Multiplicity and Elasticity: investigating the structural implications of temporally layered materials and their playing out through a portfolio of compositions

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A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration (Statement of Authorship)

I, the author, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously presented for an award at this, or any other, university.

This submission meets the guidelines for a PhD submission in composition laid out by the University of Sheffield Department of Music: a portfolio of approximately 90 minutes total duration and an accompanying commentary not exceeding 10,000 words. The portfolio's total duration, according to the durations specified in the scores, is **circa 87 minutes** and the word count of this accompanying commentary is **10,000 words**. As per the University's Guidance, footnotes are not included in this word count.

Acknowledgements

Completing this research has been hugely rewarding. I feel very fortunate and privileged to have had the opportunity to work with countless world-class performers, composers, musicians, and researchers. Their expertise and advice have been invaluable.

Amongst those, I am especially grateful for the support of my supervisor Professor Dorothy Ker and her continued guidance in helping refine my research proposal, secure funding, and develop my skills as a composer and researcher throughout the project. My research was generously funded by a University of Sheffield Faculty of Arts Research Scholarship, for which I am also incredibly grateful.

Lastly, I would like to thank everyone who has taken an interest in my PhD or supported me in any way throughout the process, especially my family and friends. I am particularly grateful for my girlfriend, Katie, whose patience and encouragement has helped me navigate the many challenges that the project has presented me with.

Abstract

This PhD documents a practice-based exploration of the relationship between temporally layered materials and musical structure, with a particular focus on temporal elasticity and compositional process. It proposes the novel concepts of *ambiguity as multiplicity*, *polyrhythmic approximation*, and a distinction between *external* and *internal* rhythmic layering.

The portfolio, of approximately 90 minutes total duration, contains eight compositions scored for chamber instrumental and vocal forces ranging from solo double bass to a mixed ensemble of 14 musicians. Each piece investigates a different approach to temporal layering and elasticity, in turn offering a range of innovative notational solutions. By building upon the established practices of metric modulation, polytempo, and isorhythm, they varyingly explore the decoupling of rhythm, metre, and tempo, and investigate the temporal significance of repetition-variation relationships, instrumental resonance, and timbre. Each of these compositional techniques is employed systematically to devise a number of unique compositional processes centred around material combinatoriality, ordering, and iterative transformation, facilitating the generation of temporally layered materials and the manipulation of their playing out.

The accompanying 10,000-word commentary details the aims, methodology, results, and conclusions of this research, reflectively contextualising the work within the 20th and 21st Century repertoire upon which it builds. Holistically, the PhD documents the development of a novel set of compositional techniques and a personal musical language. This research will be of value to composers working across a range of media and aesthetics, as well as to those interested in the relationship between music and time.

Portfolio Information

Goldilocks and the Three Clocks (2021)

Oboe, Bass Clarinet in Bb, Violoncello
c. 6'30"
Submitted recording was made during a performance given by the University of Sheffield New Music Ensemble.

Predictive Uncertainty (2021-22)

Piano Trio
8'15"
Unfortunately, the recording device at the workshop with the Leonore Piano Trio failed. A NotePerformer audio export has been provided instead.

Tremors in the Rift Between (2022)

Double Bass Solo
23'
Submitted recording was made during a performance given by James Banner.

Music, When Soft Voices Die (2022)

Vocal Consort (Countertenor/Alto, Tenor 1, Tenor 2, Baritone)
c. 5'
Submitted recording was made during a workshop with The Orlando Consort.

Metrognomon (2023)

String Quartet
c. 8'
Submitted recording was made during a performance given by the Arditti Quartet.

Circles Drawn Freehand (2023-24)

Piano Solo
c. 10'
Submitted recording was made during a workshop with Rolf Hind.

Roads to Rome/Roam (2023-24)

Flute and Clarinet in Bb. **PLEASE NOTE** that this score is a Playing (Transposing) Score, **NOT** a Score in C.
c. 18'
Submitted recording was made during a workshop with Rarescale.

In Gnomonine (2024)

Sinfonietta (Large Mixed Ensemble)
c. 8'
Submitted recording was made during a performance given by the University of Sheffield New Music Ensemble. **PLEASE NOTE** that, unfortunately, this performance was given without vibraphone or viola due to performer absence.

A folder containing the submitted scores and recordings can be accessed here:
https://drive.google.com/drive/folders/13JGzCiOufHdYVqjafTeC7r367lelrbhu?usp=sharing

List of Terms

External **Rhythmic Layering** is a term I use to refer to all musical materials in which rhythmic independence is audibly prominent at a surface level. Some examples include polyphony and polyphonic techniques (such as canon), polyrhythm, polytempo, and phasing.

Internal **Rhythmic Layering** is a term I use to refer to musical materials which employ rhythmic independence in their construction, but which do not project this independence explicitly at a surface level. Examples would include pitch cycle phasing and isorhythmic technique.

Temporal Dissonance is a term coined by Conlon Nancarrow to refer to the audible conflict between temporally distinct materials (often either a polyrhythm or polytempo). As with pitch dissonance, the level of perceived temporal dissonance depends on ratio, context, and listener subjectivity.

Ambiguity as Multiplicity refers to my idea that multiplicity is inherent to the nature of ambiguity. In relation to temporal layering, the concept and its technical execution enables composers to construct temporal ambiguity as a means of implying a temporally layered musical structure.

Polyrhythmic Approximation is a novel compositional technique proposed as part of this research. The technique involves subjecting a polyrhythm to variation by using precise rhythmic notation to introduce nuanced aperiodicity within one (or both) of the polyrhythm's periodic strands.

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Introduction

The Topic

Through a portfolio of compositions, I explore how structure emerges from temporal layering. By exploiting various musical parameters, I investigate how the construction of temporally layered materials might imply specific strategies and processes for manipulating their playing out. This approach has allowed me to investigate artistic concerns relating to temporal multiplicity and elasticity.

Research Questions

The portfolio and commentary detail my exploration of the following research questions:

- How might differing approaches to temporal layering imply different approaches to, and processes for, shaping its temporal transformation?
- What new structural possibilities result from letting these processes play out?
- What are the limits of temporal complexity and how might these limits help define structural and material boundaries?
- How might these techniques help present time as elastic?

These questions scrutinise my entire creative workflow, enabling me to examine my conceptualisation, generation, and transformation of temporal layering.

Methodology and Resources

For each composition, I produced sketches and plans by hand before using Sibelius to typeset a first draft. A key resource was access to instrumentalists and ensembles, and I used performer feedback to help finalise each score. I composed pieces for the University of Sheffield New Music Ensemble, whom I directed throughout my PhD, and world-leading professionals. This allowed me to explore my ideas at various levels of complexity. I then wrote a critical reflection and organised performances or recordings where possible.

Commentary Outline

I will firstly review relevant repertoire and literature to define the scope of the project and contextualise my research questions and aims. I will examine numerous approaches to consider how composers have variously constructed and transformed temporally layered musical materials. Significantly, I will highlight unexplored and under-developed aspects of contemporary practice in preparation for the discussion of my own work. However, the commentary's 10,000-word scope makes this contextualisation necessarily selective. I will therefore use footnotes to highlight additional sources consulted in the research process.

The composition commentaries (ordered chronologically) document my compositional aims and approaches in relation to my research questions and context. Alongside the portfolio, these reflections will help demonstrate my original contribution to contemporary compositional technique and knowledge. In the Conclusion, I will reflect upon how the portfolio addresses my research questions and consider potential future research.

Chapter 1: Context and Background - Literature and Repertoire Review

External Rhythmic Layering and Notation

My exploration of temporal processes has suggested a distinction between *external* and *internal* rhythmic layering, each of which can serve both aesthetic and pragmatic purposes. *External* rhythmic layering, the focus of this subchapter, employs multiple distinct layers of rhythm or pulse to project surface-level temporal dissonance and structural frameworks. *Internal* rhythmic layering (discussed later) can inform structure in a similar way but does not itself project surface-level temporal dissonance, instead utilising cyclicality to present elastic repetition and blur material boundaries. These approaches can be viewed as two sides of the same coin: each employs multiplicity but at different levels of musical structure.

In my own work, I have explored *external* rhythmic layering to cultivate a presentation of temporal dissonance, multiplicity, and elasticity. These complexities present a challenge to the composer in relation to their notation. Accordingly, a discussion of the examples below inevitably entails a detailing of the notational approach taken in each.

In Charles Ives' original 1908 notation for *The Unanswered Question* (Ives, 1953), he superimposes successively quicker Italian tempo markings (distinct from the trumpet and strings' steady *adagio*) in the woodwind quartet to programmatically reflect a disconnect between question-and-answer phrases. The avoidance of specific metronome marks enables Ives to project non-standard ensemble coordination, further accentuating the *accelerando* and distinction between layers.[1]

Contrastingly, in *String Quartet* (Lutoslawski, 1965), Lutoslawski uses a partbook approach to explore the expressive potential of textural contrast, juxtaposing sections of asynchronous material collage with more strictly coordinated passages.[2] Birtwistle takes a similar approach in *5 Distances for 5 Instruments* (Birtwistle, 1992), utilising independent and global metronome marks alternately to contrast sections of freer tempo independence with fragments of rhythmic unison. This allows Birtwistle to both reflect the distinct expressive qualities of each instrument in the wind quintet and explore their potential unification. To

[1] A detailed account of the history of Ives' notation of this work can be found in: (Hitchcock & Zahler, 1988). McDonald (2004) also brings to light some of this detail in the context of Ives' narrative intentions.

[2] An in-depth exploration of the relationship between pitch, duration, and texture in Lutoslawski's *String Quartet* is contained within: (Selleck, 1975). Alternatively, Klein (1999) presents a broader discussion of the composer's use of texture as a structural device.

accentuate the *external* rhythmic layering, Birtwistle uses independent *accelerandi* and *rallentandi* (indicated with arrows), ensuring structural stability through tempo-establishing horn cues and *fermata*-controlled resynchronisations.

Metric modulations project tempo changes more precisely, employing rhythmic ratios to connect and distinguish successive tempi. This allows composers to coherently juxtapose distinct materials and embed flexibility within the structure's temporal flow. The score of *Silbury Air* includes a "pulse labyrinth" diagram and a composer's statement noting Birtwistle's interest in juxtaposing blocks of interrelated tempi via a "process of continuous metric modulation" (Birtwistle, 1977, rev. 2003). **Figure 1a** shows how Birtwistle re-notates a **crotchet = 90** pulse in 5/4 metre as **dotted quaver = 90** in 12/16 metre. This allows Birtwistle to establish the new pulse of **quaver = 120** in the proceeding 2/8 metre. **Figure 1b** demonstrates how the same modulation could be achieved using triplets.

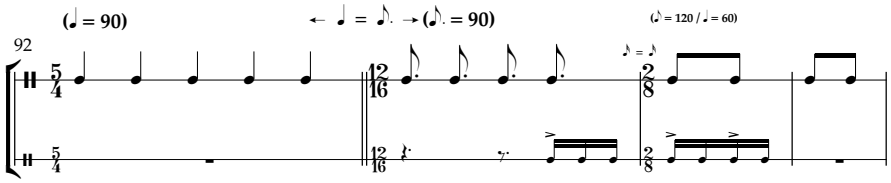


Figure 1a. Rhythmic outline of the metric modulation in bars 92-95 of *Silbury Air*, as notated by Birtwistle (1977, rev. 2003).

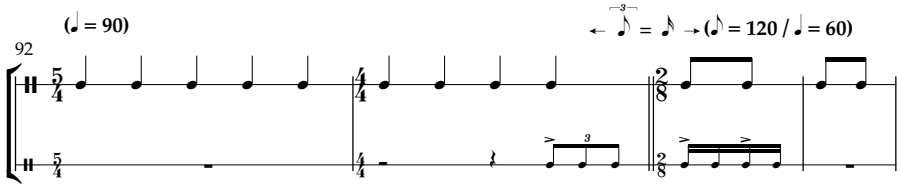


Figure 1b. Rhythmic outline of the same metric modulation, re-notated using triplets.

In *Pulse Sampler* (Birtwistle, 1981), Birtwistle explores a similar pulse labyrinth structure but with the contrasting aim of introducing tempo independence between the parts, using a "pulse mobile" (**Figure 2a**) to stagger tempo changes between the claves and oboe. **Figure 2b** exhibits how Birtwistle creates structure through the repeated juxtaposition, superimposition, and convergence of tempi, presenting sequential temporal dissonances in a manner analogous to chains of suspensions and resolutions in traditional counterpoint.

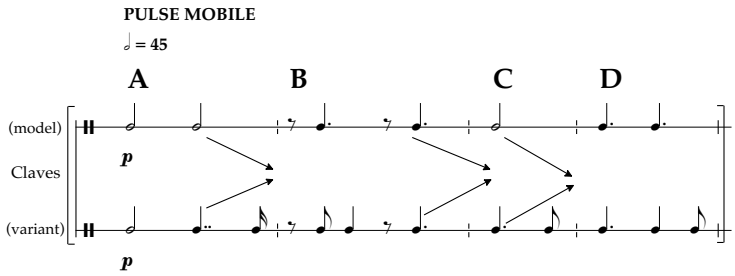


Figure 2a. The "pulse mobile" in *Pulse Sampler* (Birtwistle, 1981). Units (or unit variants) **A**-**D** are played in order. Any unit but **A** may be skipped.

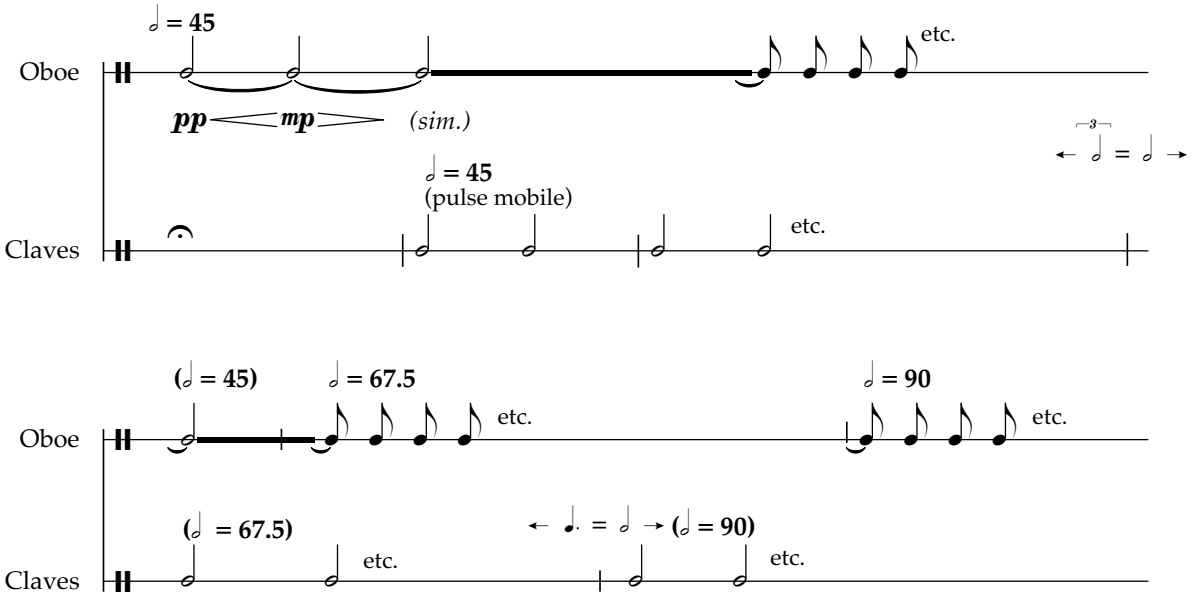


Figure 2b. *Pulse Sampler* (Birtwistle, 1981): structural reduction of the opening.

Elliott Carter takes a different approach to *external* rhythmic layering from Birtwistle, being more interested in projecting polyrhythms over extended durations to generate structural frameworks in pieces such as *String Quartet No. 5* (Carter, 1995). For a given polyrhythmic ratio and duration, there are limitations to how it may be notated. Using the formulas outlined below, Carter calculates a pre-compositional structure that maintains the polyrhythm's precise periodicity whilst recontextualising it within contrasting tempi. Simply put, the structural polyrhythms project fluctuating polytempi, enabling Carter to explore temporally diverse materials and establish structural boundaries. Conlon Nancarrow reflects on the distinction between polyrhythm and polytempo, suggesting that the latter are usually more temporally dissonant than the former due to the injection of aperiodic movement within each layer (Thomas, 2000, p. 143).

To construct a structural polyrhythm, Carter chooses a ratio of mutually prime numbers (Mead, 2007, p. 85). This means that their only common factor is 1 (for example, 10:21). Carter chooses numbers that can be expressed as products of the following prime factors: 2, 3, 5, and 7 (Mead, 2007, p. 85). Carter does this to improve performability, not trusting performers to subdivide by larger prime numbers (Mead, 2007, p. 85). This is particularly significant given my interest in performable limits, hence my exclusion of Nancarrow's player piano works despite their significance in relation to *external* rhythmic layering.[3]

Mead (2007) provides formulas to calculate the ratio of each pulse stream to the metre ("Fractions") and the amount of those metres it would take for the polyrhythm to complete ("Timespans") (p. 85). I have used these formulas to calculate Timespans for a 10:21 polyrhythm (see **Figure 3a**). **Figures 3b-d** show notated realisations of Timespans 14 and 6, and a potential full realisation of the polyrhythm using these Timespans. Here, because the Timespan ratio is 7:3, the surface tempo ratio is 3:7 (hence the metric modulation from **crotchet = 126** to **crotchet = 54**). Significantly, the embedded tempo in the 21-attack layer remains constant either side of the modulation: all attacks occur every two subdivisions (minim triplets before, crotchet septuplets afterwards). However, the 10-attack layer's embedded tempo does change, shifting from every seven quintuplet crotchets to every three quintuplet crotchets.

A:X = 10:21

*A = 10 = 2*5; a = 2, b = 5*
*X = 21 = 3*7; x = 3, y = 7*

Substituting into the Mead's formula table:

Fractions	**Timespans**
(7/5)•10 = (2/3)•21 (= 14)	2*7 = 14
(3/5)•10 = (2/7)•21 (= 6)	2*3 = 6
(3/2)•10 = (5/7)•21 (= 15)	3*5 = 15
(7/2)•10 = (5/3)•21 (= 35)	7•5 = 35

Over timespan 14, 7/5:2/3 would project the polyrhythm 10:21

In 4/4 metre, 7/5 would equal every 7 quintuplet crotchets; 2/3 would be every 2 triplet minims
Timespan 14 – completes after 14 bars of 4/4 (etc…)

Figure 3a. Calculations for a 10:21 polyrhythm using Mead's formulas (Mead, 2007, p. 85).

[3] An extensive case study-based analysis of Nancarrow's use of polyrhythmic and polytemporal ratios, and their connection to his concept of "temporal dissonance", can be found in: (Thomas, 2000). A discussion of how Nancarrow uses the player piano to facilitate the realisation of these materials is provided in: (Drott, 2004).

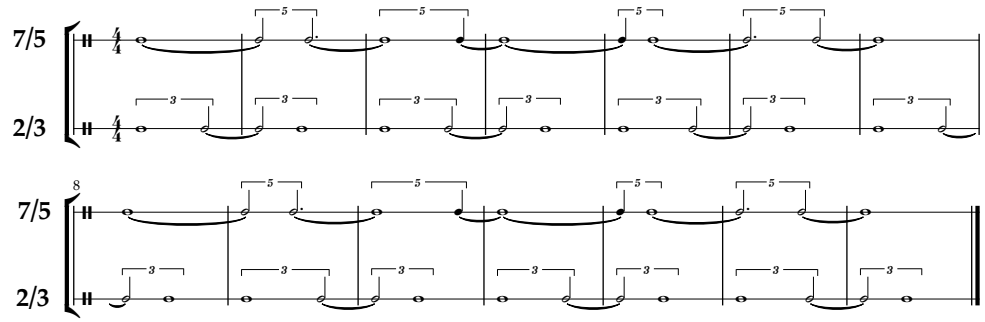


Figure 3b. Notation of Timespan 14.

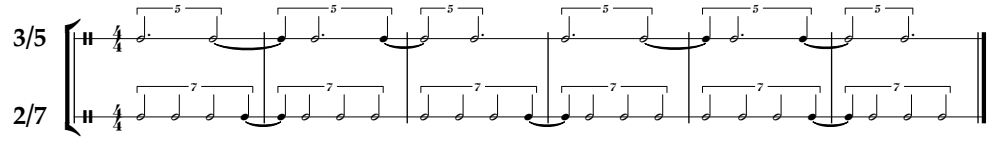


Figure 3c. Notation of Timespan 6.

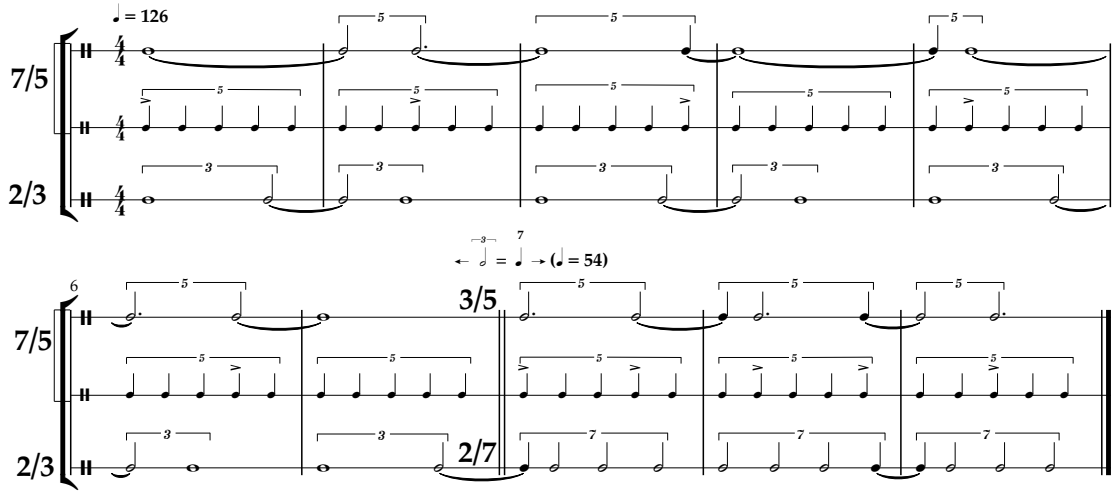


Figure 3d. A potential full realisation of the 10:21 polyrhythm, succeeding the first seven bars of Timespan 14 at **crotchet = 126** with the final three bars of Timespan 6 at **crotchet = 54**. The accenting of quintuplets in the middle staff show the 10-attack layer's change in embedded tempo.

Amongst others in the so-called "New Complexity" school (Michael Finnissy, Richard Barrett, Chris Dench, and James Dillon), Brian Ferneyhough has developed tuplet-based notation to explore highly dense, complex, and precise polytemporal relationships. In bars 51-53 of *String Trio* (Ferneyhough, 1995), a 7:4 overarching tuplet is passed from the violin to the viola and then to the cello, creating a continuous pulse of **semiquaver = 192.5** (**quaver = 96.25**) within the metronome mark of **quaver = 55** (see **Figure 4**). Similarly, the violin's 11:8 tuplet

demisemiquavers in bar 52 continue into bar 53, creating a pulse of **demisemiquaver = 302.5** (**quaver = 75.625**).[4]

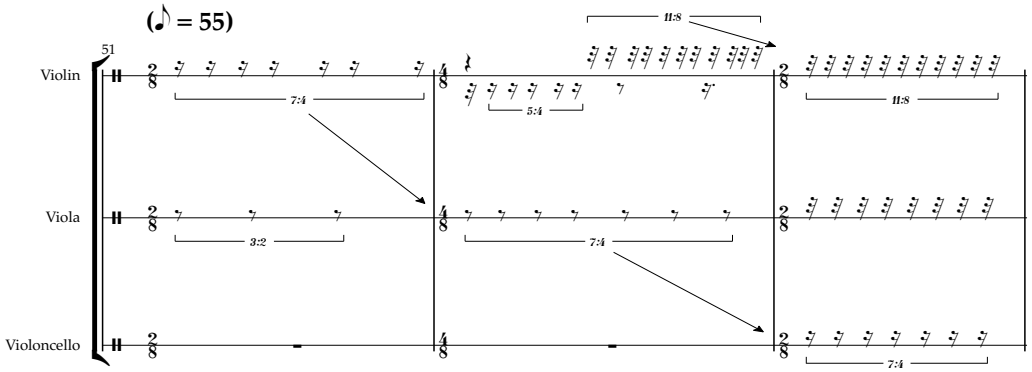


Figure 4. Rhythmical structure of bars 51-53 of *String Trio* (Ferneyhough, 1995). Nested tuplets and additional tuplet-based voices have been omitted for simplicity.

More recently, Marc Yeats (2021) has proposed polytemporal partbooks "supported" by timecodes and stopwatches with the aim of surpassing the sonic complexities of Ferneyhough without increasing notational complexity (p. 3). Yeats' approach facilitates local indeterminacy within fully determinate structures, a feature he notes his attraction to (Yeats, 2021, p. 12). He concludes that the approach facilitates temporal independence of all performers regardless of ensemble size but admits its incompatibility with precise coordination or interlocking rhythms (Yeats, 2021, pp. 144-145). Below, I have produced a potential structural outline for a section of a duet using this approach (see **Figure 5**). Following rehearsal mark **1** (timecode: 19 seconds), each performer proceeds through different metrical sequences at different tempi.

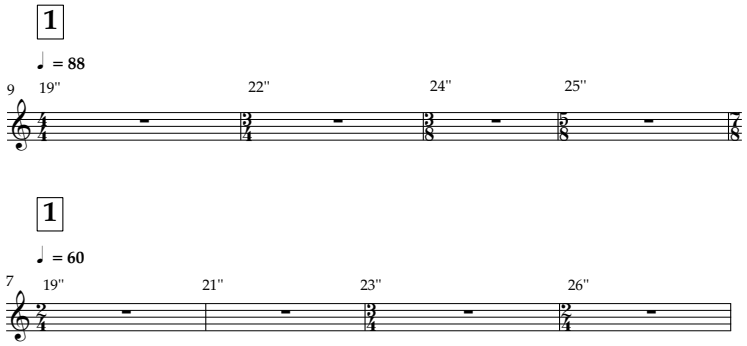


Figure 5. A possible timecode-supported polytemporal framework.

[4] A wider discussion of Ferneyhough's various approaches to notation is contained within: (Duncan, 2010). Whilst primarily focused on the composer's temporal aims and compositional processes, Exarchos (2016) also illuminates some interesting connections between the way Ferneyhough constructs his materials and the notational choices he makes.

Yeats is not the first composer to develop a notation system centred around chronometric durations: Dubinets (2007) credits Earle Brown with the invention of time-space notation (p. 412), a format which replaces metre and rhythm with a proportionality between duration and visual space. This allows composers to combine temporally distinct materials within a precise structure, although not necessarily with precise alignment between parts. In *Music for Cello and Piano* (Brown, 1955), each system of music is marked to last 15 seconds, enabling performers to play each system within that duration but independently of each other or any strict underlying pulse (see **Figure 6**).[5]

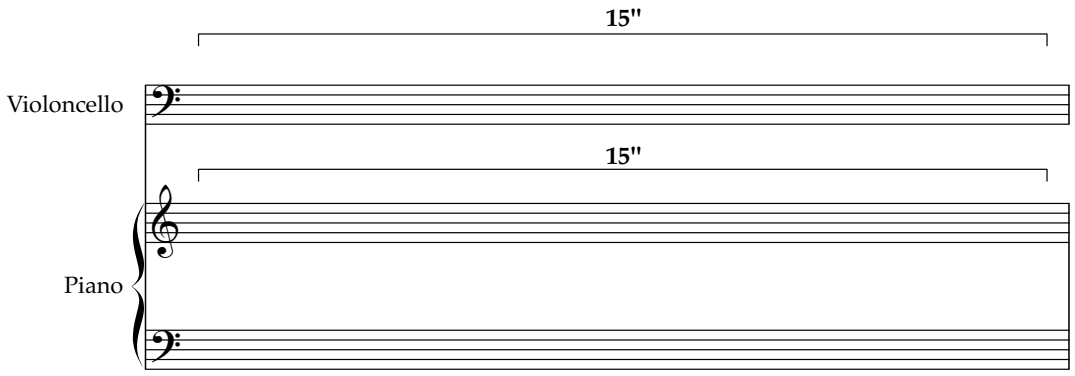


Figure 6. The time-space framework of 15-second systems in *Music for Cello and Piano* (Brown, 1955).

Evidently, notation plays a significant role in accommodating novel musical materials. However, notational innovation can itself facilitate new compositional technique (Dubinets, 2007, pp. 410-411). For example, in *Roads to Rome/Roam*, I used a novel notational system to generate and organise temporal independence. More broadly, I have used notation to support my exploration of *external* rhythmic layering.

Internal Rhythmic Layering

Internal rhythmic layering phases structural cycles to present a singular repeating entity as multiple. An example of this approach can be found in the opening bars of *Carmen Arcadiae Mechanicae Perpetuum* (Birtwistle, 1977/1978). **Figure 7** shows how Birtwistle phases the two violin pitch cycles, each containing four double stops, against the viola's pitch cycle of three double stops. The materials of the other three instrumental groupings (double bass and

[5] The composer's own account of his notational philosophy can be found in: (Brown, 1986). Similarly, Dubinets (2007) provides a broad overview of Brown's various notational innovations, including those of time-space and mobile notation.

marimba, brass, winds) exhibit similar construction but with contrasting pitch cycles and rhythmic patterns, creating an interlocking machine-like effect.

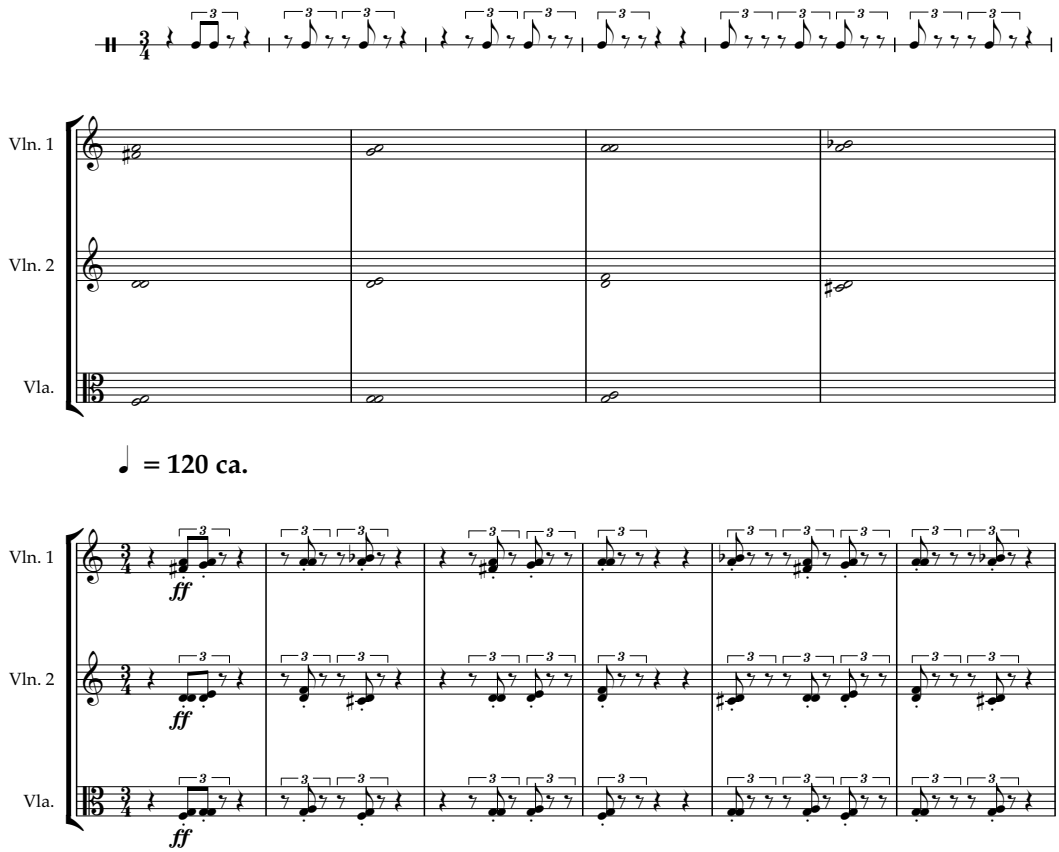


Figure 7. The upper string's rhythmic pattern, double stop cycles, and their combination in the opening bars of *Carmen Arcadiae Mechanicae Perpetuum* (Birtwistle, 1977/1978).

Interestingly, Birtwistle structures the piece by phasing these recurring blocks of material against cycles of parameter variation in a quasi-isorhythmic fashion. More typically, isorhythms phase rhythmic cycles (*talea*) against pitch cycles. The technique subjects limited materials (one *talea*, one pitch cycle) to variation through their combination, demonstrating how *internal* rhythmic layering can help generate and structure material. In the first movement (*Liturgie de cristal*) of *Quatuor pour la fin du temps* (Messiaen, 1942), Olivier Messiaen uses isorhythm to reflect notions of timelessness and eternity. Messiaen superimposes a *talea* of 17 durations with a cycle of 29 chords in the piano, and a *talea* of 15 durations with a 5-note pitch cycle in the cello (see **Figure 8**).

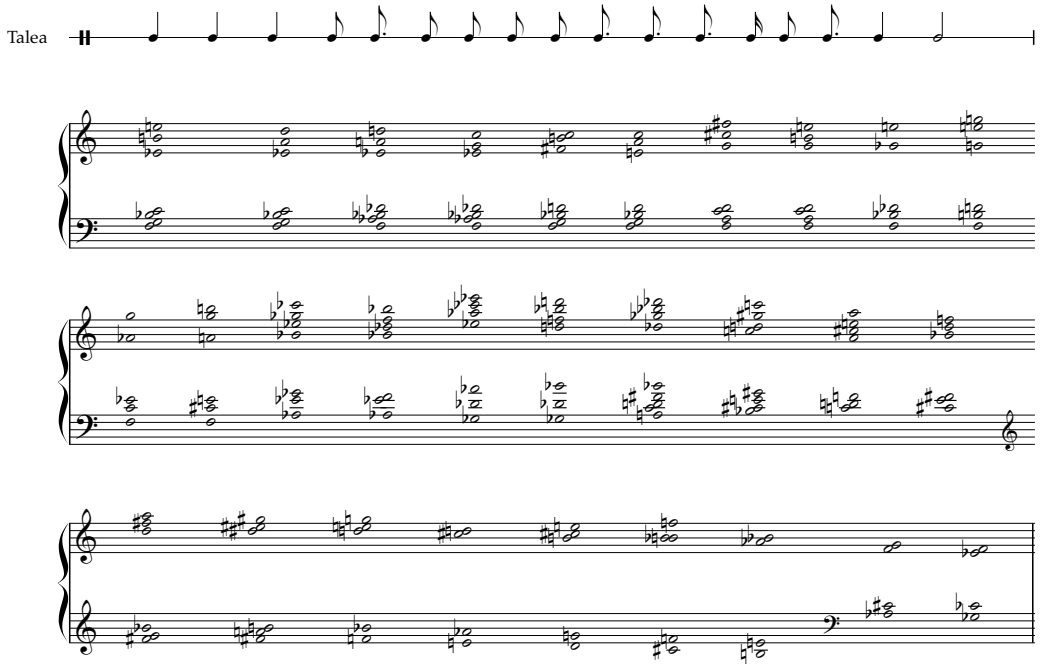


Figure 8a. The *talea* and chord cycle of the piano isorhythm in *Quatuor pour la fin du temps* (Messiaen, 1942).

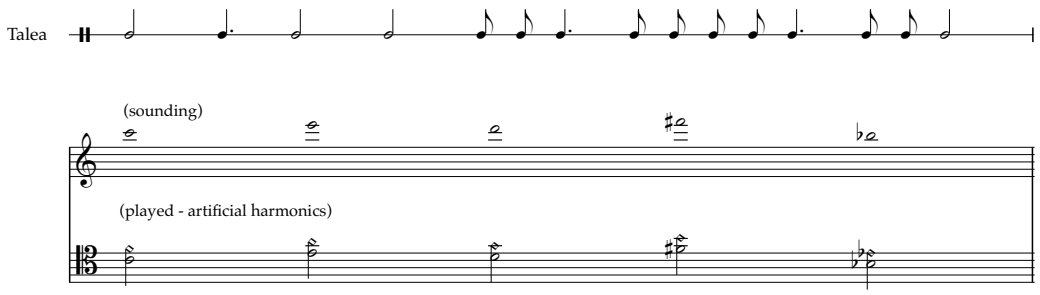


Figure 8b. The *talea* and pitch cycle of the cello isorhythm in *Quatuor pour la fin du temps* (Messiaen, 1942).

Each iteration of the cello isorhythm lasts one cycle of the 15-duration *talea*, which includes three complete presentations of the five pitches. Contrastingly, the piano isorhythm is significantly lengthier because the lowest common multiple of 17 and 29 is 493. At **crotchet = 54**, the full isorhythm (377 crotchet beats in total) would last nearly seven minutes. However, Messiaen cuts the isorhythm short, concluding the movement less than halfway through the complete structure to project a sense of the infinite. Messiaen compounds this effect by concluding the cello isorhythm mid-cycle: the isorhythm and its *internal* pitch cycle are left incomplete.

Whilst isorhythms often underpin structures without undergoing transformation, some composers have varied the layers *internal* to their isorhythms, heightening the technique's capacity for material variation whilst undermining its cyclicality. Wright (1993) notes Louis

Andriessen's shortening of *talea* durations to build momentum in *De Tijd* (p. 10). Isorhythmic transformation has been central to my research (see *Metrognomon* and *In Gnomonine*). Isorhythms are commonly associated with motets and so have often been used alongside canon and other polyphonic techniques (as explored in *Music, When Soft Voices Die*). Similarly, in the above example, Messiaen superimposes two distinct isorhythms with different imitations of birdsong (Messiaen, 1942). Isorhythms are good examples of how periodicity, repetition, and process can combine: the contrasting periodicities of *internal* layers interact to produce a repeating structural framework. More broadly, *internal* rhythmic layering helps composers transform materials, develop layered structures, and explore temporal cyclicality. As I will show, I have sought to develop *internal* rhythmic layering in relation to both its construction and transformation to heighten these temporal affordances.

Resonance and Timbre

In *Intermission VI* (Feldman, 1953), Morton Feldman uses resonance to define duration, stating that each sound should be held until "barely audible". Similarly, Boutwell (2013) suggests that Feldman uses decay times to mimic tempo fluctuation between successive sounds in *de Kooning* (p. 549). However, Feldman also uses decay to control layered durations. Discussing *Intermission V*, Noble (2016) points to the way material emerges from a resonant *fortississimo* cluster (p. 41). Here, Feldman layers decay times by exploiting dynamic and registral extremes, the sustain and *una corda* pedals, chords of varying density, and grace notes (see **Figure 9**).

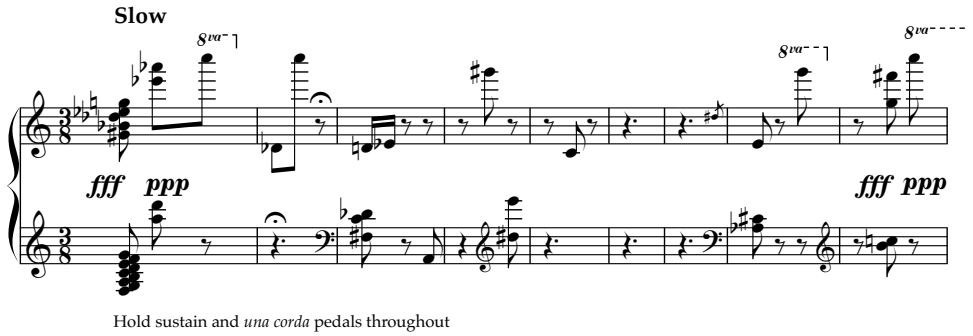


Figure 9. *Intermission V*, bars 1-9 (Feldman, 1952).

Spectralism, an approach pioneered by Gérard Grisey and Tristan Murail, is centred around timbral manipulation of harmonic and inharmonic spectra. Grisey (2000) suggests that spectralism was developed "to give form to the exploration of an extremely dilated time and to allow the finest degree of control for the transition from one sound to the next" (p. 1). Significantly, he suggests that these techniques facilitate the "superimposition and

juxtaposition of forms flowing within radically different time-frames" (Grisey, 2000, p. 3). In *Vortex Temporum* (Grisey, 1994-1996), Grisey uses 1/8th-tone microtonality, unpitched air sounds, percussive effects, changes in bow position and pressure, and nuanced piano pedalling to distinguish between material layers and control their rate of transformation.[6]

Rebecca Saunders' music, whilst not spectral in construction, exhibits a similar relationship between timbre and temporality. Abram (2021) notes how Saunders often juxtaposes and then merges two contrasting timbres (gestalts of *glissandi*, *tremolo*, bow position, *vibrato*, isolated pitches, and clusters) whilst simultaneously exploring the spectrum of stasis between resonance and silence (pp. 20-22). Saunders controls the duration and quality of these liminalities carefully, as seen in the precisely measured rests between phrases in *Fury* (Saunders, 2005). Similarly, Abram cites Saunders' statement that "the timbral mutation of one sound into another" is a primary compositional concern (p. 20). These interests in transformation and its rate indicate that timbral manipulation is central to Saunders' consideration of temporality.

McMullan-Glossop (2017) suggests that timbral juxtaposition can create a temporal "push and pull effect" (pp. 504-506). Saunders achieves this by making various vertical and horizontal material connections, using contrasting approaches to timbral blending, shading, and transformation to do so (McMullan-Glossop, 2017, pp. 506-524). In *Song – A Short Study* (Saunders, 2001), Saunders uses silently depressed keys alongside *fortissimo* upper-register clusters and *sforzando* sustain pedal depressions to passively excite the piano strings, changes in bow position, variable *vibrato*, and chords of shifting density. This timbral variety enables Saunders to present temporal fluctuation across her layered orchestration of a simple melody.

In my own work, I have explored how timbral diversity and manipulation alongside control of instrumental resonance might be used to project temporal layering, as well as how these techniques might interact with other temporal multiplicities (see *Tremors in the Rift Between*).

Repetition and Variation

Harrison (2007) quotes Bridget Riley's statement that repetition is "at the root of both movement and stasis" (p. 4), implying its capacity to construct temporal multiplicity. Morton Feldman's late work is characterised by the "reiteration of self-similar motifs, often within altered or differing contexts" (Harrison, 2013, p. 45), suggesting that traversing repetition-

[6] A broad account of spectral music, as well as a detailed analysis of *Vortex Temporum*, can be located within: (Wang, 2012). Alternatively, Jakubowski (2018) presents a discussion of the relationship between spectral technique and Grisey's articulation of the work's form.

variation boundaries can project contradictory temporal implications. *Triadic Memories* (Feldman, 1981) begins with the right-hand marking the 3/8 metre with dotted crotchets alternating between G and Bb in the piano's highest register whilst the left-hand rotates through a mobile of G#, D, A, and C# in quadruplet figurations in the lower register. Feldman maintains this two-part texture for 90 bars, imposing opposing registral trajectories onto each part so that the voices swap registers. Feldman then implements more extensive transformation, introducing grace notes, additional pitches (for example, Gb in bars 81-82), voices, fragmentation, and chords. He compounds the resulting temporal ambiguity through his use of half-pedal resonances and prevailing triple metre framing despite the salient quadruplet phrasing.

Birtwistle employs multi-scale repetition and variation to elasticate temporality in *Harrison's Clocks* (Birtwistle, 1997-98). Each movement begins with identical polyrhythmic downward flourishes in the piano's lowest register. In the first movement, Birtwistle varies this gesture, rescaling it into an ascending-then-descending arch and altering the polyrhythmic ratio from 5:7 to 6:7. This presents multiplicities beyond the polyrhythm's *external* rhythmic layering: the gesture expands, one polyrhythmic strand contracts, and the other remains constant. Birtwistle repeats this variation exactly each time, accentuating these temporal contrasts. Discussing *Clock IV*, Vojcic (2010) suggests that Birtwistle subjects the "cuckoo" mechanism (two-note gestures: high-low or long-short) to rhythmic augmentation and slower tempi conjointly (pp. 16-28). In this example, Birtwistle uses the steady periodicity of the clusters to accentuate the slowing of the "cuckoo" mechanism (Vojcic, 2010, pp. 29-30).

In *Repetitions in Extended Time* (Harrison, 2008), Harrison explores repetition on multiple scales, enabling him to project a multi-scale cyclical structure and coherent surface homogeneity. Discussing the piece, Harrison (2012) notes how each section is slower and contains more exact repetition than the previous (p. 62). Elsewhere, Harrison (2013) describes the piece's "latticed textural surface of interlacing loops and circles" (p. 56). This quality results from his use of independent repetition across the layers of piano demisemiquavers, bass clarinet and electric guitar tuplet figurations, swelling keyboard chords, and string *glissandi* and trilling. Subsection A1 contains 16 bars but only four written-out bars, with different bars being repeated a different number of times in each part (see **Figure 10**).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bcl., Egui.	1	2-3		2-3		2-3		2-3		2-3		2-3		2-3		4
Kbd. 1 & 2, Vc.	1-4				1-4				1-4				1-4			
Pno.	1-2		1-2		1-2		3-4		3-4		3-4		3-4		3-4	
Vln.	1-2		1-2		1-2		1-2		1-2		3-4		3-4		3-4	

Figure 10. A table showing the independent repetition of bars in subsection A1 of *Repetitions in Extended Time* (Harrison, 2008).

Broadly, repetition implies cyclicality whereas transformation implies linearity. By combining the two, composers can project contrasting temporal implications. Exploring these relationships between material treatment, structure, and temporal layering has been important throughout my research, particularly in *Predictive Uncertainty* and *Roads to Rome/Roam*.

Process and Structure

I chose many of the above case studies for their engagement with process: Carter's structural polyrhythms exhibit elements of processual construction and Grisey (2000) notes how spectralism favours process over "traditional development" (p. 3). These examples also demonstrate the broader temporal importance of processes: they control material transformation through time. This subchapter deals with the relationships between process, structure, and temporality.

In interview with Samuel Andreyev (2023), Jean-Luc Hervé makes an analogy that I identify with, likening the process-material relationship to the scientific practice of observing phenomenon and then finding mathematical functions to explain them (13:45). Discussing his own processes, Steve Reich (2004) observes that material types reciprocally imply process types (p. 35). Christensen (2004) suggests that compositional processes can either generate or transform material and be either "rule-determined", "goal-directed", or "indeterminate" (p. 115). Christensen presents Reich's phase-shifting as a "rule-determined transformation process" (p. 116). Despite Christensen highlighting the interplay between rules and goals (p.

97), his categorisations are not as mutually exclusive as he suggests: phase-shifting is also "goal-directed" (Reich completes these processes to restore phase).[7]

Regarding "goal-directed transformation processes", Christensen (2004) points to György Ligeti's systematised expansion and contraction of pitch space, dynamics, and tempi in *In zart fliessender Bewegung* (pp. 104-107). However, this example exhibits transformational and generative elements, further problematising Christensen's discrete categorisations. Discussing *+R*, Roger Redgate (2017) notes his interpolation of metrical structures and tempi permutations in relation to a specific desired surface quality (p. 119). Redgate details how his use of multiple independent processes facilitates material overlap (p. 121), suggesting that the same process can construct and transform temporal layering.

Whilst processes vary between composers, compositional intentions are often even more diverse. Reich (2004) emphasises his intent to create an audible unity between process and material (pp. 34-35) whereas David Lang intends for his processes to be less transparent (Brown, 2010, p. 180). Hervé's intentions are more balanced: he notes the "colour" that his processes project despite their lack of immediate transparency (Samuel Andreyev, 2023, 12:10).

Similarly, the balance between systematisation and intuition varies significantly. Traversing these boundaries introduces temporal elasticity: processual regularity is juxtaposed with spontaneous flexibility. Redgate (2017) notes how he uses points of alignment between simultaneous processes to arbitrarily filter outputs (p. 123). This approach resembles that of a "sieve" process.[8]

Redgate (2017) notes his aims to respond intuitively to process outputs and integrate desired results with unexpected emergent materials (pp. 118-119). Similarly, Horacio Vaggione (2001) suggests that processes allow composers to explore new musical possibilities through system design (p. 54). My research examines how processes might be designed to generate and transform temporally layered materials. Accordingly, the processes I have developed and played out are wide-ranging in their construction, transparency, strictness, and material-structure relationships.

[7] A detailed account of Reich's phase-shifting technique can be found in: (Saltini, 1993). Alternatively, Horlacher (2000) provides a more general discussion of rhythmic and metrical processes in Reich's work.

[8] Xenakis' own discussion of his "sieve" concept is contained within: (Xenakis, 1990). Exarchos (2016) provides a broader analysis of Xenakis' and Ferneyhough's contrasting uses of the technique in relation to their explorations of musical temporality.

Chapter 2: The Compositions

Goldilocks and the Three Clocks (2021)

I composed *Goldilocks…* as a compositional *étude* on polytempo and metric modulation. These techniques had defined my MA portfolio (Thomas, 2021): in *Coexisting Lines*, I combined five solos in independent tempi. I initially presented the piece as a partbook alongside a graphic representation of the structure. Seeking more accurate ensemble coordination, I used tuplets to re-notate the piece within a global metronome mark and full score format.

In *Goldilocks…*, I constructed polytemporality holistically from the outset to maintain greater structural control. Loosely adopting the narrative of *Goldilocks and the Three Bears*, I juxtaposed sections of interrelated tempi marked **'Too fast'**, **'Too slow'**, and **'Just right'**. I also explored superimposition, employing polytempo between these sections. This polytempo is grounded by the salient pulse of **crotchet = 72**, a temporal reference point established through the cello's opening ostinato (see **Figure 11**).

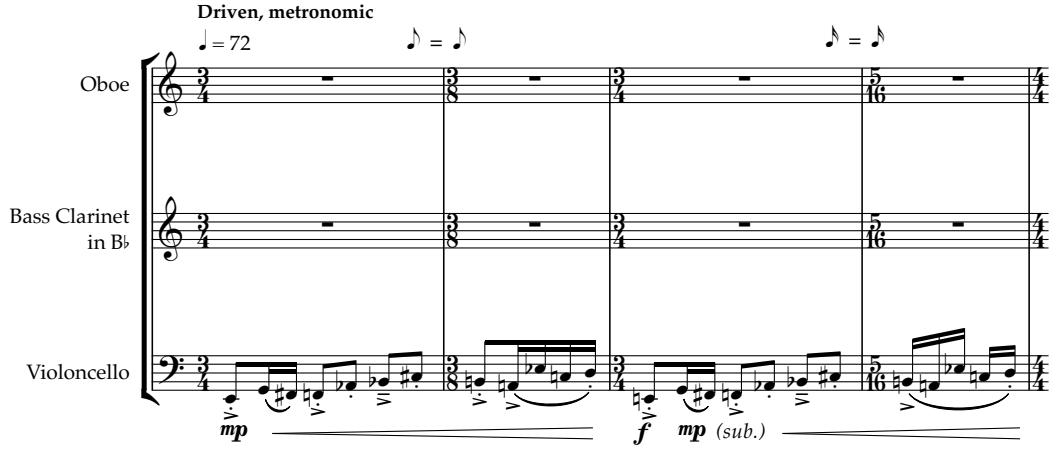


Figure 11. *Goldilocks…*, bars 1-4.

To contrast against the piece's prevailing textural independence, I implemented gradations of synchronisation. I punctuated the piece with silences, producing effects akin to unison through unified inaction (see bar 101, beat two). Similarly, I used unison attacks to provide focal points and mark metric modulation completions (see bar 92, beat one).

I chose the instrumentation to help distil temporal layers, an effect I accentuated by employing various articulations, slap tongue, *pizzicato*, changes in bow position, and percussively tapping the cello. I also varied the timbral-textural profile by including solo and duo passages. In bars 34-36, the oboe and bass clarinet duet highlights the change in material and tempo.

Similarly, I clarified the polytempo by staggering instrumental entries (see **Figure 12**). In this example, I used the cello's crotchets and quavers to establish the metronome mark of **crotchet = 72** before the bass clarinet enters in triplet figurations and the oboe joins in dotted groupings. Accents and phrases rarely align between parts, imitating the effect of contrasting metric structures. I transformed this polytempo by introducing quintuplets and passing tempi between instruments.

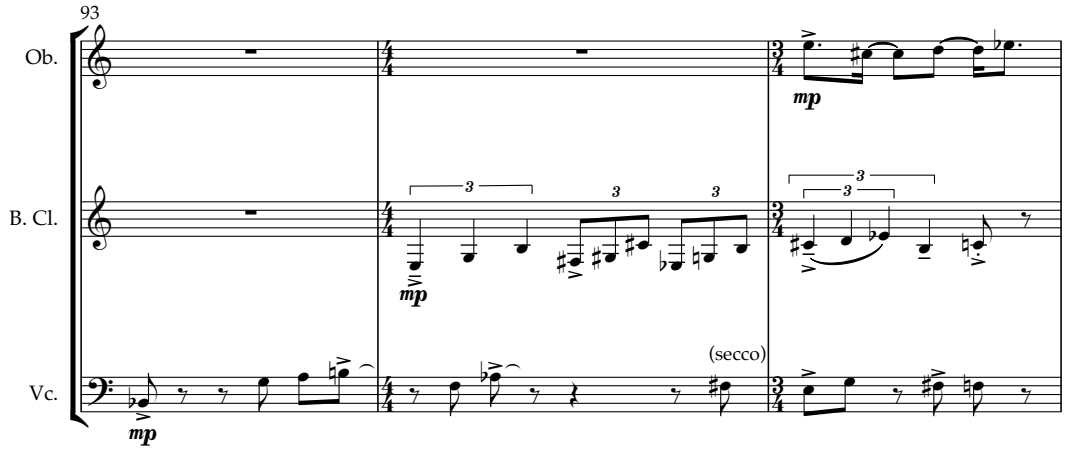


Figure 12. *Goldilocks…,* bars 93-95.

Goldilocks… was performed during a concert showcasing Marc Yeats' timecode-supported polytemporal compositions. Hearing *bricolage VI* (Yeats, 2022) alongside *Goldilocks…* was interesting, with Yeats' more extensive tempo independence and flexibility emphasising temporal distinction. However, whilst directing concert rehearsals, I observed that following parts and stopwatches simultaneously resulted in extended rehearsal time and performance challenge. Yeats' pieces also lacked any rhythmic synchronisation, demonstrating the textural control that global metronome marks afford (see the chorale beginning in bar 121 of *Goldilocks…*).

As an *étude*, I composed *Goldilocks…* to develop strategies for handling complex textures. Its inclusion in the portfolio should help document the project's starting point and contextualise my later, more novel, explorations of *external* rhythmic layering.

Predictive Uncertainty (2021-22)

In analysing Bach and Debussy, Thomson (1983) frames "functional ambiguity" as the deliberate suggestion of more than one possible meaning (p. 3). In *Predictive Uncertainty*, I aimed to construct tempo ambiguities to explore temporal layering and elasticity. Accordingly, I developed a structure in which stasis is used to delay changes in tempo. This contrasts Carter's

downplaying of metric modulations in *String Quartet No. 5* (Carter, 1995), in which textural reduction serves the recontextualisation of the (newly notated) previous tempo (see **Figure 13**).

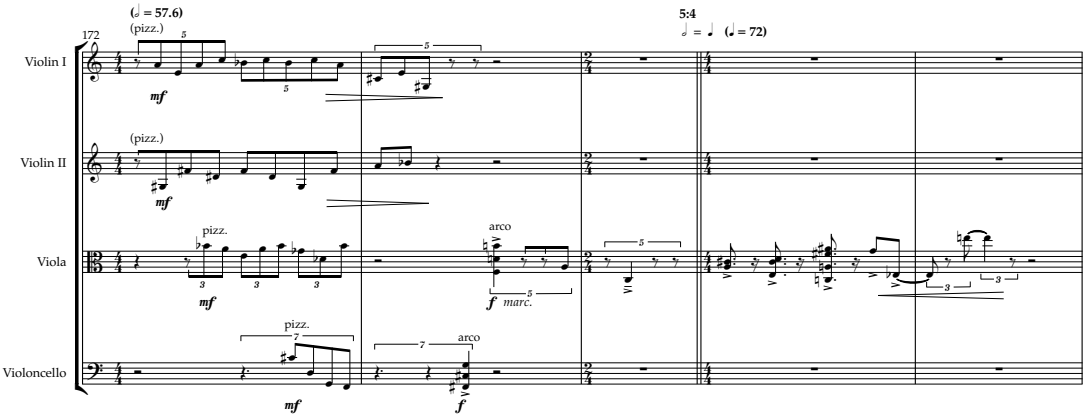
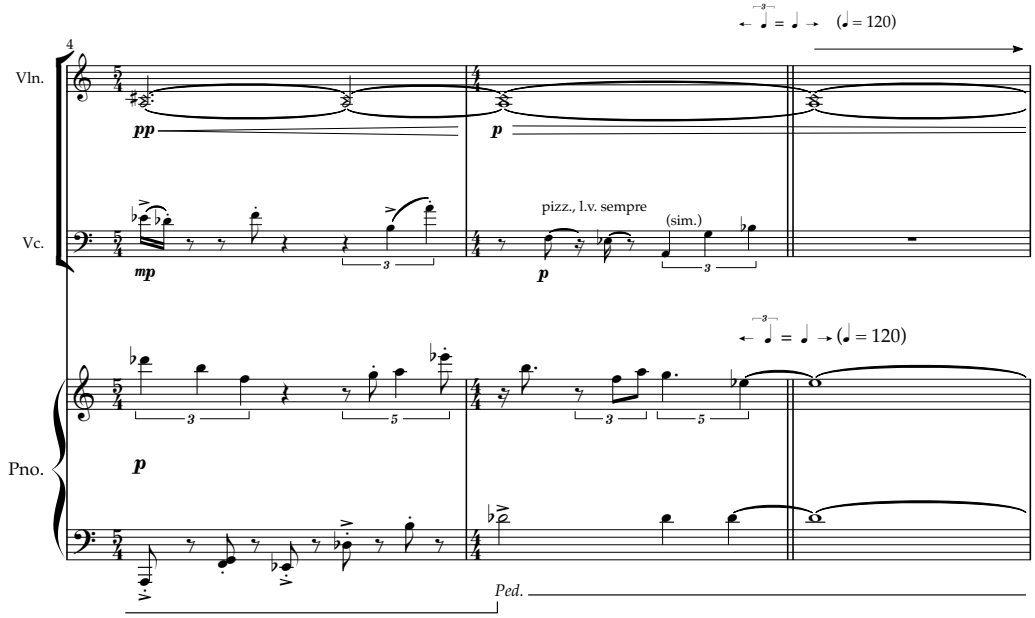


Figure 13. *String Quartet No. 5*, bars 172-176 (Carter, 1995).

Due to metric modulation's employment of ratio, the introduction of multiple distinct pulses makes the ratio of forthcoming changes ambiguous. In *Predictive Uncertainty*, I established multi-layered polyrhythms, using metre as a functional pulse-accommodating frame rather than perceptually. I exaggerated these ambiguities by interrupting tempo changes with abrupt stases to make the ratio, direction, and placement of tempo changes ambiguous. **Figure 14** shows the first instance of this device: in bars 5-6, the triplets modulate the tempo from **crotchet = 80** to **crotchet = 120**, with quintuplets and dotted figures providing decoys. I then withheld indication of this change until bar 8.



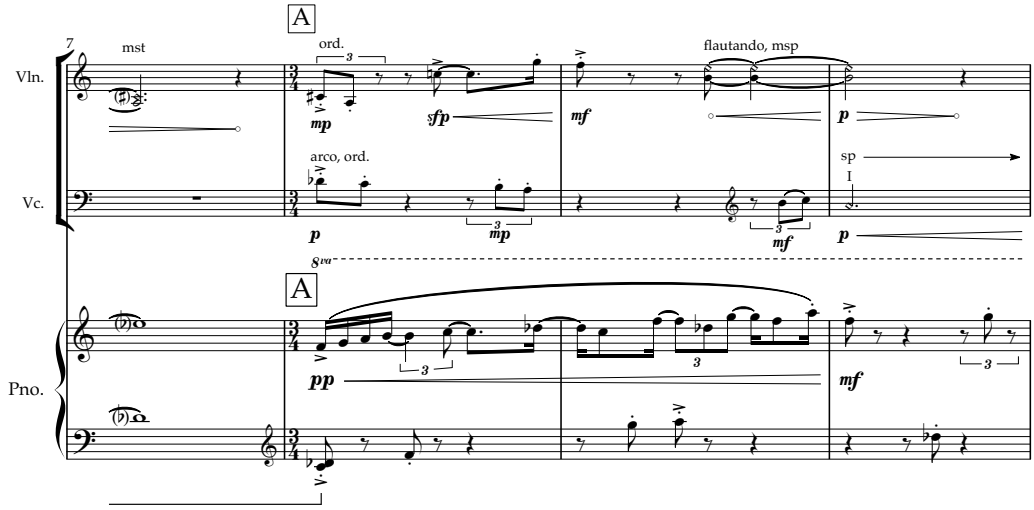


Figure 14. *Predictive Uncertainty*, bars 4-10.

I did not confine these ambiguities to instances of stasis. **Figure 15** shows an extract in which I undermined pulse regularity through consistent use of triplets and quintuplets in 5/4 metre, presenting temporal elasticity horizontally and vertically.

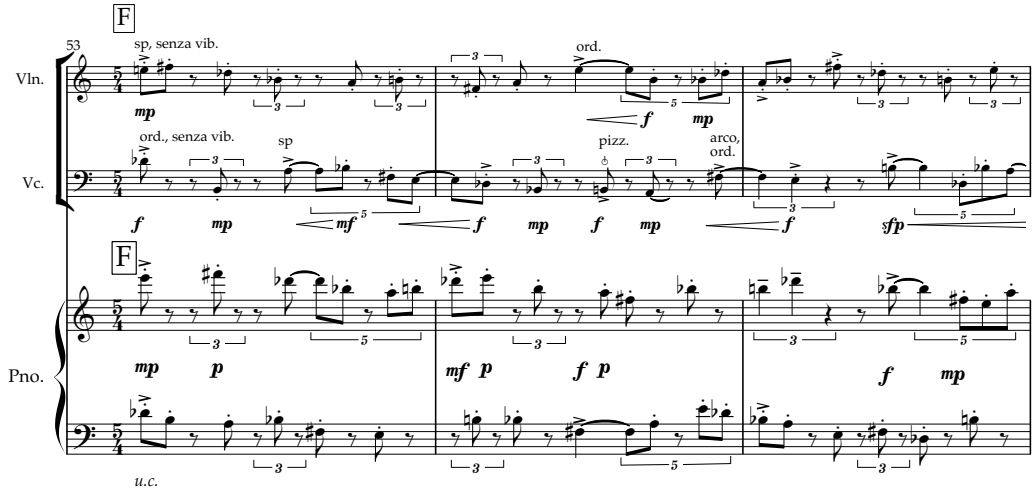


Figure 15. *Predictive Uncertainty*, bars 53-55.

I chose the instrumentation for its diverse potential across both manually sustained sounds and decaying resonances, using the sustain pedal, *sostenuto* pedal, and passive string excitation to control piano resonance. Similarly, I explored various string techniques, including *pizzicato* resonances controlled by range and technique (for example, Bartók), harmonics, *glissandi*, and changes in bow position to heighten the material's volatility. I was also drawn to the piano trio as an unconducted ensemble, preventing visual clues from undermining the intended temporal ambiguities.

Adlington (2006) notes Birtwistle's intent of "ambiguating" the relationship between recurring sections in *Verses for Ensembles* (p. 133). Here, I sought to achieve a similar effect through my handling of the structure, which is akin to that of *Récitation No. 9* (Aperghis, 1978) (see **Figure 16**).

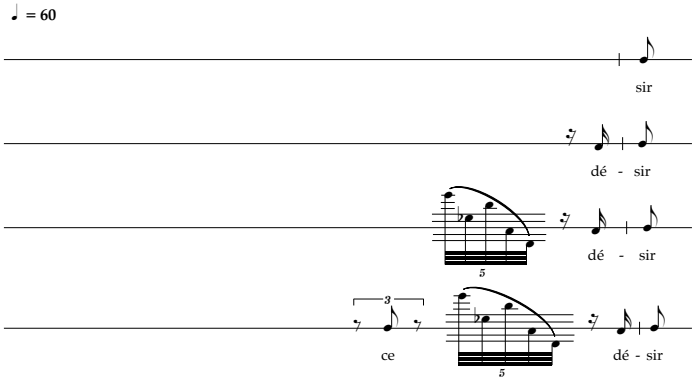


Figure 16. Opening systems of *Récitation No. 9* (Aperghis, 1978).

This "*récitation*" is constructed by successively prefixing gestures to the previous series of gestures until the full ordering is revealed. In *Predictive Uncertainty*, I applied this structure to larger subsections of material. My transformation of these materials deviates from Aperghis' use of exact repetition, compounding the temporal ambiguity. **Figure 17** shows the descending piano figure of bars 14-15 moving to the cello in bars 174-175.

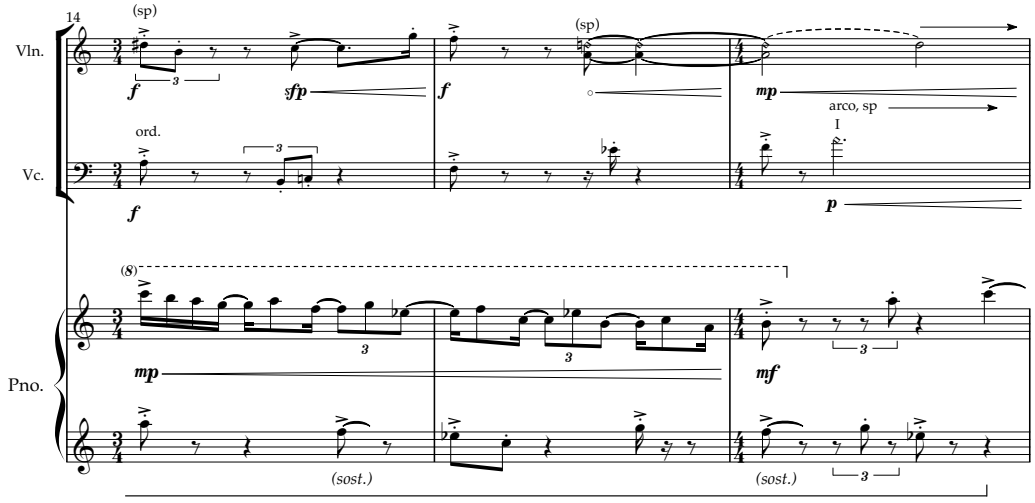


Figure 17a. *Predictive Uncertainty*, bars 14-16.

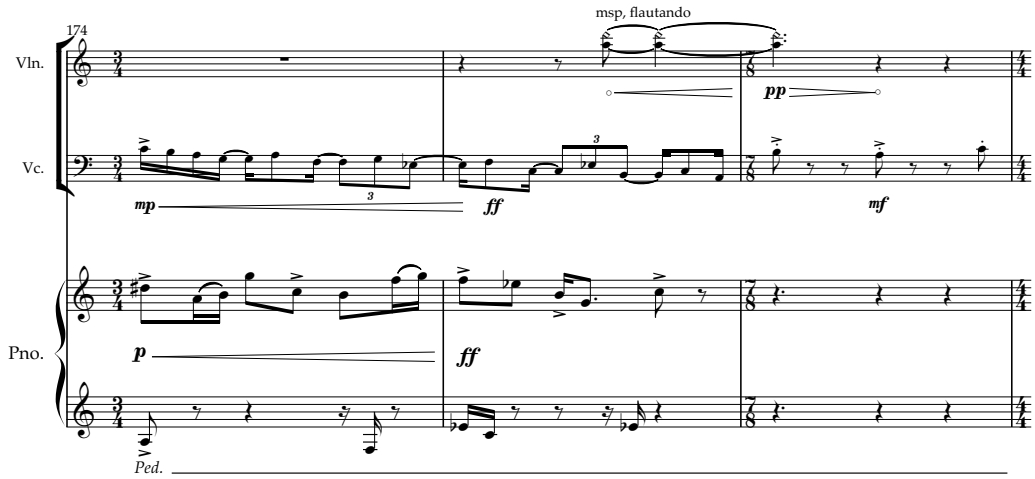


Figure 17b. *Predictive Uncertainty,* bars 174-176.

I also repeated sections at different tempi. In the above example, bars 14-16 are played at **crotchet = 120** whereas bars 174-176 are played at **crotchet = 100**. I achieved this through the multi-layered polyrhythms, which facilitate diverse tempo sequences. With the "*récitation*" also continually restarting further away from its opening (and concluding) material, these structural elements helped me to compound temporal ambiguity.

This multi-directionality and structural blurring influenced my pitch organisation. Each of the six subsections (other than the last) shifts from one hexachord to another, with one pitch in the second hexachord deviating from the first (see **Figure 18**). However, I often sustained departing pitches between hexachords to ambiguate harmonic motion. The complete ordering reveals a shift from one transposition of the harmonically ambiguous whole-tone scale (Hexachord 6.) to the other (Hexachord 1b.).

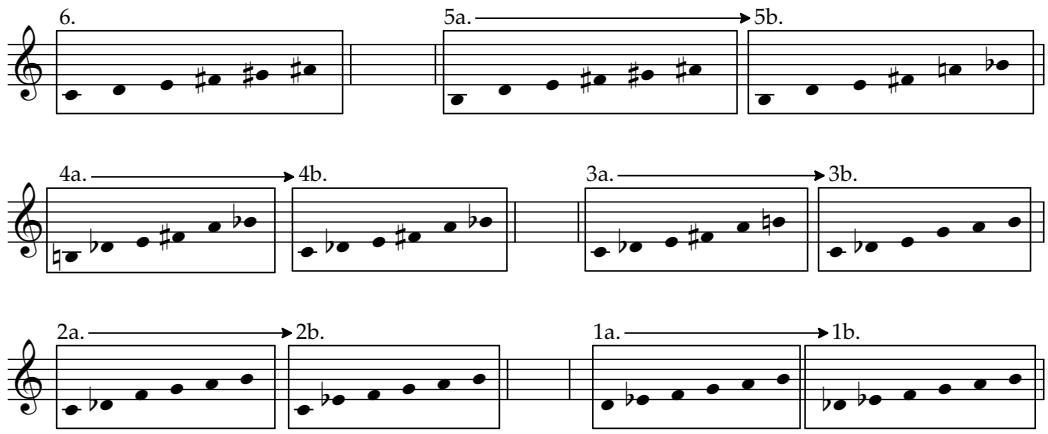


Figure 18. *Predictive Uncertainty*: hexachords.

Whilst each section contains sequential micro pitch alterations, the harmonic shift from the end of one section to the start of the next becomes more significant each time, presenting additional multiplicities. **Figure 19** shows the structural interaction between subsection/hexachord set and metronome mark.

Section No.	**(X)**	**1**		**2**				**3**						**4**							
Subsection/ Hexachord Set	(X)	1	(X)	2	(X)	1	(X)	3	(X)	2	(X)	1	(X)	4	(X)	3	(X)	2	(X)	1	(X)
Bar No.	1	2	6	8	20	22	26	27	32	33	45	47	51	53	66	67	72	74	86	87	91
Tempo, crotchet =	(80)	80	(120)	120	(80)	80	(60)	60	(60)	60	(80)	80	(120)	120	(75)	75	(100)	100	(80)	80	(60)

Section No. (cont.)	**5**									**6**								**(X)**
Subsection/Hexachord Set (cont.)	5	4	(X)	3	(X)	2	(X)	1	(X)	6	5	4	(X)	3	(X)	2	(X)	1	(X)
Bar No.	92	104	110	111	116	117	129	130	134	135	140	152	158	159	168	169	180	181	185
Tempo, crotchet = (cont.)	60		(75)	75	(100)	100	(80)	80	(100)	100			(75)	75	(100)	100	(80)	80	(50)

Figure 19. *Predictive Uncertainty*: structural table.

In *Predictive Uncertainty*, I systematically explored my *ambiguity as multiplicity* concept. I used this process to define the materials, establishing a pre-compositional tempo sequence to present evolving relationships between recurring materials. The interaction between material, tempo, and additional transformation presents an alternative to Aperghis' "*récitation*" structure and other multi-directional forms (for example, the palindromic *Précis* (Birtwistle, 1960)).

Tremors in the Rift Between (2022)

Meditating on growth and decay, I constructed an extreme double bass *scordatura* (see **Figure 20**) to counterpoint acoustic beating, resonance, and timbre. I sought to expand the instrument's sonic capacity and propose an alternative approach to string writing.

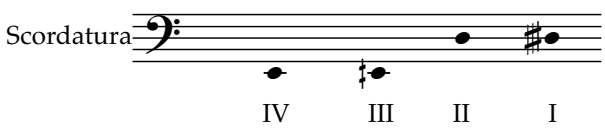


Figure 20. *Tremors…*: *scordatura*.

Acoustic beating results when two pitches of similar frequency sound simultaneously, producing an interference pattern with a rate equal to the frequency difference:

Acoustic Beating Frequency (Hz) **= Frequency B** (Hz) **– Frequency A** (Hz)

I used double stops to explore acoustic beating and resonance quality, making studied use of open strings, stopped pitches, and harmonic spectra. I limited myself to partials 2, 3, 4, 5, and 6 and the stopped pitches at the nodes for those partials within the first octave of each string (see **Figure 21**).

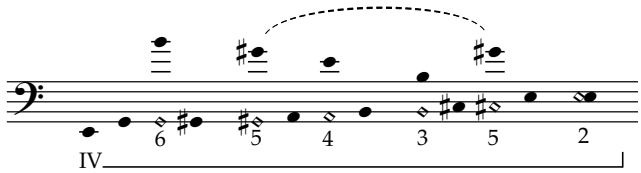


Figure 21. The IV pitches used in *Tremors…* (sounding 8vb).

Next, I generated two sets of double stops: IV+III, II+I. I ordered the IV+III set from lowest to highest acoustic beating frequency and the II+I set from highest to lowest. Therefore, the beating tempo of the IV+III set increases as that of II+I decreases. I then freely combined them into a structural framework (see **Figure 22**). The difference in intervallic relationship between IV+III (quartertone) and II+I (three quartertones) highlights their distinction. Controlling acoustic beating to generate a structural framework is distinct from most uses of the phenomenon: Glover (2013) notes Phill Niblock's foregrounding of beating across converging and diverging pitch trajectories (pp. 16-17).

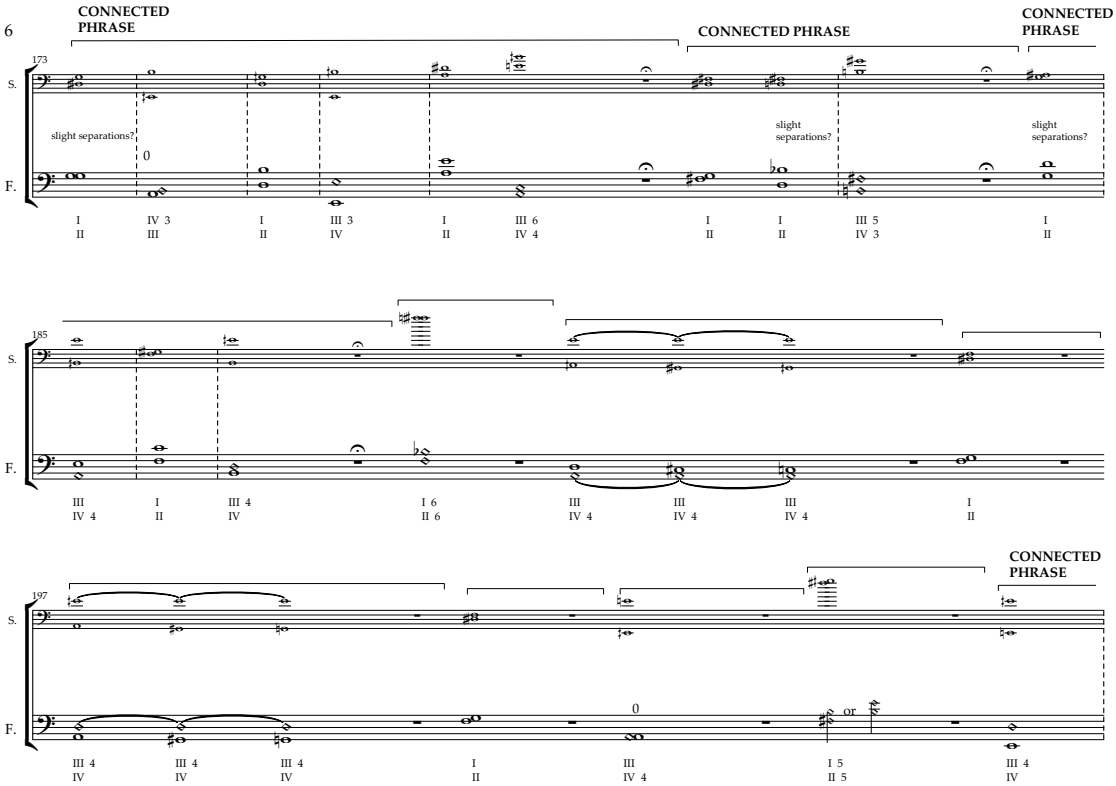


Figure 22. *Tremors…*: structural sketch (extract).

When composing-out this pitch structure, I loosely applied voice-leading principles to connect dyads into phrases of increasing length, occasionally using *laissez vibrer* ties to blur phrase boundaries. Aiming to foreground resonance and timbral quality within this pitch structure, I used varying *pizzicato* types, changes in bowing technique and position, and extreme dynamic contrast. I also modified time-space notation to incorporate "full decay" times, allowing resonance to control and layer durations. This lack of rhythmic prescription helped focus my aims and was also well-suited to the improvisation-focused practice of James Banner, the performer for whom I was writing.

The extreme detuning (and consequent reduced string tension) of III and I decrease their resonance significantly: double basses are designed as resonators for standard tuning, not my *scordatura*. This presents a disparity in timbre and resonance quality between the standardly tuned and detuned strings. Notably, certain detuned-string harmonics only sounded if played *sul ponticello* or nail *pizzicato*. Forcing two strings with different vibrational capacity to sound simultaneously created additional instability. I used these emergent challenges to define material boundaries, hence the separation of some dyads into isolated pitches.

Music, When Soft Voices Die (2022)

In composing for Renaissance-specialists the Orlando Consort, I explored isorhythm, canon, and polyphony. Conjointly, I chose a poem whose meaning could be reflected through temporal complexity: *Music, when soft voices die* (Shelley, 1824).

To paint the poem's image of memory longevity, I began with all singers presenting couplet one ("Music, when soft voices die, Vibrates in the memory;") (Shelley, 1824). I then set couplet two for the upper three voices, superimposed atop Baritone fragments of couplet one to embody remembered musical vibrations following the death of multiple "voices". I repeated this process, leaving behind Tenor 2 and Tenor 1 on couplets two and three respectively.

I used fragmentation and augmentation to transform each couplet's subject into a distorted memory. **Figure 23** shows how this process completes: each couplet fades out sequentially before the Countertenor's solo presentation of the final line ("[Love itself] shall slumber on.") (Shelley, 1824). Despite systematically dividing couplets between singers, I handled material deconstruction and contrapuntal relationships intuitively.

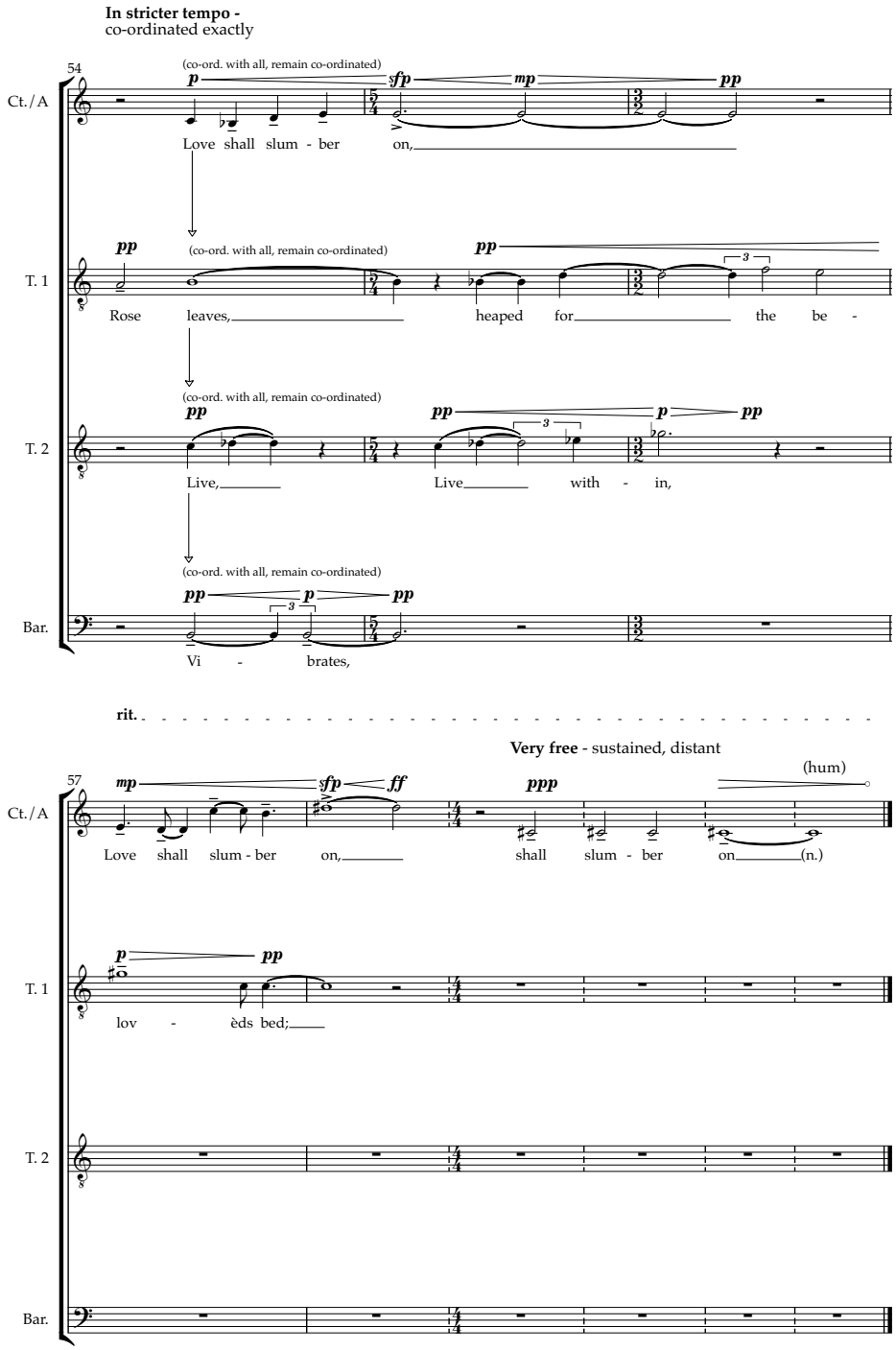


Figure 23. *Music…*, bars 54-62.

This piece was my first exploration of isorhythm. I was, and remain, attracted by their coherent structuring of independent cycles and their capacity for varying limited materials. In the opening section, I used isorhythm alongside canon and freer ensemble coordination to embody independently murmuring voices. With each singer presenting different text from bar 45, I decided to embed syllabic dissonance into the material from the outset. Accordingly, I constructed an isorhythmic interaction between three independent cycles: a *talea* of eight

rhythmic values, a melodic shape of six pitches, and a seven-syllable text phrase (see **Figure 24**). My canonic treatment of this material produced an interweaving mobile of the poem's opening line. I heightened this murmuring effect by repeating C_4 successively within the pitch cycle.

Parameter:	**Cycle:**							
Rhythm	crotchet	dotted crotchet	quaver	quaver	quaver	quaver	quaver	crotchet
Pitch	C_4	C_4	C_4	D_4	C_4	B_3		
Syllable	Mu-	sic	when	soft	voic-	es	die	

Figure 24. *Music…*: opening isorhythmic cycles.

Following cycle realignment, I began expanding the pitch space diatonically within C major by altering each singer's pitch cycle independently. After the second isorhythmic completion, I introduced chromatic alterations on "Vibrates". I then set the second line in full, using homophonic chromatic harmony diverging from a unison C_4 (see **Figure 25**) to distinguish the adjacent textural complexities.

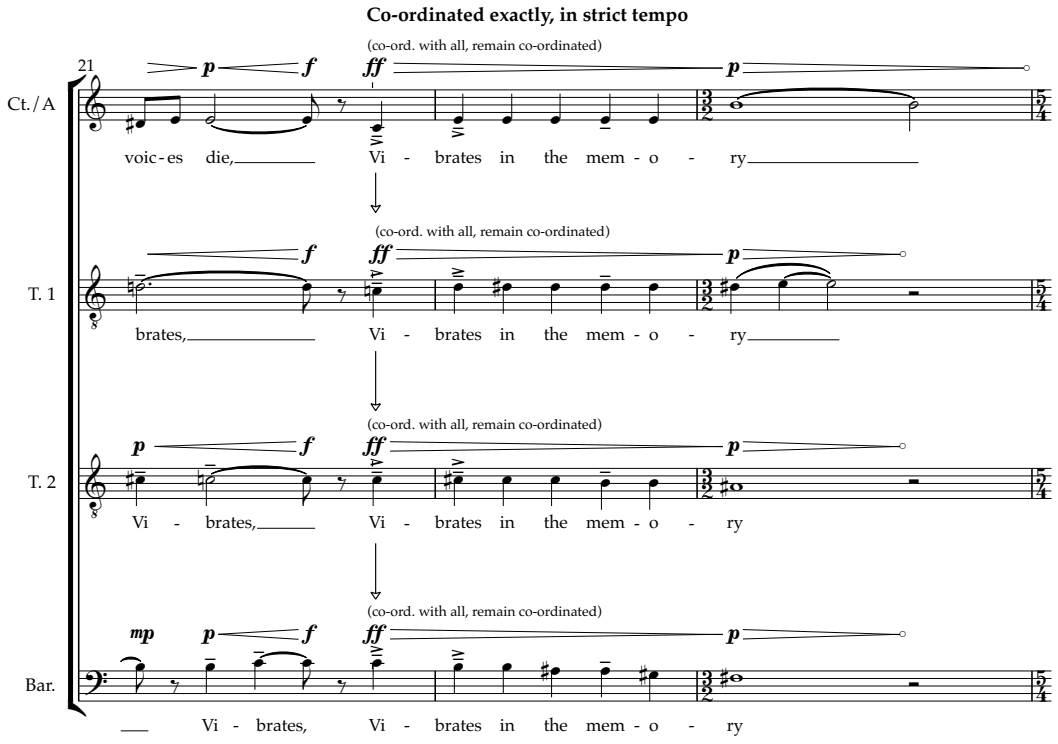


Figure 25. *Music…*, bars 21-23.

The piece's most complex textures (bars 1-21 and 44-53) result partially from freer ensemble coordination. Shifting between ensemble coordination states was an important dimension of

my approach to temporal layering here, as it has been for many composers (see *External* Rhythmic Layering and Notation). I took the novel approach of asking the three upper voices to perform with a *rubato* that is "not strictly co-ordinated" with the Baritone's steady "but not over-accented" tempo. I conveyed these intentions using dashed and solid barlines alongside written instructions. This enabled me to organise intricate and dense polyphony without complicated rhythmic notation, distinguishing my approach from Ligeti's micropolyphony (for example, *Requiem* (Ligeti, 1965)).

From bar 43, I combined this ensemble coordination state with independence of text. To maintain textural control, I sought out instances where couplets shared similar words or syllables and used them as coordination targets. I used arrows and written instructions to notate these gestures (see **Figure 26**), increasing their frequency throughout the section to gradually unify the texture.

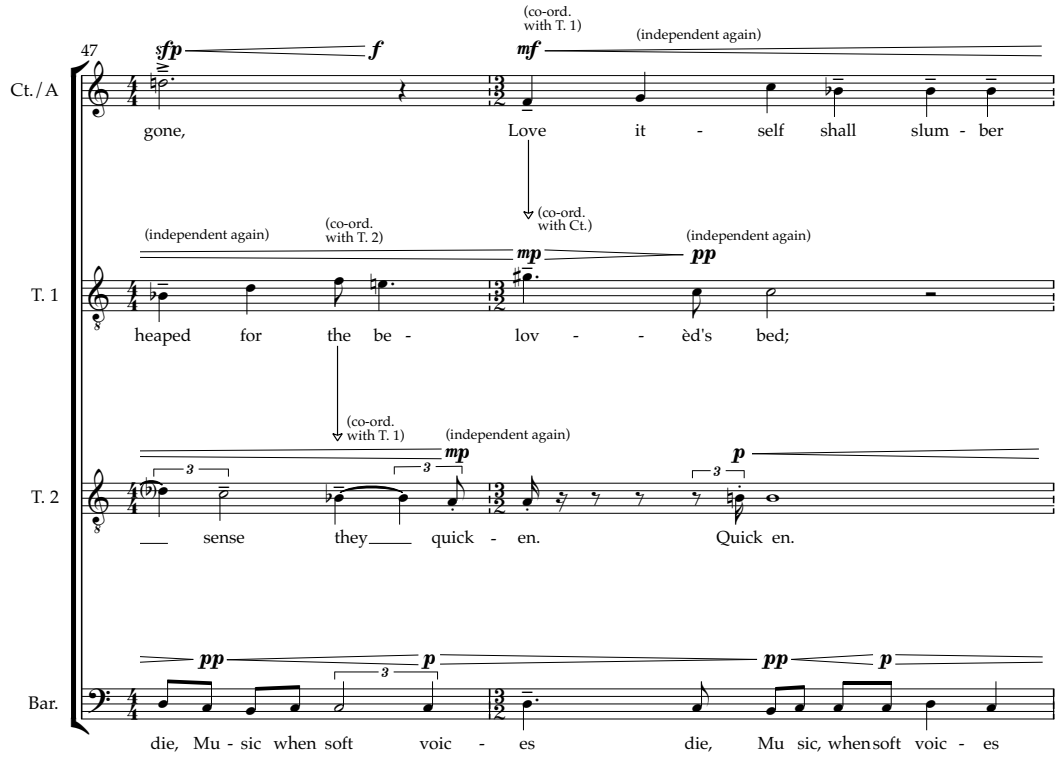


Figure 26. *Music…*, bars 47-48.

This piece demonstrates how the setting of a carefully selected text might employ temporal layering to explore its meaning. My use of isorhythm, canon, independent *rubato*, and independence of text aided textural diversity whilst helping unify distinct materials. For example, the canon-based presentation of couplet two connects it to couplet one's initial setting. However, strict ensemble coordination and its non-isorhythmic construction result in a

significantly different textural quality. Through emphasising these similarities and differences, I investigated new structural possibilities and explored the text's portrayal of memory.

Metrognomon (2023)

The Arditti Quartet's virtuosity encouraged me to explore the limits of temporal complexity and elasticity. The title combines "Metronome" and "Gnomon" (the shadow-casting fin of a sundial), reflecting my investigation of rhythm-metre decoupling and layering of periodic and aperiodic materials. The two pulse layers (beginning in the second violin and viola) denote the *Metronome*. Beginning in the first violin, the *Gnomon* moves independently of the *Metronome*, juxtaposing the metre of each bar with the tuplet or subdivision ratio projected onto that bar. **Figure 27** shows these layers in the opening bars.

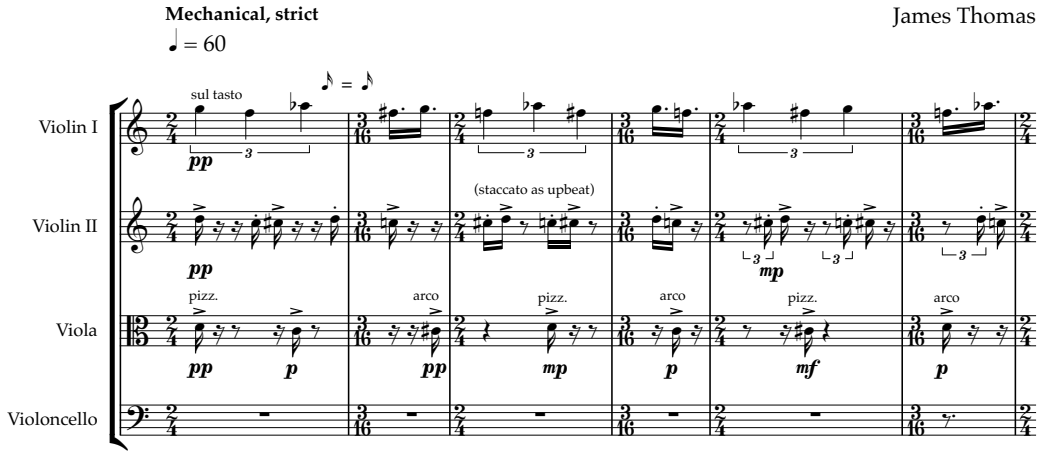


Figure 27. *Metrognomon*, bars 1-6.

Beginning with triplet crotchets in a 2/4 bar, I composed the *Gnomon* by using tuplet ratio to determine the number of beats in the following bar. Beat size was chosen arbitrarily (hence 3/16, as opposed to 3/8). Following the initial 2/4-3/16 loop, I developed this process, dividing every other 2/4 bar into quintuplet quavers before closing the loop with a 5/16 bar divided in two (see **Figure 28**). Each loop is followed by a re-ordered (2/4-5/16-2/4-3/16) loop.

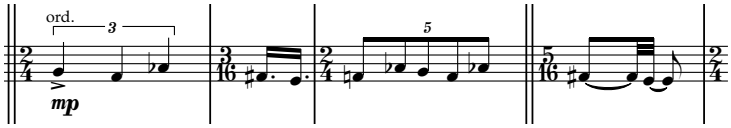


Figure 28. *Metrognomon*, Violin II, bars 37-40.

From bar 65, I introduced additional ratios to transform the *Gnomon*. I used 6:5 tuplet semiquavers (grouped into quavers) to trigger 3/8 from 5/16, with 5:6 tuplet semiquavers

facilitating the reverse motion. I then compounded temporal complexity by embedding 3:2 ratio polyrhythms within each 5/16 bar (see **Figure 29**). Here, the viola maintains the 3/8-5/16 fragment whilst the cello foreshadows the return of the 2/4-3/16-2/4-5/16 sequence.

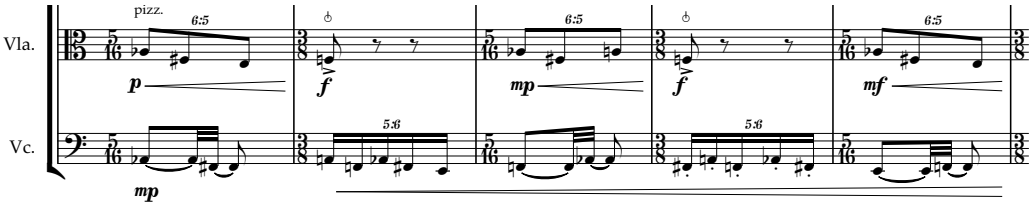


Figure 29. *Metrognomon*, Viola and Violoncello, bars 118-122.

The *Gnomon* allowed me to trigger metric modulations, enabling material and tempi to recontextualise one another. I used nested tuplets to embed additional temporal layering: bar 135's underlying quintuplet triggers the proceeding 5/16 bar whereas the nested triplet echoes the preceding 3/16 bar (see **Figure 30**). I divided surrounding 3/16 and 5/16 bars into four to compound this increased complexity.

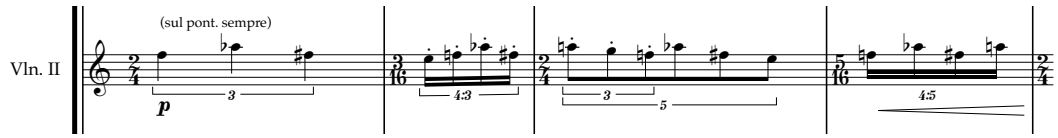


Figure 30. *Metrognomon*, Violin II, bars 133-136.

From bar 213, having broken from the *Gnomon*, I revealed the salient metrical sequence by placing unison attacks on the metrical stresses of each bar (see **Figure 31**). I made this transition gradually, distorting the *Gnomon*'s rhythmic process (Violin I, bars 202-207) before introducing metre-revealing attacks as it concludes (bars 209-212). I also used the cello's preceding melodic passage to delay the first full-ensemble attack until bar 218. Contrastingly, I made the *Gnomon*'s return (a 2/4-5/16 fragment beginning in bar 229) more abrupt, heightening temporal contrast.

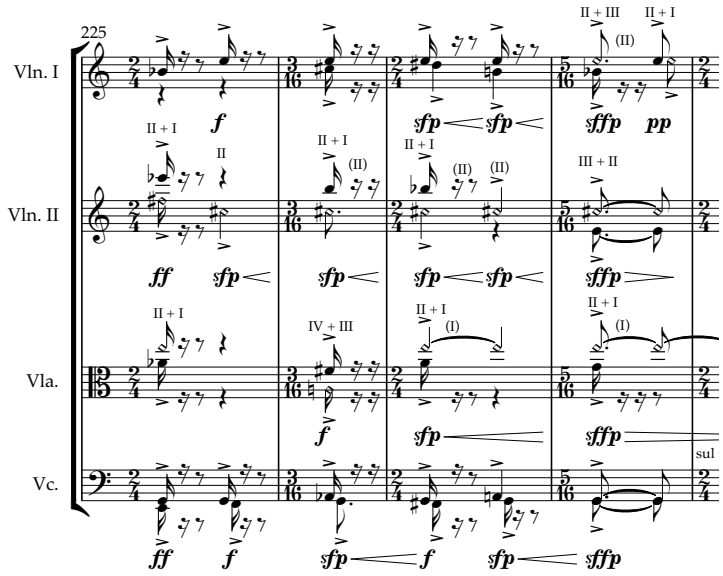


Figure 31. *Metrognomon*, bars 225-228.

I used the *Metronome* to highlight the durational consistency of metrical loops (2/4-3/16-2/4-5/16 and 2/4-5/16-3/8-5/16 each sum to six crotchets), compound metrical ambiguity, and undermine chronometric time. With each *Metronome* layer maintaining independence, I used dynamic accents to emphasise points of alignment (see **Figure 32**) and foreshadow ensemble coalescence during the section of metrical clarity.

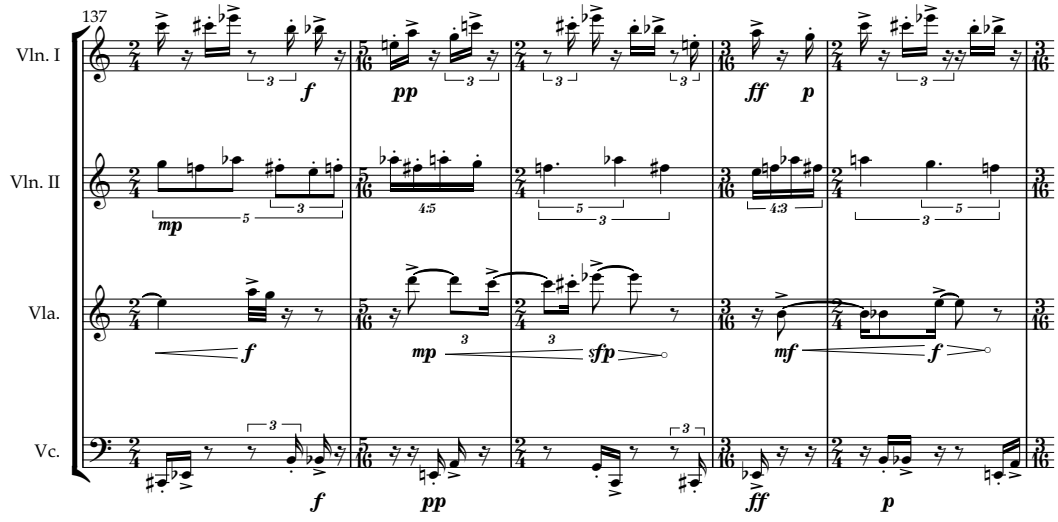


Figure 32. *Metrognomon*, bars 137-141: occasional *forte*/*fortissimo* unisons between Violin I and Violoncello.

I embellished some pulses with anacruses to compound temporal elasticity. In bar 17, viola triplet semiquavers distort pulse periodicity. I communicated desired emphasis using *staccato*/unaccented "as upbeat" written instructions (borrowed from *Hoquetus Irvineus* (Birtwistle, 2014)). Other *Metronome* variations include the sustaining of pitches between pulses (for example, Viola, bar 9), its transformation into continuous semiquavers and triplets

(Violoncello, bars 112-117), its appearance as ostinato (Violin I, bar 133), and the embedding of additional periodicities (see **Figure 33**).

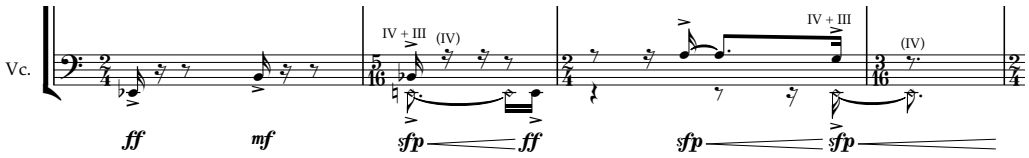


Figure 33. *Metrognomon*, Violoncello, bars 161-164: crotchet pulses double-stopped with harmonics every third pulse, each of which is extended until the following attack.

The pitch structure comprises two pitch cycle sets. I applied the first to the *Gnomon*, using isorhythmic technique to determine iteration repeats. I applied the second to the *Metronome* layers, ensuring that they completed (and mutated) conjointly with the *Gnomon* set by moving between pulse lengths and embellishments freely. This helped me to connect and distinguish layers. I successively appended pitches to each cycle before removing them from the start of the *Gnomon* cycle and the start and end alternately of the *Metronome* cycle (see **Figure 34**). I signposted pitch addition and removal through harmonics and double stops.

Iteration No.	***Gnomon* Pitch Cycles**	***Metronome* Pitch Cycles**
1	G-F-Ab-F#	D-C-C#
2	G-F-Ab-F#-E	D-C-C#-Eb
3	G-F-Ab-F#-E-F	D-C-C#-Eb-B
4	G-F-Ab-F#-E-F-Ab	D-C-C#-Eb-B-Bb
5	G-F-Ab-F#-E-F-Ab-F#	D-C-C#-Eb-B-Bb-E
6	G-F-Ab-F#-E-F-Ab-F#-A	D-C-C#-Eb-B-Bb-E-A
7	F-Ab-F#-E-F-Ab-F#-A	D-C-C#-Eb-B-Bb-E-A-G
8	F-Ab-F#-E-F-Ab-F#-A-G	C-C#-Eb-B-Bb-E-A-G
9	Ab-F#-E-F-Ab-F#-A-G	C-C#-Eb-B-Bb-E-A
10	F#-E-F-Ab-F#-A-G	C#-Eb-B-Bb-E-A
11	E-F-Ab-F#-A-G	C#-Eb-B-Bb-E
12	F-Ab-F#-A-G	Eb-B-Bb-E
13	Ab-F#-A-G	Eb-B-Bb

Figure 34. *Metrognomon*: pitch cycles.

The fourth layer comprises quasi-*cadenzas* (Violin I, bars 41-62; Violin II, bars 69-96; Viola, bars 133-168; and Violoncello, bars 169-215). I composed the violin *cadenzas* using the *Gnomon* pitch cycles, and the viola and cello *cadenzas* using the *Metronome* pitch cycles. Through combination with open strings, this enabled me to emphasise the harmonic profile's

prevailing semitonal dissonances. These *cadenza*s, which successively grow in length and intensity, consist of double stop interjections and melodic fragments (see **Figure 35**).

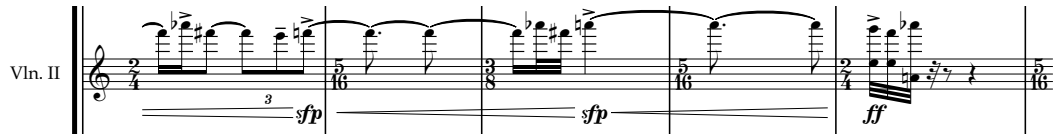


Figure 35. *Metrognomon*, Violin II, bars 81-85: *cadenza* extract.

In *Metrognomon*, I explored the relationship between *external* and *internal* rhythmic layering to investigate the limits of temporal complexity. I employed various cyclical structures, processes, and intuitive decision making to recontextualise my materials and construct temporal elasticity, concerns I explored further in *Circles Drawn Freehand*.

Circles Drawn Freehand (2023-24)

Exploring my interest in working with limited materials, I subjected a 5:6 polyrhythm to monothematic variation using my novel *polyrhythmic approximation* technique to connect multiple magnitudes of cyclical structure and present time as elastic. My strategy was to juxtapose 5:6 polyrhythms, 5:6 polyrhythms with one rhythmic strand being presented inexactly (for example, 5:c.6), and iterations presenting the same strand exactly and inexactly (for example, 5:c.5). I created recurring cycles from the finite combinatorial possibilities (5:6, 5:c.6, c.5:6, 5:c.5, 6:c.6, and reciprocals), maintaining one strand's value and changing the other between iterations. I allocated the 5-strand to the pianist's right hand and the 6-strand to their left, reversing this hierarchy halfway through the structure (5:6 becomes 6:5). My systematic and cyclical approach to combinatoriality (see **Figure 36**) distinguishes it from Birtwistle's labyrinth-like structures of material and tempi pairings in *Pulse Sampler* (Birtwistle, 1981).

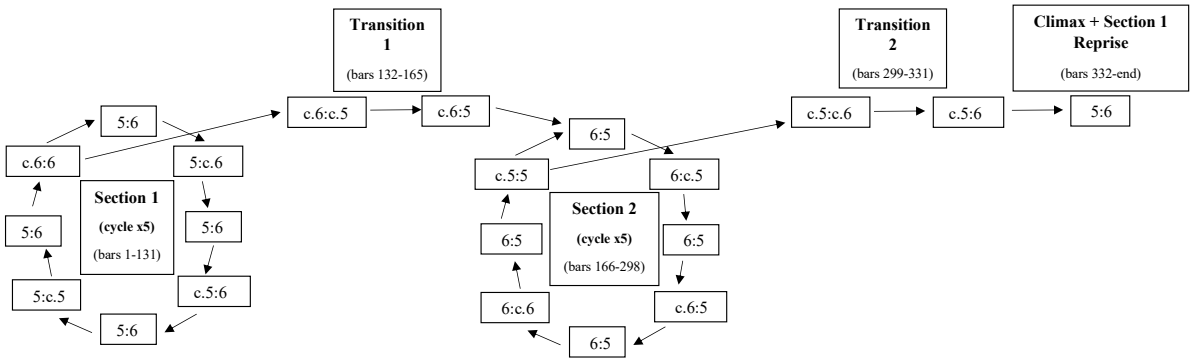


Figure 36. *Circles Drawn Freehand*: structural diagram.

Having decided that a 5:6 ratio would most-optimally balance rhythmic nuance with performability, I tested how various tuplets, nested tuplets, and subdivisions could produce *polyrhythmic approximation* within different metres. Whilst Carter juxtaposes precise and approximate pulse values to connect materials extracted from a structural polyrhythm to the polyrhythm itself in *String Quartet No. 5* (Aylward, 2009, pp. 96-97), I used the technique to elasticate chronometric time. **Figure 37a** shows six almost evenly spaced attacks in a 5/4 bar, creating a 5:c.6 ratio. I re-notated these rhythms using semiquaver subdivisions and shorter metres to improve horizontal and vertical consistency (see **Figure 37b**). Whilst the resulting 9:8 semiquavers could be written using nested triplets (crotchets or quavers), I communicated the 2:3 ratio between hands by grouping the 9:8 semiquavers into dotted quavers.

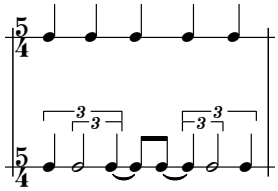


Figure 37a. Initial sketch of a 5:c.6 iteration in a 5/4 bar.

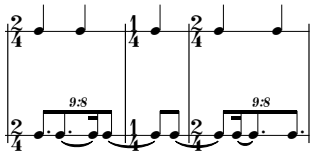


Figure 37b. The iteration shown in **Figure 37a** re-notated.

I accentuated the cyclical structure by assigning two pitch cycles to each of the pianist's hands. Until **Transition 2**, where all pitch cycles are presented consistently, each hand presents one cycle constantly and the other periodically. I further distinguished **Section 1** and **2** by inverting the hierarchy between primary and secondary pitch cycles. **Figure 38** shows the pitch cycles and their structural organisation.

RH1	[C-Eb-Bb-F-Ab-F#]
RH2	[C#-E-Bb-Eb-G-F#]
LH1	[B-D-C#-A-E-G]
LH2	[B-D-C-A-F-Ab]

Figure 38a. *Circles Drawn Freehand*: pitch cycles.

	Primary Pitch Cycles	Secondary Pitch Cycles
Section 1 (bars 1-131)	RH1 LH1	RH2 LH2
Transition 1 (c.6:c.5, bars 132-149)	RH1 LH1	RH2 LH2
Transition 1 cont. (c.6:5, bars 150-165)	RH1 LH2	RH2 LH1
Section 2 (bars 166-298)	RH2 LH2	RH1 LH1
Transition 2 (bars 299-331)	RH1, RH2 LH1, LH2	N/A
Climax (bars 332-361)	RH1, RH2 LH1, LH2	N/A
Climax cont. (bars 362-387)	N/A – unordered pitch sets (distinct from pitch cycles)	N/A
Section 1 Reprise (bars 388-end)	RH1 LH1	N/A

Figure 38b. *Circles Drawn Freehand*: pitch cycle hierarchies across the structure.

I used the *sostenuto* pedal to layer primary pitch cycle resonances with non-resonant presentations of secondary pitch cycles. During **Transition 2**, I maintained the dryness of **RH1** and **LH1** despite making all cycles "primary". I treated secondary pitch cycles malleably: **Section 1** exhibits intuitively fragmented presentations of **LH2** in the right hand (bars 18-20) and **RH2** in the left hand (bars 23-24).

I began the piece with each hand repeating the first note of their primary pitch cycles. For **Section 1**, I devised a rule to temporarily introduce the next pitch in the cycle corresponding to the strand undergoing *approximation* before including it permanently in the following structural cycle. I repeated this process until both six-note primary pitch cycles were revealed. Contrastingly, I successively removed pitches from the secondary pitch cycles, which I initially employed in completed form. The pitch cycles in **Section 2** undergo the same processes: **RH1** and **LH1** begin incomplete and are added to whereas **RH2** and **LH2** begin complete and are removed from. However, because I reversed the pitch cycle hierarchy, **Section 2** exhibits the opposite primary and secondary pitch cycle trajectories, completing the macro structure.

I ensured that the pitches of **RH1** and **RH2** were completely distinct from those of **LH1** and **LH2** respectively, helping highlight layer distinction. Their mutually complimentary construction also enabled me to gradually establish and then deconstruct contrasting

dodecaphonic harmonic profiles. This imbalance towards cyclical transformation (over exact repetition) distinguishes my approach from that outlined by Harrison (2007), who notes his intent to establish "an equilibrium between stasis and motion" in relation to pitch cycles (p. 8). Building upon *Predictive Uncertainty*, I heightened temporal ambiguity by periodically fragmenting polyrhythmic iterations and displacing sustain pedal changes from pitch cycle changes.

To mark structural cycle completions, I employed disruptive gestures in the registral extremes of the piano. These interjections foreshadow the toccata-like **Transition 2**, where I interpolated transformation of the secondary pitch cycle materials and interjecting flourishes amongst polyrhythmic iterations. I concluded the section with a climax centred around the pitch cycles and the interjection gesture pitches to consolidate the link between these materials. Görgün (2020) notes how Horacio Vaggione takes a similar approach within an electroacoustic context, circulating iterative transformations across structural layers to connect and distinguish them (pp. 169-170). I completed the structure with a slower and quieter repeat of the opening bars distorted by a late pedal change to imply that the piece is merely one cycle of a larger loop existing beyond its audible confines.

This piece exhibits a circular macro structure, the looping of cycles within **Sections 1** and **2**, the micro loop of each polyrhythmic variant, and pitch cycles. In extrapolating a single polyrhythm into a multi-layered structure, I was able to investigate the limits of rhythmic nuance and new structural possibilities in pursuit of temporal elasticity. *Polyrhythmic approximation* of the 5:6 ratio also enabled me to coherently introduce other polyrhythmic ratios (for example, 10:9), furthering the malleability and variable density of the temporal counterpoint.

Roads to Rome/Roam (2023-24)

In this duo, I sought to combine my prior explorations of polytempo, repetition, and ensemble coordination to project temporal elasticity. Beginning at the same tempo, each player changes tempi independently via independent metric modulations. I used tempo ratios as repeat ratios so that the performers move through the structure together. In bar 4, the flautist shifts to **crotchet = 90** whereas the clarinettist remains at **crotchet = 60** (the tempo ratio is 3:2). Accordingly, the flautist plays their material three times and the clarinettist plays their material twice (see **Figure 39**). This strategy enabled me to solve a common challenge of notating polytempo because the number of (written) bars is consistent across parts.

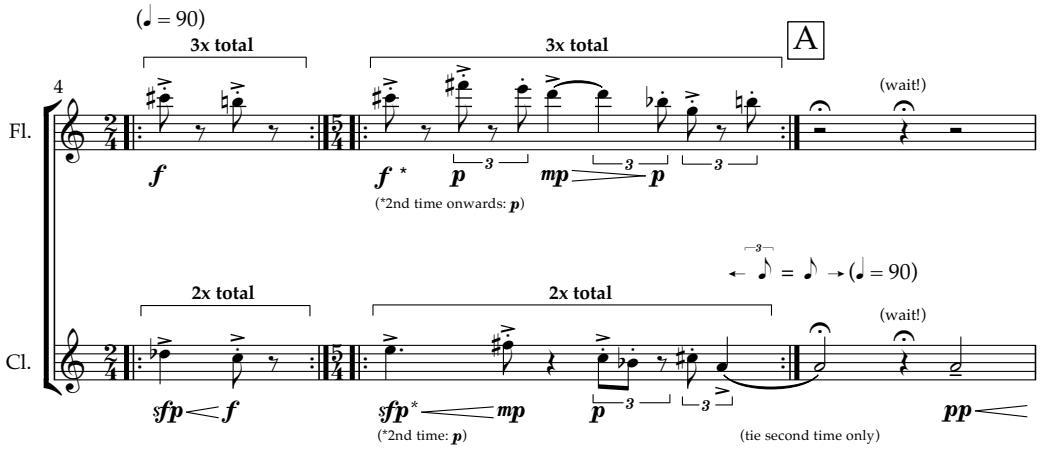


Figure 39. *Roads…*, system two: 3:2 ratio of tempo and repeats (clarinet remains at **crotchet = 60** until letter **A**).

Continuing my exploration of "*récitation*" structures, I began by composing bar-long blocks of material. Unlike in *Predictive Uncertainty*, where material and structure are universal, I superimposed two different "*récitation*" structures (one for each instrument). The flute's structure mimics that of *Predictive Uncertainty* and *Récitation No. 9* (Aperghis, 1978), successively prefixing blocks until the full eight-block ordering is presented. Contrastingly, the clarinet starts from the centre of their full ordering, successively adding blocks either side until the eleven-block structure is revealed. As **Figure 40** shows, the clarinet's structure imitates *Récitation No. 11* (Aperghis, 1978). I chose these structures because they each complete simultaneously after 36 blocks.

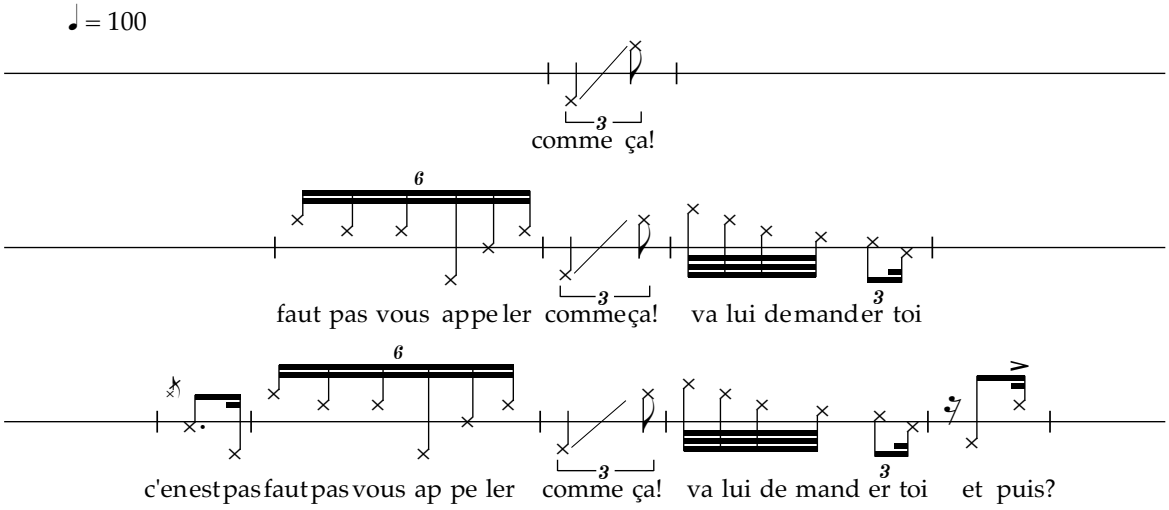


Figure 40. Opening systems of *Récitation No. 11* (Aperghis, 1978), adapted as the clarinet's sub-structure.

I composed each block to facilitate the tempo sequences of my pre-compositional plan. Where blocks needed to be capable of triggering two distinct metric modulations, I divided the block into two units and re-ordered these units as necessary (see **Figure 41**). This allowed me to

traverse various tempo relationships despite the prominence of repetition, further distinguishing my approach from Birtwistle's pulse labyrinth technique.

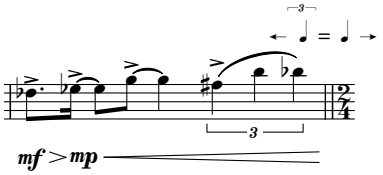


Figure 41a. *Roads…*: a flute block comprising a dotted-value unit and a triplet unit, using the triplets to modulate the flute's tempo from **crotchet = 60** to **90**.

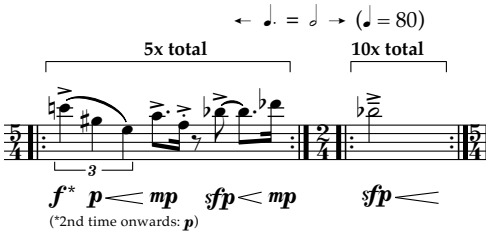


Figure 41b. *Roads…*: the same block but with unit order reversed (and altered rhythmic embellishment), using the dotted-value unit to modulate the flute's tempo from **crotchet = 60** to **80**.

As evident in the above figure, my approach to pitch contrasts with that of *Predictive Uncertainty*, in which blocks were not independent from pitch structure. Here, I blurred repetition-variation boundaries by superimposing contrasting hexachord cycles onto the sub-structures. These structural multiplicities compounded my exploration of material phasing and enabled me to avoid ensemble-level repetition despite its prominence within each part.

I knew that the challenge of maintaining specific polytemporal relationships would produce local-level indeterminacy, hence my titular reference to "roaming". I designed the notational system and tempo structure to investigate the interplay between polytempo, repeating materials, and ensemble coordination. This approach proposes a solution to my prior critique of Marc Yeats' timecode-supported polytemporal notation: my full-score format facilitated coordination state changes that would not have been possible in Yeats' system.

Following draft-stage performer feedback, I experimented with two additional forms of notation: (**A**) a fully written-out polytemporal approach, and (**B**) a fully written-out tuplet-based approach. The former presented immediate scaling issues, whereas the latter became overly complex as the tempo ratios increased in complexity. More significantly, **B** would not have fostered the indeterminacy encouraged by my original system. **Figure 42** shows the first instance of polytempo in these alternative systems.

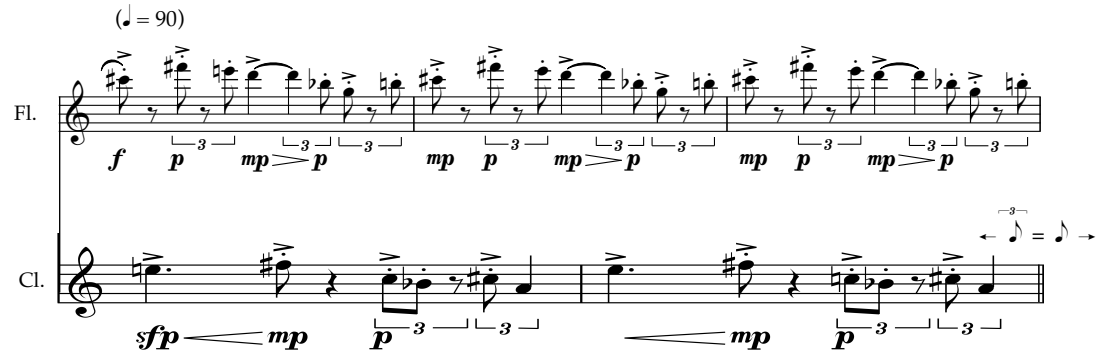


Figure 42a. *Roads…*: alternative notation system **A**.

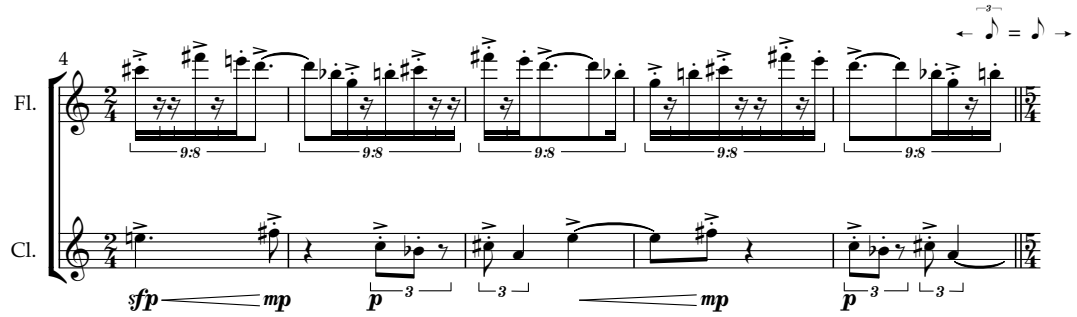


Figure 42b. *Roads…*: alternative notation system **B**.

In returning to my original approach, I sought to improve practicality. I added shorter bars containing simpler rhythms in between metric modulations: the quavers in (written) bar 88 allow the clarinettist to establish **crotchet = 90** before having to execute quintuplets (see **Figure 43**). I also employed first time only dynamic accents, allowing performers to signpost structural progress. These additions support performance without negating indeterminacy.

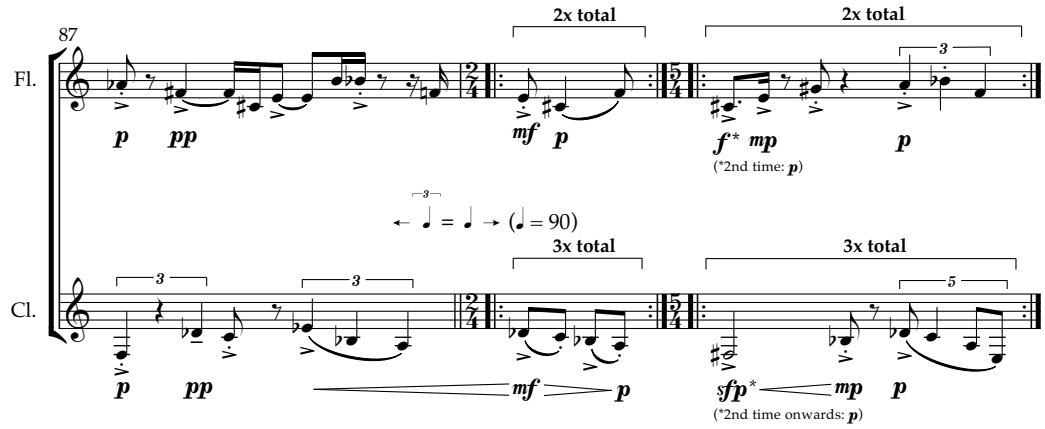


Figure 43. *Roads…*, (written) bars 87-89.

To compound temporal elasticity, I employed opposing *rallentando* and *accelerando* trajectories simultaneously. I used these bars, which swap start and end tempo values in each

part, to mark phrase ends. Following the initial workshop, I added solo passages, rotating thematic fragments, scalic figures, and less texturally complex materials between these phrases (see **Figure 44**). I paired this structural segmentation with rising dynamics and instrumental register to facilitate a *fortissimo* and high register presentation of the climactic polytemporal ratio (9:10). I then employed quiet dynamics, low instrumental register, limited pitch range, and limited polytempo to differentiate the *coda* from the core materials whilst suggesting melodic connections between them.

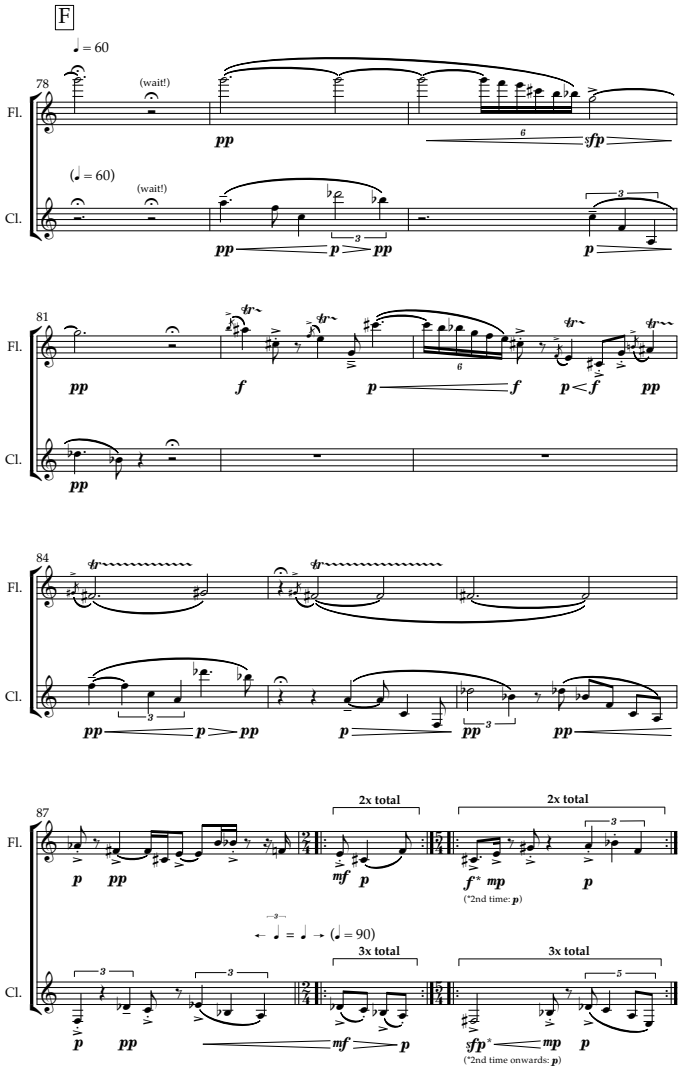


Figure 44. *Roads…*, (written) bars 78-89: a section of contrasting material before a return to the block structure at (written) bar 87.

This piece is my most extensive exploration of polytempo and its limits to date. Through devising a novel notational system, I investigated new structural possibilities relating to independence of tempo, repetition, and material. The resultant phasing, heightened by local-level indeterminacy, facilitated a distinctive presentation of temporal multiplicity and elasticity.

My approach was well-suited to the chamber context but a larger ensemble piece exploring a similar structural process would likely require tuplet reformatting.

In Gnomonine (2024)

Seeking to present a suspension between cyclicality and linearity, I applied contrasting decay durations to isorhythm. My engagement with isorhythm led me to the *In Nomine* plainchant. The chant has a rich compositional history from Taverner's 16th century *Gloria tibi Trinitas* (Taverner, 1923), its extensive use throughout the Renaissance and Baroque eras, to the recent *IN NOMINE: The Witten In Nomine Broken Consort Book* (Ensemble Recherche, 2004). I used the plainchant as a cantus firmus and to derive pitch cycle content (see **Figure 45**). In combining "In Nomine" and "Gnomon", I sought to highlight the plainchant, cyclicality and chronometers, and the poetic connection between resonance and shadows.

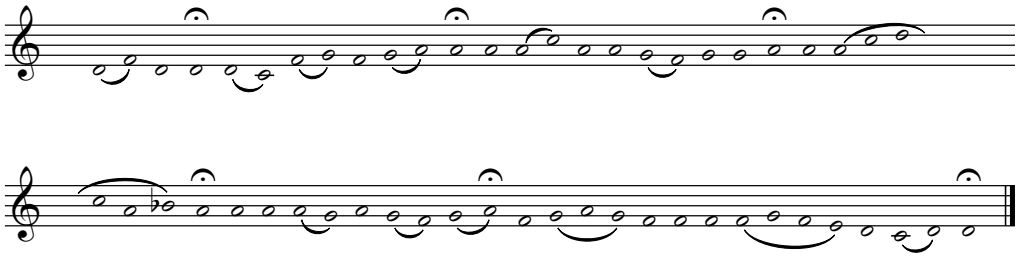


Figure 45a. The *In Nomine* plainchant.

D	**E (+Eb)**	**F**	**G**	**A**	**Bb (+B)**	**C**

Figure 45b. *In Gnomonine*: isorhythmic pitch content, as derived from the plainchant (with two chromatic alterations used for creating harmonic motion).

I began by composing cycles of duration independent of the cycles determining attack placement (*talea*) and pitch to create three-tier isorhythms. These are usually lengthier than two-tier isorhythms with similar cycle lengths because the lowest common multiple of cycle lengths increases as the number of independent cycles increases. This approach builds upon *Music, When Soft Voices Die,* where I embedded a syllable-cycle into each isorhythm. However, I designed the additional cycles in *In Gnomonine* to have greater temporal influence, using them to overlap sustained notes with proceeding attacks. This allowed me to blur line independence and directionality.

My decoupling of attack and duration distinguishes my approach from similar methods. In *Modes de valeurs et d'intensités* from *Quatre Études de Rythme* (Messiaen, 1950), Messiaen combines unordered modes of 36 pitches, 24 note durations, 12 attack qualities, and 7 dynamic levels across three layers. Contrastingly, in *Structures: Premier Livre* (Boulez, 1952), Boulez subjects ordered parameter sets to serial treatment. In both examples, the separation of duration and attack quality results in varied note lengths. However, unlike my approach, neither facilitates attack overlap within a given layer.

My duration cycles included decaying resonances (**d**) and held notes (**h**), to which I assigned duration descriptors of short (**s**), medium (**m**), or long (**l**). During pre-compositional planning, I constructed duration cycles by combining duration types and lengths (for example, **[md-sh-lh]**). I defined held rhythmic durations as follows:

(**s**) = crotchet and shorter
(**m**) = crotchet-minim (inclusive)
(**l**) = minim and longer

This flexibility distinguishes my approach from Messiaen's successive additions of demisemiquavers, semiquavers, and quavers. To classify resonance durations, I considered register, dynamic, and note production.

Building upon *Metrognomon*, I transformed isorhythms upon completion. I superimposed three distinct isorhythmic layers in canon so that the piece concludes with all layers completing an iteration simultaneously. This enabled me to juxtapose isorhythmic cyclicality with linear transformation and project an unfolding from sparse simplicity to dense complexity.

Each isorhythmic layer contains two three-tier isorhythms with identical *talea* but with swapped pitch and duration cycle lengths. This allowed me to create cycles of dyads with contrasting *internal* durations that complete conjointly because the lowest common multiple of cycle lengths remains constant. To blur material boundaries, I alternated which cycle got extended with each transformation and occasionally manipulated values within cycles whose length remained constant between iterations. **Figure 46** shows the isorhythmic structure.

Isorhythmic shorthand:

2:3:4 = *talea* of 2 attacks, pitch cycle of 3 pitches, duration cycle of 4 durations

[3-5] = attacks on the 3rd and 5th quavers of the 3/2 bar

[F-G-A] = pitch cycle

[md-sh-lh-ld] = duration cycle

Merged cells show the continuation of an iteration. Reminders of current iterations are placed in brackets.

	Bar 2	**Bar 8**	**Bar 12**	**Bar 24**	**Bar 30**
Isorhythm 1a	**1:2:3** [1] [F-G] [md-sh-lh]	**1:2:4** [2] [F-G] [md-sh-lh-ld]	**1:3:4** [3] [F-G-A] [md-sh-ld-lh]	**2:3:4** [3-5] [F-G-A] [md-sh-lh-ld]	**2:3:5** [3-6] [F-G-A] [md-sh-lh-ld-mh]
Isorhythm 1b	**1:3:2** [1] [A-D-E] [mh-ld]	**1:4:2** [2] [A-D-E-B] [mh-lh]	**1:4:3** [3] [A-D-E-B] [mh-lh-ld]	**2:4:3** [3-5] [A-D-E-Bb] [mh-ld-lh]	**2:5:3** [3-6] [A-D-E-Bb-C] [mh-lh-ld]
Isorhythm 2a	**N/A**				
Isorhythm 2b	**N/A**				
Isorhythm 3a	**N/A**				
Isorhythm 3b	**N/A**				

	Bar 40	**Bar 43**	**Bar 45**	**Bar 49**	**Bar 53**
Isorhythm 1a	**(2:3:5)**		**2:4:5** [3-9] [F-G-A-Bb] [md-sh-lh-mh-ld]		
Isorhythm 1b	**(2:5:3)**		**2:5:4** [3-9] [A-D-E-Bb-C] [mh-lh-ld-sd]		
Isorhythm 2a	**2:1:3** [3-5] [D] [md-sh-mh]	**2:1:4** [3-4] [D] [md-sh-mh-ld]	**3:1:4** [3-4-8] [D] [md-sh-ld-mh]	**3:2:4** [3-5-8] [D-F] [md-sh-mh-ld]	**3:2:5** [3-6-8] [D-F] [md-sh-mh-ld-lh]
Isorhythm 2b	**2:3:1** [3-5] [C-E-B] [mh]	**2:4:1** [3-4] [C-E-B-G] [sd]	**3:4:1** [3-4-8] [C-E-Bb-G] [mh]	**3:4:2** [3-5-8] [C-E-Bb-G] [mh-sd]	**3:5:2** [3-6-8] [C-E-Bb-G-A] [mh-sh]
Isorhythm 3a	**(N/A)**				
Isorhythm 3b	**(N/A)**				

	Bar 55	Bar 56	Bar 58	Bar 59	Bar 62
Isorhythm 1a	**3:4:5** [3-7-9] [F-G-A-Bb] [md-sh-lh-ld-mh]				
Isorhythm 1b	**3:5:4** [3-7-9] [A-D-Eb-Bb-C] [mh-lh-sd-ld]				
Isorhythm 2a	**(3:2:5)**				
Isorhythm 2b	**(3:5:2)**				
Isorhythm 3a	**(N/A)**	**3:2:1** [1-6-9] [D-E] [md]	**4:2:1** [1-6-9-11] [D-Eb] [sh]	**4:3:1** [1-8-9-11] [D-Eb-B] [md]	**4:3:2** [1-8-9-12] [D-Eb-B] [md-sh]
Isorhythm 3b	**(N/A)**	**3:1:2** [1-6-9] [A] [mh-sd]	**4:1:2** [1-6-9-11] [A} [mh-ld]	**4:1:3** [1-8-9-11] [A] [mh-ld-sd]	**4:2:3** [1-8-9-12] [A-G] [mh-sd-ld]

	Bar 63	Bar 65	Bar 68	Bar 71
Isorhythm 1a	**(3:4:5)**			
Isorhythm 1b	**(3:5:4)**			
Isorhythm 2a	**4:2:5** [3-6-8-11] [D-F] [md-sh-mh-lh-ld]		**4:3:5** [3-5-10-11] [D-F-Bb] [md-sh-mh-ld-lh]	
Isorhythm 2b	**4:5:2** [3-6-8-11] [C-Eb-Bb-G-A] [mh-sd]		**4:5:3** [3-5-10-11] [C-Eb-Bb-G-A] [mh-sd-sh]	
Isorhythm 3a	**(4:3:2)**	**5:3:2** [1-5-8-9-12] [D-Eb-Bb] [md-lh]		**5:4:2** [1-5-6-9-12] [D-Eb-Bb-C] [md-sh]
Isorhythm 3b	**(4:2:3)**	**5:2:3** [1-5-8-9-12] [A-G] [mh-ld-sd]		**5:2:4** [1-5-6-9-12] [A-G] [mh-ld-sd-sh]

	Bar 75	Bar 79	Bar 83	Bar 86
Isorhythm 1a	**3:4:6** [3-8-9] [F-G-A-Bb] [md-sh-lh-ld-mh-sd]	**3:5:6** [3-6-9] [F-G-A-Bb-Eb] [md-sh-lh-ld-sd-mh]		
Isorhythm 1b	**3:6:4** [3-8-9] [A-D-Eb-Bb-C-F] [mh-lh-ld-sd]	**3:6:5** [3-6-9] [A-D-Eb-Bb-C-F] [mh-lh-ld-sd-md]		
Isorhythm 2a	**(4:3:5)**		**4:3:6** [3-5-8-11] [D-F-Bb] [md-sh-mh-ld-lh-sd]	**5:3:6** [3-5-8-10-11] [D-F-B] [md-sh-mh-ld-sd-lh]
Isorhythm 2b	**(4:5:3)**		**4:6:3** [3-5-8-11] [C-Eb-Bb-G-A-F] [mh-sh-sd]	**5:6:3** [3-5-8-10-11] [C-Eb-B-G-A-F] [mh-sd-sh]
Isorhythm 3a	**5:4:3** [1-4-5-9-12] [D-Eb-Bb-C] [md-sh-lh]			
Isorhythm 3b	**5:3:4** [1-4-5-9-12] [A-G-F] [mh-ld-sh-sd]			

	Bar 87	Bar 89	Bar 92	Bar 94
Isorhythm 1a	**(3:5:6)**	**4:5:6** [3-4-5-9] [F-G-A-B-Eb] [md-sh-lh-ld-mh-sd]		
Isorhythm 1b	**(3:6:5)**	**4:6:5** [3-4-5-9] [A-D-Eb-B-C-F] [mh-lh-ld-md-sd]		
Isorhythm 2a	**(5:3:6)**		**5:4:6** [3-5-6-9-11] [D-F-B-C] [md-sh-mh-ld-lh-sd]	
Isorhythm 2b	**(5:6:3)**		**5:6:4** [3-5-6-9-11] [C-Eb-B-G-A-F] [mh-sd-sh-ld]	
Isorhythm 3a	**6:4:3** [1-2-4-5-9-12] [D-Eb-B-C] [md-lh-sh]	**6:5:3** [1-2-5-8-9-12] [D-Eb-B-C-F] [md-sh-lh]		**6:5:4** [1-4-5-8-9-11] [D-Eb-B-C-F] [md-sh-lh-sd]
Isorhythm 3b	**6:3:4** [1-2-4-5-9-12] [A-G-F] [mh-ld-sd-sh]	**6:3:5** [1-2-5-8-9-12] [A-G-F] [mh-ld-sd-sh-lh]		**6:4:5** [1-4-5-8-9-11] [A-G-F-B] [mh-ld-sd-lh-sh]

Figure 46. *In Gnomonine*: tables showing isorhythmic cycle details, placements of entry, and transformations.

I divided the ensemble into pairs and assigned two pairs to each isorhythmic layer (see **Figure 47**), excluding the Trumpet and Violin I. I changed the orchestration of each isorhythmic layer with each transformation, exploring pairings and their combination. This occasionally made it challenging to meet isorhythmic durational demands, particularly as attack density increased. I solved this problem using chords and pitch *tremolando*.

Isorhythmic Layer:	1	2	3
Orchestration:	Ob.+Pno. / Sax.+Vc.	Fl.+Hp. / Vln.II+Vla.	Cl.+Vib. / Bsn.+Cb.

Figure 47. *In Gnomonine*: isorhythmic layer orchestrations.

To juxtapose cyclicality with linearity, I sought to fit a singular unfolding of the 54-note *In Nomine* plainchant within the 102-bar isorhythmic structure (framed by a bar either side). To do this, I placed attacks 17 triplet crotchets apart. These triplets distinguish the chant from the quaver profile of the isorhythms. I controlled rhythm and instrumental resonance to manipulate duration in reflection of the chant's phrasing.

I employed trumpet fragments to signpost instances of simultaneous isorhythmic mutation or points where isorhythmic mutations align with chant phrases. These fragments highlight the chant's triplet profile and isorhythmic harmonic shifts (the isorhythms alternate flat and natural forms of B and E). Initially outlining this tetrachord, I gradually transformed the phrase to include these pitches alongside those absent from the core material and heighten repetition-variation dichotomies (see **Figure 48**).

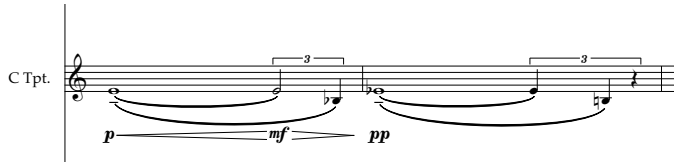


Figure 48a. *In Gnomonine*, bars 45-46: initial trumpet fragment.

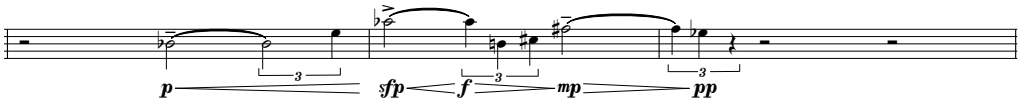


Figure 48b. *In Gnomonine*, bars 98-100: final trumpet fragment.

I paired trumpet fragments with Violin I *tremolandi* between open strings, stopped pitches, and natural harmonics, which I also used in isolation to mark adjacent isorhythmic transformations. I compounded the stasis-motion suspension by superimposing a clock-like cycle of 12 periodically spaced dyads throughout the 102-bar isorhythmic structure (see **Figure 49**).

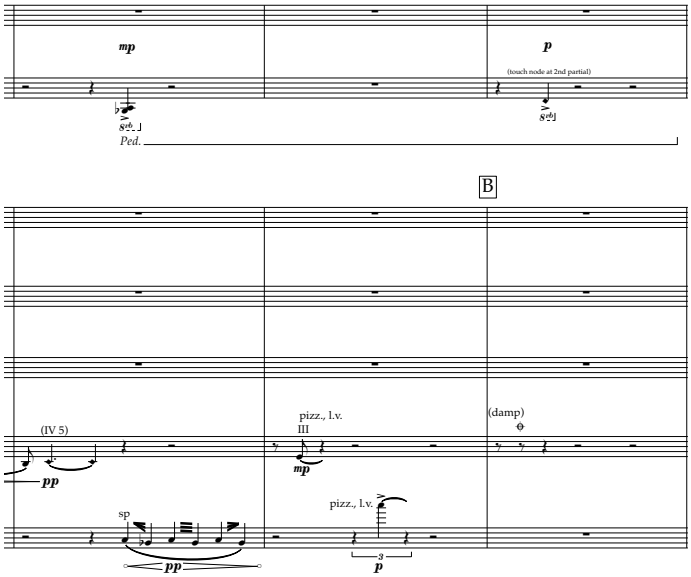


Figure 49. *In Gnomonine*, bars 10-12: a dyad clock-strike orchestrated as a sustain-pedal-supported piano resonance shadowed by contrabass *sul ponticello tremolando*.

This piece exhibits a new approach to isorhythm, both in the multi-dimensionality of their layering and in my separation of note attack and duration. This enabled me to blur boundaries between linearity and cyclicality, and project a structure suspended between growth, stasis, and decay. I considered my aims and methods when defining my materials and processes, hence the intricacies of the isorhythmic structure but relative rhythmic simplicity. Collectively, this approach facilitated my projection of contrasting timbral and resonance qualities across a temporally complex and layered structure.

Conclusion

This PhD investigates the relationships between temporal multiplicity, process, and structure through a portfolio of compositions. In each composition, I distinctly constructed and manipulated the playing out of temporally layered materials to explore an elastic conceptualisation of time. I investigated temporal limits (see *Metrognomon*) and experimented with notation to balance complexity and clarity (see *Circles Drawn Freehand*). In *Roads to Rome/Roam*, I used notation itself to novelly construct temporal layering. These examples evidence my investigation of new structural possibilities, particularly those concerning multi-scale repetition.

My quasi-scientific methodology (testing compositional hypotheses and observing the results) has enabled me to explore several phenomena in detail. The most significant insights include my *ambiguity as multiplicity* concept, *polyrhythmic approximation* technique, novel isorhythmic approaches (including three-tier interactions and canonic treatment), *scordatura*-manipulated resonance and acoustic beating, novel notational systems and solutions, and unique resonance-centred textures. More broadly, my approach has allowed me to strengthen formal coherence despite increased surface complexity, establish processual and intuitive material control, and explore contrasting conceptualisations of time. Whilst this research has supported the development of my compositional voice, it is for the above reasons that I hope it may also be of value to composers across a diversity of aesthetics.

Undertaking this PhD has been artistically, personally, and professionally rewarding. My methodology was well-suited to achieving my aims and I relished the opportunities to compose for contemporary music specialists as these projects resulted in high quality recordings and interesting discussions. Composing for student performers was also valuable in helping me distil my musical aims.

Concerning future research, I propose an extrapolation into the orchestral context. I composed two short orchestral pieces during my PhD, with *Spiralling* being shortlisted (but not selected) by Enno Poppe for the 2024 Grafenegg Festival "Ink Still Wet" workshop. Given my prioritisation of recordings, I instead selected *In Gnomonine* to represent my efforts in large ensemble composition within this portfolio. In writing for a professional orchestra, I would seek to investigate *external* rhythmic layering on a larger scale. Additionally, I would be interested to establish interdisciplinary collaborations to explore the implications of my

techniques within multi-media contexts, with these extended canvases potentially accommodating more complex temporal multiplicities and elasticity.

The portfolio also documents how my compositional concerns have evolved over the project. Ongoing reflection has suggested a web of interconnections between the pieces, enabling me to continually refine and consolidate my compositional interests and priorities. Accordingly, I would suggest that an analogy can be made between my compositional processes and my creative methodology more broadly: each is systematic, iterative, and explores combinatoriality. Undertaking this research has therefore suggested a multitude of directions for my continued exploration of temporal multiplicity and elasticity across a diverse range of potential future projects.

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