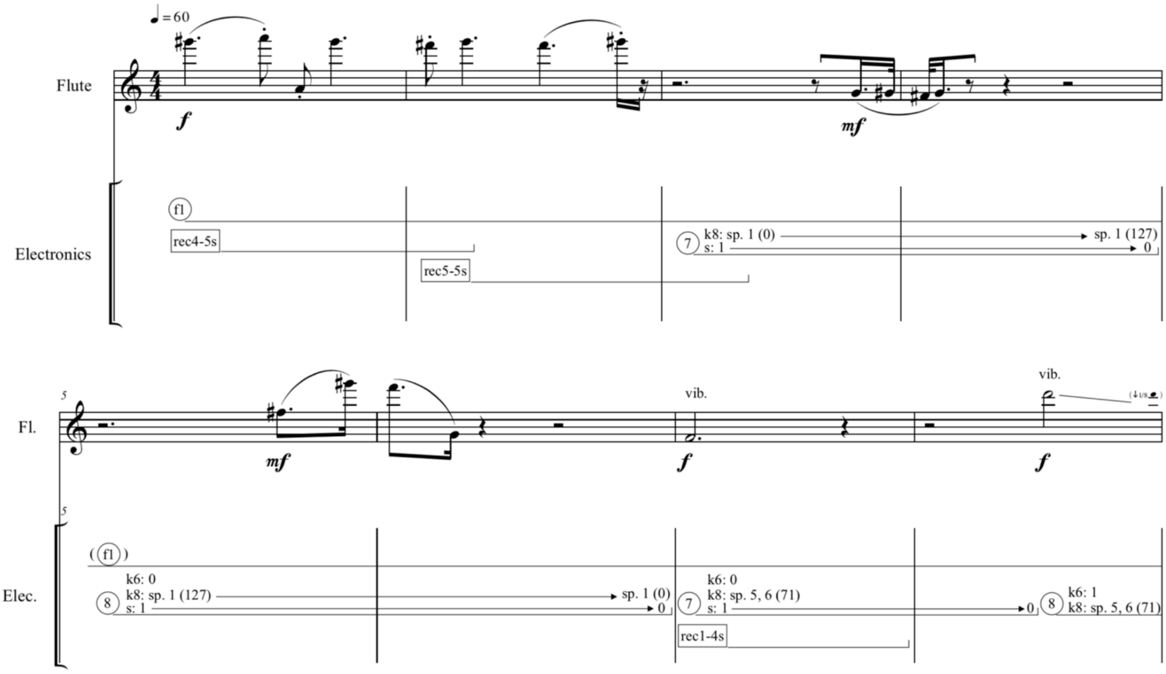

Figure 21 Pointillistic sound texture with silences in movement II in mm 1–8 in *Is There an If?*

- A5: *Spatialisation*

The interactive system is connected to eight speakers that are positioned around a concert venue. Granular sounds are circulated in the space according to the instruction on the score, filling the performance space with granular flute sounds, while the flautist plays from the centre of the stage without changing position.

This chapter used the logic of annotated portfolios to examine the eight compositions for varied instrumentation and media that form part of the submitted portfolio. Through the annotations provided, idiosyncratic strategies based on serial and microsonic approaches for sonic interaction were identified and examined. Annotations are framed within five topics not only to reflect areas where integration between acoustic and computer-generated sounds may occur but also relate to the research and artistic context of applying various compositional approaches to sonic interaction. These strategies are particularly evident in mixed-media works, which built on the preliminary experimentation on formulating idiosyncratic strategies in a fixed-media piece, *Synthesis?* (3.2), and acoustic instrumental pieces, *A Study for String Quartet* (3.3), *String Quartet* (3.4) and *Solo for Bb Clarinet* (3.5). Specifically in the mixed-media work, *A Study for Violin and Electronics* (3.6) and *Trio* for Eb and bass clarinets and electronics (3.7), serial instrumental and synthesised sounds are combined using a three dimensional pitch-based serial structure in an attempt to integrate them perceptually through cohesive pitch organisation. In contrast, *Requiem for Beauty* and *Is There an If?* use real-time interactive granulation to examine morphological transformation deriving from the interaction between granular and acoustic instrumental sounds (3.8 and 3.9). In mixed-media pieces, interactive control in digital interactive systems shows the importance of sonic gestures to form serial and granular sound masses in real-time during the performance of the compositions. These sound masses juxtapose and superimpose in space, enveloping the audience through spatialisation techniques with surround sound systems. These works attempt to achieve integration of acoustic and computer-generated sounds through interactions that are pre-planned in notated score instructions for acoustic instrumental (orchestral instruments and voice) and live electronics performers. Sonic interaction and integration are explored through the development of idiosyncratic strategies that utilise digital interactive systems and notation as compositional tools to create a dynamic interplay between acoustic instrumental and computer-generated sounds.

Chapter 4 – Conclusion

This composition portfolio, comprising eight pieces for different instrumentation and media, examines the integration of acoustic and computer-generated sounds. Throughout this research, idiosyncratic strategies for sonic interaction of diverse sound sources based on serial, indeterministic and microsonic approaches were identified and examined. This chapter provides a summary, highlights how the three research questions are addressed, acknowledges limitations, and suggests avenues for future research.

This portfolio is contextualised within the framework of integration of acoustic and computer-generated sounds (1.1) using serial pitch and harmony, micromontage and granulation techniques, as well as random selection for sound generation and formal processes (Chapter 2). Following the methodology of annotated portfolios (1.3), individual pieces are brought together and presented using appropriate media, providing indices pointing to features within the works alongside brief textual annotations. Idiosyncratic compositional strategies are identified within annotations (3.2–3.9) that are framed within five topics that relate to integration: pitch to noise continuum, sonic gesture, sound mass, juxtaposition and superimposition of sound, and spatialisation (3.1).

The annotations and index points in the eight compositions point towards how the practical work answers the three research questions. The first research question: 'To what extent can idiosyncratic compositional strategies be developed with the purpose of integrating acoustic (instrumental and vocal) and computer-generated (digital effects and synthesis) sounds in contemporary concert music?' is answered through the composition of fixed-media and mixed-media pieces. Specifically, the fixed-media work *Synthesis?* develops idiosyncratic strategies in the studio using micromontage techniques, which involves recorded inputs from sources such as a clavichord and field recordings, along with algorithmically generated sounds (3.2). Furthermore, mixed-media works *A Study for Violin and Electronics* (3.6) and *Trio* for Eb, bass clarinet and electronics (3.7) develop strategies for integration between acoustic and computer-generated sounds by using a pitch-based serial matrix from the instrumental composition *String Quartet* (3.4) and developing it further as an algorithmic system the uses a three dimensional serial pitch structure for sound synthesis. Moreover, *Requiem for Beauty* (3.8) and *Is There an If?* (3.9) implement real-time granulation in interactive systems to generate live interactions between acoustic and computer-generated sounds. In these mixed-media works, notation is essential in organising interactions in time both for instrumental and live electronic performers. Furthermore, digital interactive systems are important in generating and managing sonic interactions in the studio, using recorded and synthesised sources, and for live processing and synthesis, using real-time controls via MIDI interfaces.

The second research question: 'How can digital interactive systems be used to integrate acoustic and electronic sounds by algorithmically generating musical structures through serial methods, generating both synthesised sounds and note information for musical notation?' was specifically examined in *A Study for Violin and Electronics* (3.6) and *Trio* (3.7). These compositions use the pitch-based serial method developed in *String Quartet* (3.4), and *Solo for Bb Clarinet* (3.5). In order to explore the integration between computer-generated sound and acoustic instruments, a three dimensional serial pitch structure was implemented in SuperCollider based on the pitch matrix of *String Quartet*. This pitch structure is used to generate pitch information for notation for the instruments and for serial interactive systems where pitches are randomly selected, synthesised and recorded. These sounds are sequentially triggered according to the instructions on the electronics part in the score where each number corresponds to a sound file.

The third research question: 'How can micromontage and granulation techniques be applied to generate sonic interactions between acoustic and computer-generated sounds using pre-recorded and live inputs?' is answered in the works *Synthesis?*, *Requiem for Beauty* and *Is There an If?*. *Synthesis?* uses Logic Pro X to carry out micromontage techniques using field recordings, treated clavichord and algorithmically-generated sound in ChucK using field recordings as inputs (3.2). In contrast to the fixed studio-based approach, *Requiem* and *Is There an If?* generates live interaction between acoustic and computer-generated sounds through a digital interactive system. Particularly, *Requiem* uses vocal extended techniques, brass extended techniques, recorded readings of text by soprano as input for granulation. Parametric controls of granulation are applied in real-time during the performance using a granular interactive program which spatialises instrumental and computer-generated sounds in the concert space (3.8). The last piece of this portfolio extends on *Requiem*, exploring the integration of acoustic and computer-generated sounds, however, utilising a flute to explore the live processing of the instrument in real-time using an interactive system to establish interaction during a performance. In line with the research of Schachter on the live simultaneous gestural and structural co-actions of performers, this piece requires performers to choose sequences of movement to play (3.9).

While the idiosyncratic strategies developed effectively integrate acoustic and computer-generated sounds, limitations were identified in this research. The current serial interactive systems for *A Study for Violin and Electronics* and *Trio* generates sound with a fixed timbre using sine and saw waves which limits timbral diversity. Furthermore, developing digital systems using primarily a single technique used across different pieces creates limitations due to large similarities in the outputs. For example, systems for *A Study* and *Trio* use serial techniques and yield similar results. *Requiem for Beauty* and *Is There an If?,* on the other hand, utilise granular systems that are closely related and yield comparable processing outputs. These systems show constraints in what they can achieve sonically, which places aesthetic limitations on the compositions.

Future research involves solving the limitations identified above and expanding them through further research. The first limitation related to limited timbre could be improved by using more advanced synthesis techniques that allow for evolving timbral characteristics. These techniques could generate distinct timbres for the synthesis of each serial note. To counteract the second limitation, which concerns the limitations of using the same implementation of a technique in a digital system across different compositions, integrated systems could be developed. For example, an interactive system encompassing both pitch-based serial procedures and granulation could be developed. Moreover, future work on integration of acoustic and computer-generated sounds could explore the combined use of serial and granular techniques to examine sonic interaction using serial sounds as granular input, or organising the properties of sound grains based on serial procedures. This approach would exemplify the integration of composition techniques using digital interactive systems, thereby extending the current research on sonic interaction.

Appendices

Appendix 1

Program note of Requiem for Beauty

Performed by the Chimera Ensemble at Sir Jack Lyons Concert Hall on Friday 7 June 2019

Requiem for Beauty (2019) **Shu-Yu Lin**
2018 Terry Holmes Composer and Performer Award (b. 1990)

Please sit in the middle section of the Concert Hall, both for your ear protection and to enhance your listening experience. Please do not sit directly in front of a speaker.

John Stringer *conductor*
Clare Lesser *soprano*
Immy Wood *actor*
Lily Brown *flute*
Molly Bridgeman *clarinet*
Josh Quinlan *bass clarinet*
Rosa Juritz *bassoon*
Oliver Bryant *contrabassoon*
Cassidy Cramer *horn*
Hazel Matthews *trumpet*
Peter Raven *trombone*
Brandon Cox *tuba*
Gertrūda Valasevičiūtė *violin*
Jacob Williams *viola*
Chris Rundell *cello*
Oscar Ridout *piano*
Shu-Yu Lin *electronics*

The title for my work came from Gao Xingjian's (b. 1940) film, *Requiem for Beauty*, which is a haunting literary-visual hybrid. I chose the English translation of the title because the text materials that the singer delivers are presented in both the original Mandarin Chinese and the English translation by Gilbert CF Fong. The vocal part explores the idea of translation as negotiation between languages, and the ensemble as a whole explores the idea of translation between art forms in a more inter-semiotic sense.

Each of the 13 movements, played without a break, presents a different performance possibility for the instrumentalists, vocalist, electronics and actor, moving planes of sonic 'colour' through the instrumental groupings from background to mid- and foreground and around the performance space. Key concerns in *Requiem for Beauty* are fluidity and continuity; inspired by the multi-canvas paintings ('Triptyque') of Zao Wu-Ki (1921-2013), who fused Chinese and Western painting techniques to create artworks with different canvas materials.

Contemporary extended techniques are used to bring a nuance of absurdism, especially in the vocal part. For example, the 'exhale' and 'inhale' instructions provide a different kind of physicality to Western 'classical' singing technique whilst also paying tribute to pioneers in the field such as Cathy Berberian and Luciano Berio.

The soprano sings in English and Chinese, and a prior recording by the soprano of a more extended version of the lyrics (also bilingual) is used as one of the source materials in the electronics part, as well as live recordings of Clare's singing during the concert performance, and clarinet recordings by Chiung-Yu Ku. To bring the electronics forward and back I applied granular synthesis to the vocal part, a technique that allows the composer to chop a sound into samples (the 'atomic' level of a sound, or the 'grain') and to remould these fragments to create new ones. In some places the instrumentalists echo the density of the grain, while in others they stretch a sound into a long drone. Use of extended contemporary playing techniques further assists the implementation of sound spatialisation, akin to a painting.

Requiem for Beauty is a collaborative project with soprano Clare Lesser, commissioned as the 2018 Terry Holmes Composer & Performer Award. We would both like to take this opportunity to express our gratitude to Terry Holmes for his support and generosity.

(*S-YL*)

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