Control, Flexibility, Flux and Complexity: A Timecode-Supported Approach to Polytemporal Orchestral Composition

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

In addition to the commentary, a portfolio of parts for the orchestral and ensemble timecode-supported polytemporal test-pieces, computer-generated audio models for the orchestral test-pieces and studio remote and live recordings created as part of this project can be accessed in this PhD Materials folder. Content is itemised below. Where available, all other live recordings referenced in the commentary but predating this project are accessed via footnote URLs located in the relevant text areas.

1. *the heaven that runs through everything* (2018). Original version for large orchestra. The folder contains parts and an audio model rendition.
2. *the heaven that runs through everything* (2018). Version for standard orchestra. The folder contains parts and an audio model rendition.
3. *[and] a powerful flame came out of the earth [...]* (2019). For large orchestra. The folder contains parts and an audio model rendition.
4. *[...] which constantly generates a pulviscular cloud [...]* (2019). For chamber orchestra. The folder contains parts and remote recording.
5. *Cutouts for Ensemble* (2019) for ten players. The folder contains parts and a remote recording.
6. *pulviscular observation* (2019) for double string quartet. The folder contains parts and a live recording.
7. *pulviscular compression* (2019) for nineteen string players. The folder contains parts and a live recording.
8. *the unimportance of events* (2019) for seventeen players. The folder contains parts.
9. *obscure sorrows* (2019) for clarinet and violin. The folder contains parts.
10. *the unimportance of events* (2021) for twenty-two players. The folder contains parts and the link to a live video recording.

Acknowledgements

I was not naturally drawn to academia. As a self-taught composer with no music education, no technical language to express my ideas and no academic qualifications, universities felt like alien places full of the kind of learning I did not possess. Despite twenty-two years working internationally as a professional composer, a lack of intellectual self-confidence prevented me from engaging with these institutions in any meaningful way.

Now, after nearly four years of doctoral study, my view of academia and my place within it has radically altered and my experiences as a practice-researcher have been transformative. Although initially resistant to suggestions and advice from those around me, I was sufficiently 'bullied' — in the kindest way — particularly and relentlessly by my partner, Mark Hewitt, into investigating the possibility of undertaking a PhD in music composition and situating my ongoing research within academia. Though reluctant, I made tentative enquiries through friends and contacts working in universities and presented my research ideas to them.

Before long, I was encouraged to apply to the University of Leeds by my current supervisor, Dr Michael Spencer, who together with Professor Martin Iddon, my co-supervisor, held my hand through the application process to secure a place at the School of Music in Leeds University and subsequently, a second application to secure a scholarship from The White Rose College of the Arts & Humanities (WRoCAH). Following a successful application to WRoCAH, I encountered Caryn Douglas (then WRoCAH Manager) and Clare Meadley (WRoCAH administrator) who became part of my life for the next three years and supported my studies and requests for additional training, experience and funding with creativity, kindness, interest and enthusiasm, making my PhD journey as useful, enjoyable and straightforward as possible.

Together, Mic, Martin, Caryn and Clare have been the face of my academic experience throughout which, I have felt valued and respected. Completing my doctoral studies would have been impossible without them, not least because entering university at PhD level as a

fifty-seven-year-old without any previous academic experience was daunting in the extreme and I needed help transitioning from ‘civilian composer’ to formal practice-researcher. The supervision I received from Mic and Martin to aid this transition and much more besides, was exemplary, focused and friendly. I had a real sense they believed in my research and my capacity to deliver it. For this support and belief, they have my heartfelt thanks.

At home, the emotional contours of my PhD journey were played out at their most acute and personal with Mark who supported me through the triumphs, trials and tribulations of the past four years, including the particularly exacting circumstances that devastated the final year of my research project due to the SARS-CoV-2 pandemic. Mark has been a strength and sounding board throughout.

I would also like to offer huge thanks to Dr Lauren Redhead, Dr Ian Pace, Dr Sadie Harrison and William APM for their resources, advice and support as well as to colleagues in academia and the wider music world, my friends and family and indeed, anyone who showed an interest in my research journey, offered advice, enthusiasm, or showed kindness, I am deeply grateful.

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Abstract

This project is situated in and takes current orchestral polytemporal praxis as its starting point and context. It seeks to expand independent simultaneous polytemporal activity to every instrumental voice in the orchestra using self-borrowed temporally unrelated heterogeneous materials while preserving the highest possible levels of structural integrity in performance. With no models to adopt in the literature that unambiguously supported my compositional aims, I developed a new composition and performance approach called timecode-supported polytemporal composition. This thesis explains what timecode-supported polytemporal music is, how it functions, how it is built, and through a portfolio of newly composed and performed pieces, examines to what extent this approach has fulfilled its compositional aims. Although timecode-supported polytemporal orchestral music fully determines structure, rhythm, pitch and expression through notation, it does not use conductors, click-tracks or scores for performance organisation. Instead, players and their materials are decoupled from each other and their actions coordinated by reading part-embedded timecode continually referenced to the rolling timecode found on orchestra-wide loosely synchronised mobile phone stopwatches with players adjusting their tempos as required throughout performance so that both align. This approach to performance introduces player-generated temporal indeterminacy where many players interpreting their respective tempos simultaneously creates cumulative degrees of misalignment between their materials when compared to concomitant material relationships fixed within computer-generated composition models. Temporal indeterminacy along with the uncertainties it generates is an anticipated and welcomed outcome of this methodology. Nevertheless, this project tests the efficacy of player-mediated timecode frameworks to limit those discrepancies and uncertainties by confining them within local detail, so they do not affect global architectural integrity. The degree to which this confinement is successful is gauged through a comparison between live and computer-generated audio recordings. Criteria for success are subjective and built around the impression of similarity between the two where the greater the coincidence, the more successful the performance is perceived to be. This view along with its definitions and rationale are examined and reflected in the project's methodology and results where despite a

range of setbacks including the impacts of the SARS-CoV-2 pandemic, it has been possible to secure performances that demonstrate and where necessary, extrapolate scaled-up results that show how the outcomes of this research project have met, and in some regards, exceeded my expectations and compositional aims. For composers, such a polytemporal expansion offers new and extended composition and performance opportunities where the use of heterogeneous materials and combinations of any simultaneous tempos become practical in the field of spatial and remote polytemporal performance as well as situated orchestral compositions of any scale or pieces exploring the movement between simultaneously synchronised and asynchronous or loosely synchronised materials where degrees of control over compositional structure and outcomes are important.

Contents

1. Introduction

> I must Create a System, or be enslav'd by another Man's. I will not Reason & Compare; my business is to Create.
>
> William Blake[1]

1.1.1 Context

As a child, long before I began composing, I had imagined being able to construct orchestral music that was made up of many different streams of simultaneous activity, a temporal polyphony rich with multiple instrumental voices, all independent of one another but behaving as one entity, like a huge architectural construction in sound. I initially conceptualised these phenomena in my visual imagination as a murmuration of starlings with behaviour that was fluid, morphing, unpredictable, reactionary, complex, capricious and mesmerising.

Simultaneously, and as a consequence of the visual, I also conceptualised the actions and relationships of these birds — these 'corporate individuals' — as sound, as if I were perceiving, interpreting and mapping their movements and positions in space to create a musical equivalent by spontaneously responding to, and performing from, the score their configurations suggested, a score that was in perpetual motion and flux. At the time, I did not have the language to describe this music. Now, as an adult, I can identify those childhood memories as polytemporal music that comprises musical materials moving at simultaneously different speeds. Decades later and still beguiled and excited by the memory of those sounds, I wanted to create orchestral music that mirrored the variety of behaviours contained within those imagined polytemporal collectives where each instrumental voice would inhabit an independent temporal trajectory simultaneously with every other voice and its autonomous temporality.

1.1.2 Determinate Outcomes

As a composer who created perceptually complex, dense and hyperactive works, I was initially drawn to investigate the scores of other polytemporal and polymetric compositions that reflected a similar aesthetic to my own to see how those composers supported and organised players and notation to determine performance outcomes. I was particularly drawn to those composers'

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[1] William Blake, *Jerusalem: The Emancipation of the Giant Albion*, ed. Morton D. Paley, Blake's Illuminated Books, 1 (Princeton, NJ: Princeton University Press, 1991), p. 144.

works that unfolded their narratives through dense polyphony articulated using material moving at what sounded like simultaneously different speeds. Works such as Ferneyhough's *La Terre est un Homme* (1976–1979) and Carter's *Variations for Orchestra* (1955) for example, discussed in the literature review, featured heavily in my thinking.

To realise my murmuration of starlings metaphor as sound within my particular aesthetic, I needed to be able to support the possibility of simultaneous, differentiated, polytemporal activity among *all* instruments of a large orchestra, a temporal functionality not apparent in any of the works I had investigated before this project began, including the orchestral works of Carter or Ferneyhough, in which polytemporal relationships were generally confined to various groups of players or hierarchically organised temporal materials but never to all players simultaneously. As discussed in the literature review, Ferneyhough and Carter, for example, frequently employed complex rhythmic notation in their conducted, synchronised score-based orchestral works to differentiate between the distinctive temporal nature of materials. In those pieces, both composers determined nearly every aspect of instrumentation, pitch, rhythm, technique, expression and tempo through notation.

Notwithstanding the inherent indeterminacies present in all performance contingent upon the variabilities of player interpretation, expression, cognitive, emotional and technical abilities, the rendition of this determinate notation generated equally specified, repeatable, determinate performance outcomes. In using the term determinate outcomes, I am referring particularly to performance outcomes that reflect the structural, rhythmic, pitch and expressive components of a piece as determined by the composer in notation being reproduced by the performer in such a way that the relationships between those elements are preserved in performance. This concept of determinate performance outcomes incorporates and anticipates the flexibilities around the nuances and indeterminacy of human interpretation mentioned above that influence precisely what is heard.

1.1.3 Potential Challenges

The connection I observed between determinate complex rhythmic notation, perceptually dense polyphonic sound worlds and determinate performance outcomes in the Carter and Ferneyhough was appealing but it presented me with a dilemma should I adopt that model to move forward. On the one hand, I wanted to greatly expand simultaneous independent polytemporal activity beyond the parameters already seen while maintaining sonically deterministic, perceptually

dense performance outcomes as the aims of this project, yet, on the other hand, taking the view that rhythmic notation, particularly in the Ferneyhough, was already complex enough, had concerns any further temporal expansion within those score-based formats could make rhythmic notation even more complex as a consequence of additional differentiation.

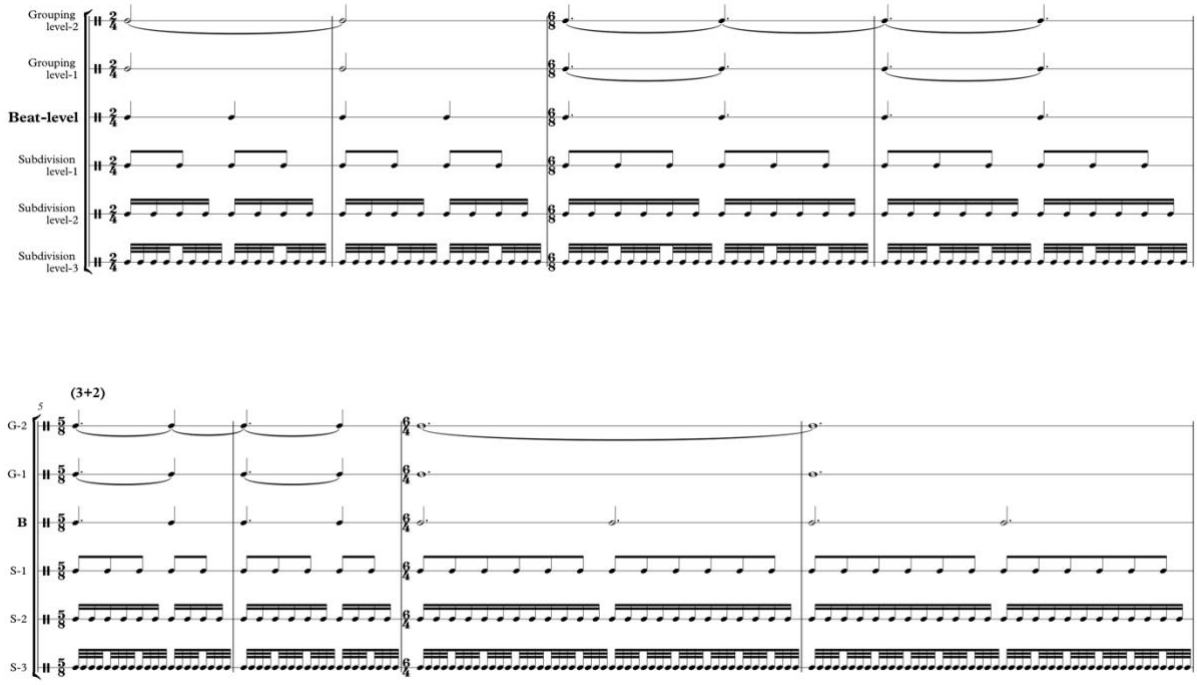
Those concerns were further amplified owing to a likely incompatibility between my established practice of using self-borrowed notation materials to build compositions and how those materials could be assimilated within synchronised score-based formats. My intention was, if at all possible, to use self-borrowed materials to expand independent simultaneous temporal trajectories to all instruments of the orchestra. However, I was aware that any attempt to do so within a synchronised score format in which meter and tempo were globally organised throughout would involve notationally determined elements such as structure and rhythm in self-borrowed materials undergoing a process of notational adaption — reformatting — that reflected calculations to preserve proportional relationships, particularly concerning tempo, between those materials and any synchronised scores they were formatted into. In all cases and despite their different notationally signified appearances, reformatted notations would have to have the same perceived pulse tempo and sense of metric organisation when performed as their concomitant 'native' (un-formatted) materials regardless of the score format, meter and tempo they had been reformatted into. Before describing notational reformatting in greater detail, it is useful to briefly outline what pulse tempo are and how they relate to polymetric and polytemporal music.

1.1.4 Pulse and Meter

Pulse can be thought of as beats of equal strength that occur regularly akin to the tick-tock of a metronome or clock although pulses can also occur at irregular intervals (see Figure 1, p. 5). Metrical elements such as pulses or beats and their subdivisions are not strictly speaking sonic elements. They have no intrinsic sound unless marked for attention by the composer or performer and may be 'felt' rather than heard.

A meter is created when pulses are perceived as being in or grouped together into patterns. Within those patterns, some beats may feel stronger than others or be accented for attention. These pulses and groupings are hierarchically organised into metric levels comprised of temporal patterns or meters perceived or felt by listeners, performers, conductors and composers when listening to, playing or conceptually imagining music.

Figure 1. Hierarchically organised metric levels



As shown in Figure 1, metrical patterns are organised around the beat level which carries the tempo – the pulse tempo – for the listener; below this, the subdivision levels, S-1, S-2, S-3, etc., organise successively smaller divisions of the beat, and above the beat level, the grouping levels, G-1, G-2, etc., organise metric materials with fewer elements and successively longer timescales. Beat level pulses are categorised through subdivisions, commonly into groups and multiples of twos or threes but other grouping patterns are also possible across all subdivision and grouping levels. With the patterns within these hierarchical levels occurring at different rates, with varied accents and differing activity levels, each is perceived as operating faster or slower than the other.

1.1.5 Pulse Tempo and Polymeter

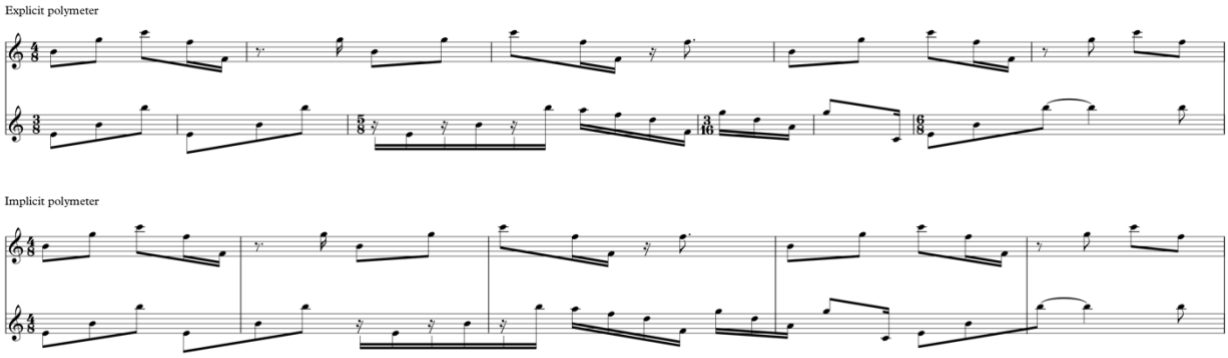
In his 2011 dissertation *Polymeter: Disambiguation, Classification, and Analytical Techniques',* Jacob Rundall describes polymeter as 'music that "gives rise to" two or more compelling metrical structures simultaneously that are not fully coincident (not identical in structure and do not coincide completely in time, level-by-level and element-by-element'.[2] These 'not fully coincident' metric structures exist in two forms: monophonic polymeter, when a monophonic texture gives rise to two or more metrical structures at the same time, and polyphonic polymeter

[2] Jacob D. Rundall, 'Polymeter: Disambiguation, Classification, and Analytical Techniques' (unpublished doctoral thesis, University of Illinois at Urbana-Champaign, 2011) <http://hdl.handle.net/2142/24474> [accessed 24 July 2018] p. 40.

that involves the simultaneous existence of two or more separate rhythmic streams that give rise to multiple metrical structures that are not fully coincident.[3]

Figure 2, p. 6, shows how polyphonic polymeter manifests as either explicit polymeter where polymeter is expressed through the notation of independent meters, using time signatures and/or independent barlines, and implicit polymeter where polymeter does not involve the notation of independent meters.[4] In both examples, despite the differing time signatures present in explicit polymeter, all meters are related to the sixteenth-note subdivision meaning that although there is metrical disagreement on the beat level, coincidence is found on subdivision level S-2. It is useful to note that polymeter is not only defined through notation as in Figure 2, it can also be identified through listening alone.

Figure 2. Explicit and implicit polymeter

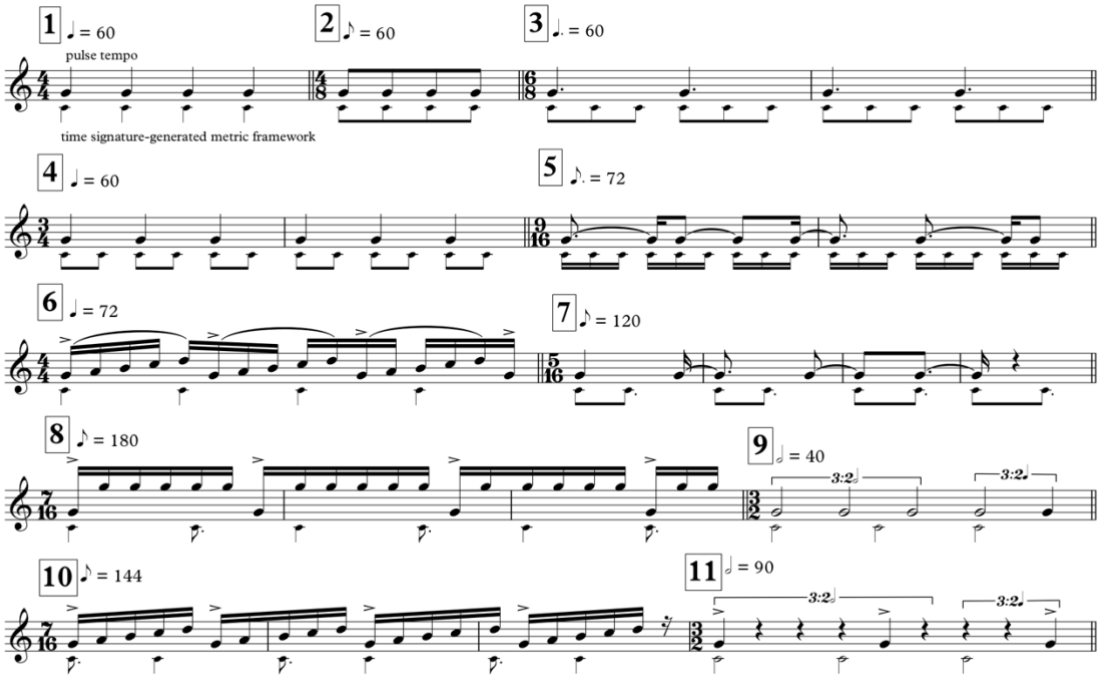


As mentioned, pulse is often perceived as the musical beat, tactus or referent level of a piece of music and carries with it the sense of speed for the listener. Figure 3, p. 7, shows eleven different notational representations of exactly the same pulse tempo at the beat level or accented at S-1 or S-2 subdivision levels, all indicated through voice one. In this example, each pulse occurs at exactly one second duration from the next. These metrical elements have no duration in and of themselves, instead, the distance between them is measured as interonset intervals (IOI) using milliseconds. Figure 3, the one-second elapsed time between one pulse and the next is equivalent to 1000 ms. For differing IOIs – for example, 300 ms, 400 ms, 700 ms, values may also be indicated as proportional relationships of 3:4:7. IOIs are determined by the prevailing speed of the music often indicated by metronome markings, text indicating tempo, the interval between accented elements or notes marked for attention in some way that themselves denote metric patterns and carry with them a sense of pulse, or combinations of all of these. When metrical elements are separated by the same IOI intervals, as in the examples illustrated here,

[3] Ibid, p. 41.
[4] Ibid, p. 43.

they are known as isochronous patterns. When metrical elements have irregular IOIs, the patterns are known as non-isochronous.

Figure 3. Pulse tempo



To the listener hearing only the upper voice, the accented or unaccented pulse tempo of examples 1 through to 11 in Figure 3, will be perceived as being identical because the IOI of each annotation is isochronous and of the same value in milliseconds. However, to the musician interpreting those notations, each requires the generation of a different internal metrical structure owing to the combination of tempo and prevailing time signature (these metrical structures are indicated by voice two). If the pulse tempo coincides with the metrical framework generated by the time signature as in examples 1 through to 4, the beat level of the bar will be audible to the listener. If not, as in examples 5 through to 11, the time signature meter will remain conceptual and only felt by the performer but inaudible to the listener with only the pulse tempo being heard. Metrical patterns and their audibility may move freely between those two conditions depending upon the metrical status of a given composition. In examples 6 to 11, where pulse tempi do not coincide or only coincide occasionally with the bar's underlying metric organisation, performers will place their materials along those timelines at positions often not coincident with the underlying conceptual meter.

With voices one and two notationally signifying two metric patterns coexisting simultaneously and conflicting within and across the same bar(s) of music, examples 6 to 11

illustrate polymeter. If the time signature generated meter and pulse tempo meters in these examples were sounded simultaneously, the polymetric conflict between their metric patterns and the speeds at which they occur would be audible to the listener. These conflicts are described as implicit polyphonic polymeter.

1.1.6 Polymeter, Polytactus and Polytempo: Definitions

In his 1987 book, *Structural Functions in Music*, Wallace Berry describes two aspects of tempo: activity tempo, that indicates 'the eventfulness of music (degree to which the temporal continuity and flow are filled with articulate impulses or related silences)' and pulse tempo, 'the frequency of pulsation at some given level' [where] 'pulse will be understood as the felt, underlying, at times regularly recurrent unit by which music's time span is measured and its divisions felt at some specified level – the basis for counting, or conducting, and for metronomic indications.'[5] Further to those, Rundall identifies one other aspect of tempo, distinct from activity tempo and pulse tempo he calls notation-tempo that refers to 'the assignment of a specific absolute time value to a specific musical note value. Notation-tempo is involved implicitly in metronome markings. Rundall states that notation-tempo and pulse tempo are not equivalent concepts.'[6]

> On the one hand, polytempo is often used to describe polymeter that involves B levels [the beat, tactus or referent level] that are not fully coincident [where polymeter is limited to meter-to-meter relationships]. On the other hand, polytempo may refer to the use of independently notated tempos (i.e., the independent assignment of real temporal values to specific musical durations). In a great many cases, music that is called polytempic involves both of these situations [Rundall suggests Nancarrow's Studies for Player Piano, including no. 19, 31, 35 and 36 for example]. [...]. As such, I propose a distinction in terminology. The first case—which involves B levels that are not fully coincident and thus involves independent pulse-tempos—will be referred to as polytactus (adj. polytactic). In contrast, the second case—which involves the independent assignment of real temporal values to specific musical durations and thus involves the independent use of notation-tempo—should continue to be called polytempo (adj. polytempic). [T]hese are in fact independent concepts, and also independent compositional practices.[7]

This distinction illustrated in Figure 4, p. 9, shows the difference between polytactic and polytemporal annotated approaches where identical materials are organised in two different ways. First, grouping A1, B1 and C1 represent independent pulse tempo materials synchronised into a polytactic score governed by a single global tempo and, in this example, identical bar

[5] Wallace Berry, *Structural functions in music*, (New York, NY: Dover Publications, 1987), p. 305.

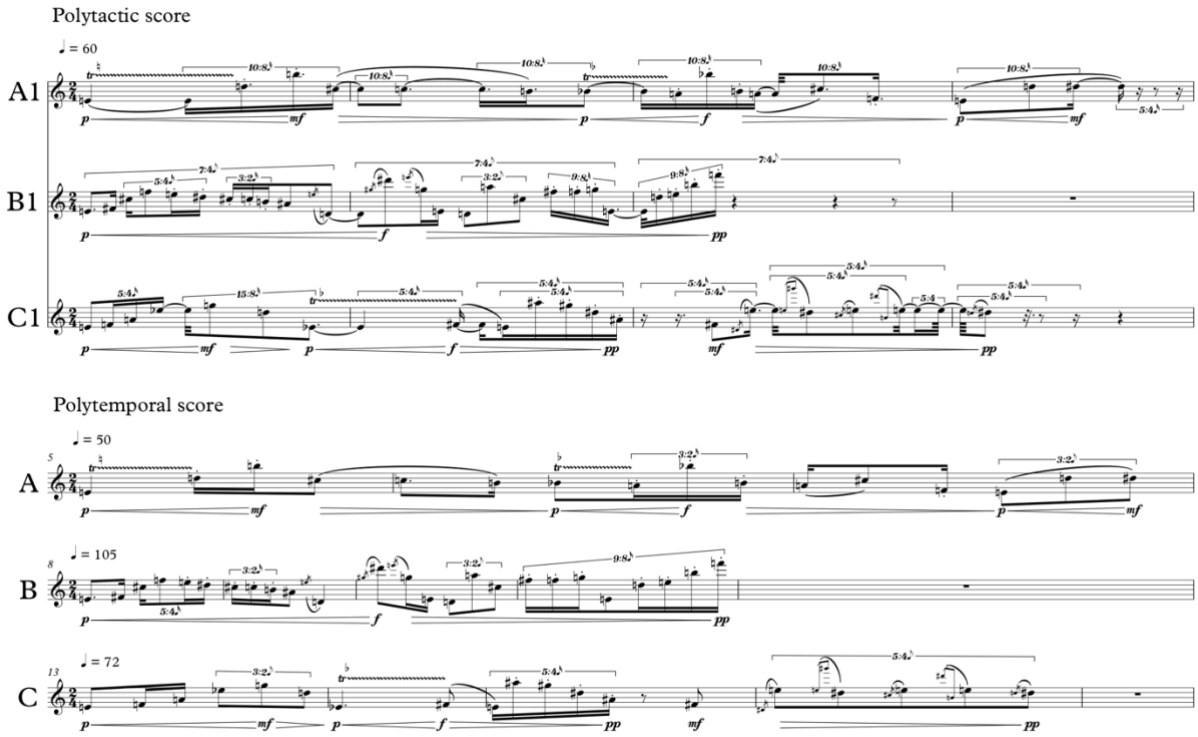
[6] Rundall, p. 26.

[7] Ibid, pp. 59–60.

structures where meters are not fully coincident; and second, below that, a polytemporal organisation of the same materials where A, B and C, clearly show differentiated metronome markings governing the tempo of each material layer annotated proportionally in relation to one another where meters on the beat level are not coincident due to the use of independent tempo.

As shown in this purely polytactic construction, independent layers of material with their own pulse tempo are governed by only one signified metronome mark at any one time. The speed at which each pulse tempo operates is implicitly expressed through notation and would have to be extrapolated in relation to the given global metronome mark to be known. It is the time signature generated metric pattern driven by the global tempo that the conductor beats. Using this beat, players would have to calculate how their own pulse tempo operated when set against the metrical structure laid down by the conductor. By contrast, the polytemporal example below explicitly states the simultaneous speed of each voice through assigned metronome markings indicating a clear relationship between specific note values and their specific musical durations for each line of music independently. Here, despite occasional polyrhythms, the time signature-generated meter is frequently coincident with the material's pulse tempo. An extract such as this may be performed using synchronised click tracks or conductors assigned to each player and synchronised to each other in some way.

Figure 4. Polytactic and polytemporal notational presentations

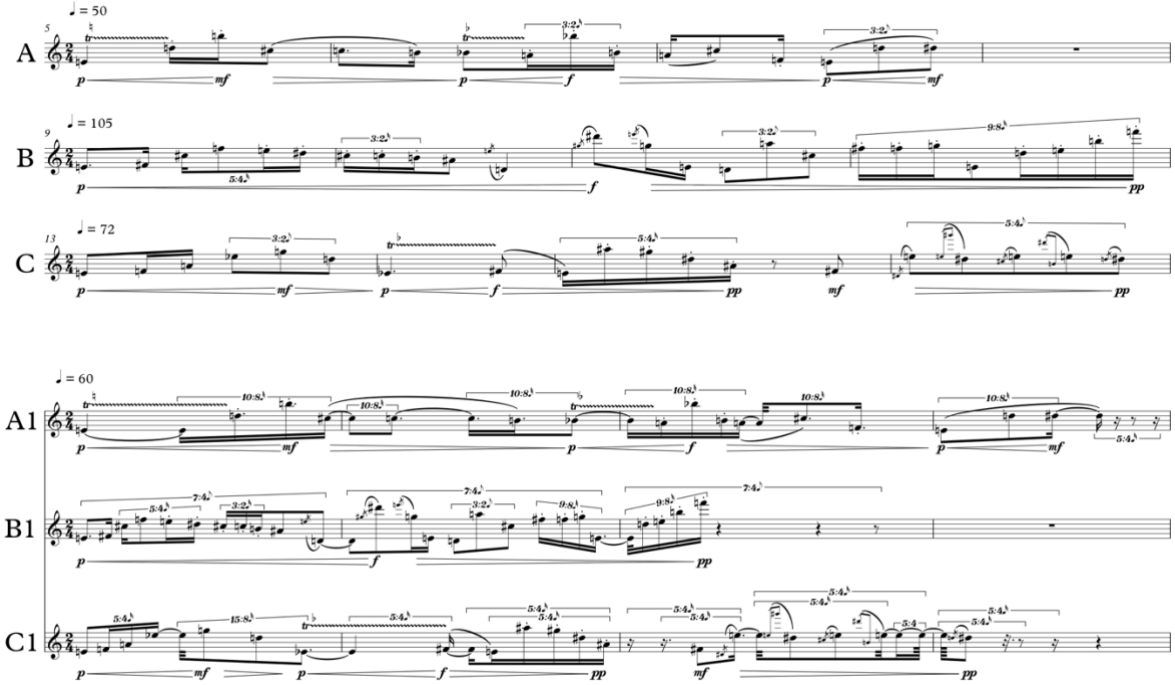


From the listeners' perspective, both approaches may produce identical temporal experiences. However, conceptually, compositionally and from the perspective of performance and despite both showing non fully coincident meters between all voices, the two annotations represent very different concepts and approaches to polymeter.

Before moving on, it is useful to note that the movement and material divisions in various compositions between what could be defined as polymetric, polytactic and polytemporal is often fluid. Polytemporal and polytactic music will frequently involve polymeter and polytemporal music comprise polytactic materials. Definitions concerning polymeter, polytactic and polytempo are also often confused and vague. Using the definitions given by Rundall and adopting those throughout this thesis, the coexistence of polymetric conditions in relation to a range of compositions is further discussed in the literature review.

1.1.7 Notational Reformatting

Figure 5. Polytemporal and polytactic score organisation



Having outlined what pulse tempo, polymetric, polytemporal and polytactic music are, the implications of maintaining identical pulse tempo speeds between native and reformatted self-borrowed material annotations and the notational and performance challenges associated

with these actions can be explained. To illustrate notational reformatting, Figure 5, p. 10, looks at materials seen previously in Figure 4, through a different lens to show a selection of self-borrowed material fragments. Two sets of materials are shown. First, native self-borrowed annotations, marked A, B, C, each showing their differentiated tempo and meters. Below those materials, a score where concomitant materials, now notationally adapted into the new score format are labelled A1, B1 and C1. Those materials have undergone the necessary adaptions so that metric and rhythmic notational organisation is reformatted to fit the new tempo and meter of that particular score format. For illustrative purposes, a four-bar score example with a tempo of sixty beats per minute (BPM) and a meter of 2/4 have been chosen as the host format. Tempo ratios between native and reformatted annotations in this format are signified as A (50 BPM) to A1 (60 BPM) = 5:6; B (105 BPM) to B1 (60 BPM) = 4:7; and C (75 BPM) to C1 (60 BPM) = 4:5.

Materials, A, B, and C could be reformatted into scores presenting any number of time signature and tempo combinations. However, owing to altered metric and temporal parameters, new calculations would be required to establish other ratios that in turn would generate different notational outcomes to those shown here. In all permutations, the IOIs of all metric materials would need to remain unchanged between native and reformatted versions.

1.1.8 Increased Notated Rhythmic Complexity

As can be seen in Figure 5, particularly regarding notational changes from B to B1 and C to C1, reformatting obscures the clarity and shape of native rhythmic and metric configurations making reformatted notations appear rhythmically more complex than their native counterparts when both are compared. Given self-borrowed materials with more complex rhythmic configurations and tempo relationships that in terms of ratio would be considerably more distant from the given tempo and polytactic score format illustrated here, reformatting from native material annotations to imported expressions would require the use of multiple nested tuplets and increasingly complex rhythmic organisation to notationally signify identical pulse tempo and IOIs between all metric levels of those materials within any new polytactic format in which they were presented.

Although feasible notationally, I felt that polytactic orchestral works created using this method of assimilating heterogeneous self-borrowed materials into synchronised score formats

would generate impractical and unacceptable levels of complex rhythmic notation for orchestral players to mediate. Within the scale of orchestral works I envisaged, temporal strata would be expanded to more than ninety differentiated simultaneous trajectories making the prospect of such extensive notational calculations and reformatting unwelcome and impractical. It remained my aim to achieve the most structurally determinate performance outcomes possible using the simplest notational means available.

1.1.9 Re-Evaluating Asynchronous Compositions: A way Forward?

Keen to avoid polytactic synchronised score formats for the reasons stated and unwilling to abandon my self-borrowing practice and in the light of finding no other existing compositional approach that unambiguously supported my compositional aims through 2. Defining the Territory: A Literature Review, I revisited a type of polytemporal ensemble composition I had written prior to this investigation in an attempt to find a possible solution. Called asynchronous pieces, these earlier works had, with some degree of success, used self-borrowed materials within polytemporal constructions in their native expressions, that is, without the need for any fundamental notational adaptation. Those pieces involved small numbers of players who performed independently from parts alone where instrumentation, rhythm, pitch, tempo, structure and expression were all determined through notation, were decoupled from each other and not annotated into scores, had no conductors or click tracks for performance organisation and where the instantiated structure of a piece relied entirely upon each player's subjective sense of tempo indications.

Despite determinate notation, imprecise interpretations of exact tempi significations in those pieces resulted in sometimes extreme flexibility around what material would occur when and in relation to which other materials. Inevitably, such actions resulted in the production of unpredictable structures. It became clear that relying upon a sense of precise tempi generated by a number of musicians playing at simultaneously different speeds without a conductor or click track to guide them was an unreasonable expectation and an unreliable approach for a composer looking for more stable outcomes in performance as it introduced significant levels of player-generated structural indeterminacy. Nevertheless, I believed this form of composition and in particular, the use of decoupled parts built from self-borrowed materials, held the key for potential temporal expansion into large-scale polytemporal orchestral constructions using far more straightforward processes than previously discussed.

However, to extend independent simultaneous polytemporal identities to all orchestral instrumentalists and crucially, guarantee a high degree of structural determination in performance, it was necessary to devise a means to support players in rendering their notated tempi in relation to beats per minute measured through precise clock-time values rather than their subjective sense of speed as evidenced in the performance outcomes of my asynchronous polytemporal pieces. I assumed that the incorporation of a framework that enabled an ongoing verification of performers' playing speeds, situated in relation to given metronomic values would, in turn, go some considerable way to stabilising rendered compositional structures as players could be supported in knowing when and where to render the required materials along the timeline of a piece.

1.1.10 The Introduction of Timecode and Stopwatches

With those thoughts in mind, I conceived of a methodology that operated using a system of organisation that somewhat flexibly held instrumentalists and structure together using timecode, that is, minutes and seconds printed above every or intermittent bars in all instrumental parts that mark the passage of time throughout the piece. Read in conjunction with the rolling timecode displayed on each players' orchestra-wide loosely synchronised mobile phone stopwatches, players could mediate their performances so that both timecodes approximately match up throughout the performance. This system would potentially enable players to know exactly where they were, where they should be and what they should be doing at any given point along the timeline of the composition. It could provide a temporal framework that helped players verify the speeds at which they were performing and adjust their tempo accordingly.

With this realisation, I believed I now had the theoretical basis to develop a new approach to polytemporal orchestral composition that would fulfil my compositional aims. It is the development of this approach, called timecode-supported polytemporal music, and the testing of its ambitions and efficacy through the performance of newly created timecode-supported polytemporal orchestral pieces that is the focus of this project.

It was clear to me that adopting this methodology would decouple players from each other, from global or group tempo control and remove the need to synchronise and annotate notation in a score. It seemed that in using timecode and stopwatches in this way, performances could be rendered from parts in which instrumentation, rhythm, pitch, tempo, structure and

expression was fully determined but where, rather than using one or several conductors to manage performances, timecode frameworks could provide players with the tools to navigate polytemporal compositional structures with confidence and a high degree of structural reproducibility themselves. Using this methodology, in theory at least, it appeared possible that the type of performance outcomes and temporal expansion I wanted would be achievable.

1.1.11 Temporal Indeterminacy

However, the combined effect of performance through parts alone, global desynchronisation of the orchestra and the newly introduced temporal individualism of players due to decoupling parts from one another and a score as well as the score and conductor's role in performance now being redundant would potentially lead to significant implications for orchestral performance practice and performance outcomes. One of these implications, central to the sonic manifestation of timecode-supported polytemporal performance — what the music sounds like — would be the generation and management of sonic flux.

I describe sonic flux as player-produced temporal indeterminacy specifically related to tempo interpretation that has implications for how elements I have determined in notation as the composer, such as structure, pitch, rhythm and expression, are instantiated as sound in relation to one another along the timeline of a piece by the performer. Sonic flux occurs within timecode-supported polytemporal music owing to the absence of a conductor or conductors, click tracks, or any sense of unifying or referential pulse between players and where those performers instead approximate, to a certain degree, the speed of performance their tempo indications specify. Owing to the action of players responding to timecode frameworks, levels of temporal indeterminacy should be confined to and affect only local (bar to bar) detail rather than global structural elements. Nevertheless, such actions and their inherent indeterminacy would result in the exact vertical alignments of pitches and their associated rhythms organised, fixed and determined in my compositional computer models being impossible to reproduce precisely in performance. As such, each rendition would be iterative in its detail and the confined differences between these outcomes brought about through player actions render performances with similar identities but never exactly fixed identities.[8]

[8] As should be clear from the definition I give of 'sonic flux' here, I do not mean to evoke Christoph Cox's use of the same phrase in his book of the same name, which, as its subtitle indicates is more concerned with sound, art, and metaphysics (Chicago, IL: University of Chicago Press, 2018).

1.1.12 Defining Near-Determinate Outcomes

I called these flexible outcomes rendered from fully determinate notation ‘near-determinate’, in the first instance, to distinguish the limited effects of player-generated temporal indeterminacy confined within timecode frameworks on the structural integrity of a piece from other forms of less confined performance indeterminacy generated by player actions when responding to music notation that does not determine in full, all or any elements such as instrumentation, pitch, rhythm, expression, tempo or structure; but more particularly, in the second instance, where the word ‘near’ refers to the anticipated degree of difference identified between comparisons of the recording of a live performance and to use a visual analogy, its slightly out of focus sonic image, with its concomitant structurally fixed compositional model’s precisely focused computer-generated sonic image. Although temporal indeterminacy and the ambiguities and ‘errors’ it engenders are an anticipated and welcomed outcome of this compositional approach, what is aimed for here is a blurred but recognisable resemblance rather than an image distorted beyond recognition. Exactly how ‘near’ and recognisable to the model’s audio output any recorded live performance outcomes are perceived to be is discussed shortly.

1.1.13 Quid Pro Quo

The production of sonic flux would introduce a type of structural flexibility into timecode-supported polytemporal compositions not found in the more structurally stable performance outcomes of the Carter and Ferneyhough previously mentioned. I saw the loss of conductors, scores and the consequent incorporation of temporal indeterminacy as a necessary quid pro quo to facilitate the incorporation of temporally distinct, heterogeneous self-borrowed materials into new polytemporal compositions that could then be used to expand simultaneous temporal independence to every instrument of the orchestra and maintain near-determinate performance outcomes without having to effect extensive notational modifications to those materials as would be the case if appropriated into polytactic score formats. In avoiding those formats altogether, I could conceive of a straightforward, simple and practical means to achieve my polytemporal compositional aims within my established practice using self-borrowed materials.

As a composer primarily interested in controlling performance outcomes through determinate notation, the decision to embrace the structural implications of temporal indeterminacy did not come easily. Despite the ameliorating actions of players managing sonic

flux through timecode frameworks, the removal of precise synchronisation throughout the orchestra and the newly afforded temporal independence of each player heralded a significant change to the operation of the orchestra.

1.1.14 Still an Orchestra?

Where players formally functioned as synchronised bodies, often playing in subdivided or tutti rhythmic unison and instrumental doublings, communicating with each other in the most subtle of ways and often performing with and through the direction of a conductor to produce cohesive, finely honed, repeatable bodies of sound frequently realised through determinate notated scores, orchestral players were now required to perform as a collective of decoupled individual soloists operating in what could be perceived as musical, communicative and temporal isolation from one another with no scores or conductors to guide them. These new parameters appeared so distant when compared to standard synchronised orchestral operation that the word ‘orchestra’ may feel inappropriate to some as a term to describe a body of musicians functioning in this manner.

I take the view that a large collection of musicians identifying as an orchestra who come together to perform music designated as orchestral by a composer with the intention to render that music as an orchestra, despite the mode of delivery or diverse functionalities required to achieve this, is operating as an orchestra. I also take the view that the music they produce is, by virtue of this activity and intentionality, orchestral music.

There are undoubtedly a host of questions that merit investigation around how timecode-supported polytemporal music performance practice affects communication, functionality, and the social and political structures of the orchestra (a few of these aspects are briefly touched upon in 3.6 Reflective Text. Though interesting and legitimate areas of inquiry and ones I hope others may pursue in time, the scope of this investigation does not extend to such matters. Instead, I have prioritised examination of the orchestral performance outcomes themselves in relation to the research questions and treated the orchestra as a performance medium through which compositions are rendered rather than the object of study itself. As such, there are no player interviews or ethnographic perspectives to this inquiry.

1.1.15 The Research Questions

Having established the parameters of the investigation, it was now necessary to test my assumptions around how this polytemporal compositional approach would function in practice through orchestral performance. To ascertain this, I first devised research questions that asked

1. How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured?
2. Which timecode frameworks best support near-determinate performance outcomes?

And second, I composed a range of timecode-supported polytemporal orchestral pieces that would enable me to answer these questions through an examination of their performance outcomes.

1.1.16 What is Being Tested?

To achieve this, I created artefacts — five timecode-supported polytemporal orchestral compositions and a selection of timecode-supported polytemporal ensemble pieces. Although pieces of music in their own right with a life beyond this investigation, I refer to these orchestral compositions as ‘test-pieces’ to identify their function within the context of this inquiry to specifically test the capacity of this approach to support all orchestral players perform with simultaneously independent speeds using decoupled parts, critically, so that near-determinate performance outcomes are achieved. To ascertain how near to structurally determinate near-determinate live performance outcomes are, recordings of live performance renditions will be compared to the fixed, fully determinate computer model renditions of the same pieces and the differences between the two examined. In this way, live performance recordings would be tested against their computer-generated counterparts for structural accuracy.

1.1.17 How Near to Determinate are Near-Determinate Outcomes?

Initially, this examination would begin through listening to and experiencing the test-pieces for the first time as live performances or rehearsals unfolded. Impressions were formed through an ongoing process of comparing my memories of computer-generated composition model playback along with any conceptual mapping of the piece formed in my imagination to the live

performance outcomes as they unfolded. Without a score to reference, comparing these compositional conditions like-for-like with any degree of accuracy was challenging and unreliable but did leave an initial impression of how similar or not I felt the two were. Later inspection of the recorded matter of both provided opportunity for more thorough analysis. Here, close listening would reveal degrees of near-determinacy through a comparison between the computer-generated composition model and live performance recordings when their timelines were aligned in software and their rendered matter compared. Using this method, described fully in 3.1.2 How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured? it would be possible to approximately measure, as it were, by ear, the proximity of identical notationally determined sonic events to one another where the smaller the amount of perceived elapsed time between events as observed individually and across the timeline of a piece, the more acceptable and near-determinate I felt the performance was.

Although a subjective, arbitrary cut-off point and using the example of the 2015 timecode-supported ensemble piece *shapeshifter*, discussed in 3.1.2 How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured? as an example of ideal near-determinate outcomes, I have defined 'near-determinate' as inhabiting a maximum time differential of between +/-0–2 seconds as assessed between key sonic events in live performance recordings when compared to their fixed computer model recording. Using this parameter and gauged across a range of pieces similarly compared, I hoped to be able to conclude how successful or otherwise I felt the methodology was in meeting my compositional ambitions. It was the result of these performance tests and the reflections and conclusions drawn from them that would provide answers to the research questions.

1.1.18 Subjectivity

To be clear, concepts such as 'acceptable', 'unacceptable' and 'near-determinate' performance outcomes used throughout this commentary represent personal, wholly subjective values with all performance tests carried out as part of the inquiry undertaken within this subjective framework. Such values evolved as part of the process of ascertaining whether I felt a composition and its performance to have succeeded or failed in relation to the conceptual expectations I held for it. However, as I was curious to probe a little deeper into why a performance may have felt more or

less successful than any other, I undertook to informally measure the comparative differences in seconds between occurrences of identical key sonic features in both the live and computerised manifestations of the pieces to arrive at an approximate time value describing how notationally determined elements such as rhythm, vertical pitch alignments and architectural structure were situated temporally throughout the compositions when compared.

As estimated values arrived at through listening, differentials were still situated as subjective inquiry. However, despite their approximated nature, the results did help focus my understanding of why a performance felt similar, near-determinate or more or less acceptable to any other, at least concerning estimated comparative temporal differentiation in seconds, and at the same time provided a means through which I could communicate those subjective values to others in more quantifiable terms. I considered communicating this information important, fist, to bring a somewhat more quantitive value to the subjectivity of my research results that without such reference would state only that performances either did or did not 'work' for me without indicating why, and second, when introducing a novel compositional approach and its outcomes to other composers, especially those with an interest in polytemporal performance instantiated through deterministic notation, such 'evidence' would potentially prove useful in encouraging them to adopt this methodology in their own work.

1.1.19 Performances

With several orchestral compositions now completed, it was time to ascertain their capacity to support the polytemporal ambition of this project through performance. Performances were initially organised through a collaboration between two orchestras; one, a student, post-graduate and semi-professional orchestra based in the northwest of England that was to perform all the compositions in the order they were written and another, a semi-professional orchestra based in Athens, Greece, who would perform one of the pieces. However, within the first eighteen months of the project, both orchestras had collapsed. This collapse had a profound impact on a research project where the evidence gathered through performance was central to proving the case for timecode-supported polytemporal composition as a new, viable approach to polytemporal orchestral composition.

Additionally, the first two orchestral pieces, *the heaven that runs through everything* (2018) and *[…] a powerful flame that came out of the earth […]* (2018) were composed to meet the particular specifications of the northwest-based orchestra. By the end of year one of this

project, two bespoke, behemoth orchestral pieces had been completed.

Despite numerous attempts across the following eighteen months to encourage performances of these pieces with other professional, amateur and university-based orchestras in the United Kingdom and abroad, it proved impossible to secure any interest in such large-scale pieces. In light of these circumstances, a second version of *the heaven that runs through everything*, using triple wind standard orchestration forces was created in the hope the reduced orchestra size would make performance possible.

For similar reasons, the fourth test-piece, *[…] which constantly generates a pulviscular cloud […]* (2019), was composed using considerably smaller forces to create a chamber orchestra composition. This piece was composed with two possible outcomes in mind: first, as music for live performance; and second, as a remotely recorded modular composition that used timecode frameworks to bring together and reassemble the recorded materials of musicians and ensembles from across the world to produce an acoustic rendition of the piece in the studio. The decision to assemble an acoustic version of the piece using remote recordings was in anticipation of the likelihood of not being able to secure a live performance within the timeframe of this project yet despite this possibility, wanting to generate a professionally performed acoustic recording of at least one of the test-pieces to demonstrate what timecode-supported orchestral music sounded like away from the computer models I had produced.

Such attitudes toward remotely recorded performances proved prescient. By early 2020, the SARS-CoV-2 pandemic had established itself as a major threat to health and led to governments around the world restricting or prohibiting most gatherings including those for music-making. Such edicts had a profound effect on orchestral performance within universities as well as the wider world. All planned orchestral performances were cancelled, and no new performances were permitted. Despite the performance of the timecode-supported double string quartet *pulviscular observation* (2019) and a recording of *pulviscular compression* for nineteen string players, no other performances of my test-pieces took place during the period.

The pandemic and its performance restrictions persisted throughout 2020 and well into 2021 with no conditional change to the circumstances of performance throughout that period. For example, a student performance of one of the orchestral test-pieces scheduled for May 2020 fell victim to such actions as did the professional premiere of a timecode-supported polytemporal orchestral piece as part of an international festival in May 2021.

However, the situation around a lack of orchestral performances was somewhat ameliorated when I fulfilled an unforeseen opportunity to write a timecode-supported polytemporal piece for twenty-two players of the BBC Scottish Symphony Orchestra as part of Tectonics Glasgow May 2021. To fulfil this opportunity, a pre-existing 2019 composition written as part of this investigation titled, *the unimportance of events*, originally for seventeen players, was expanded through the addition of five instrumental lines to become a chamber orchestra piece for twenty-two players sharing the same title, hereafter referred to as *the unimportance of events* (2021). Both the 2019 and 2021 versions of the work exist as part of this investigation.

Despite the performance challenges described throughout this project, the rehearsals, performance and recordings of *the unimportance of events* (2021) have furnished the project with significant results. As this thesis unfolds, all the test-pieces, including *the unimportance of events* (2021), are discussed and analysed to establish the efficacy of timecode-supported polytemporal composition. This examination is undertaken through a series of chapters, summarised next, that look at compositional functionality, how the test-pieces were built and an analysis of available performance outcomes along with the questions, assertions, evidence, extrapolations and conclusions that result from this investigation.

1.1.20 Further Definitions

The terms assemblage, territorialisation and deterritorialisation are used throughout this exegesis. For those familiar with Deleuze and Guattari's 1980 publication, *A Thousand Plateaus: Capitalism and Schizophrenia,* these terms will hold an additional significance in relation to the concept of the assemblage as the 'general logic' at work in *A Thousand Plateaus',* along with concepts such as rhizomes, lines of flight and abstract machines.[9]

Much of this project was undertaken before I encountered the writings of Deleuze and there is no attempt to align its content with Deleuzian thinking. Having said that, I believe there to be a great deal within timecode-supported polytemporal music's composition and performance practice, particularly as observed within the orchestra, that could be productively examined through a Deleuzian lens. Despite my curiosity, such an investigation lies outside the scope and focus of this project. Nevertheless, as there are terms shared in common with *A Thousand Plateaus* it is useful to explain the context in which those terms are used here.

[9] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Brian Massumi (Minneapolis, MN: University of Minnesota Press, 1987). Originally published in French in 1980.

In timecode-supported polytemporal music, an assemblage is seen as a musical entity generated when extant self-borrowed heterogeneous materials, often in the form of complete pieces or strands of music, are brought together in various combinations to make new pieces of music that through player mediation in performance, create iterative, immanent instantiations. This description of an assemblage is in broad alignment with the Oxford Dictionary definitions of an assemblage that states it is: '1. A collection or gathering of things or people. 1.1 A machine or object made of pieces fitted together. 1.2 A work of art made by grouping together found or unrelated objects. 1.3 The action of gathering or fitting things together'.[10]

As discussed in Ensemble compositions and their components, each orchestral assemblage is made up of a collection of smaller assemblages that form the components of the work. A process of recontextualising self-borrowed materials through combination and re-combination — plugging in and unplugging — into various assemblages where those materials in and of themselves do not change their identities (unless aspects of identity are altered through various transformational operations as discussed later) but where the combination and mediation of those materials together produce new identities and immanent outcomes where the whole (the assemblage) is greater than the sum of its parts (the self-borrowed materials). I refer to those constructions as nested assemblages and the processes of assembling them as 'recontextualising materials' and 'temporal realignment'.

Once constructed, the identity of these assemblages is constantly subject to different kinds of change brought about through player mediation of notation during performance. In timecode-supported polytemporal music, deterritorialisation is seen as the distance travelled or approximate measure of difference between the fixed (territorialized) audio generated through computer playback of a compositional model and the audio recording of its concomitant flexible, player-mediated live performance when both are compared. It is this deterritorialised imminent instantiation that is heard by the audience as the sounding music.

Taken to an extreme, player-generated deterritorialisation could destabilise the identity of a composition entirely. In timecode-supported polytemporal music, deterritorialisation is confined by players mediating notation materials within timecode frameworks. In 3.2.4 The Performer's Share: Mediating Clock-time and Musical Time, I discuss the coexistence of stabilising and destabilising actions in the mediation of the test-pieces, for example, in the homogenising agency of players mediating part-embedded timecode expressed as clock-time

[10] Oxford University Press, 'Assemblage', in *English Oxford Living Dictionaries* (2018) <https://en.oxforddictionaries.com/definition/transformation> [accessed 25 April 2019]

with the intention of generating a rendition that aligns structurally, as far as is possible, with the fixed structure of the compositional model audio in an attempt to render a sufficiently stabilised similar identity to the audio model through live performance, and in relation and opposition to this, the same player agency mediating timecode and all other notational matter but simultaneously, using a sense of musical time that despite best intentions, inevitably deviates from the fixity of signified timecode and therefore deviates from the audio model itself due to the action of temporal indeterminacy. This deviation destabilises the similarity between the audio model's identity and live performance identity, producing an immanent instantiation that is deterritorialised from the territory of the model itself, to a certain extent at least. It is this confined deterritorialised outcome that falls within my definition of near-determinate outcomes as described earlier.

1.2 Chapter Summaries

Chapter 1 is organised into two sections. First, an extended introduction that explains the context of this research project, defining the choices I have made that shape its development as well as concepts such as pulse, pulse tempo, polymetric, polytactic and polytemporal music, timecode frameworks and the role temporal indeterminacy and sonic flux play in defining what 'near-determinate' and 'acceptable' performance outcomes are and how they are defined and measured. Two research questions are introduced and the subjective context in which these are approached, discussed. The first part of the introduction closes with a brief chronology of the portfolio piece's performance histories and what impacts the SARS-CoV-2 19 pandemic has had upon these. This is followed by a clarification of terms used in common but not associated with Deleuzian assemblage theory. The second part of the introduction presents 1.2.1 The Compositions as Pieces of Music, in which each orchestral composition is introduced using the style of a programme note to orientate the reader to the music as a piece of art before a more detailed investigation of its structure and operations are given.

Following the thesis introduction, 2. Defining the Territory: A Literature Review, examines the literature focused around totemic twentieth century polytemporal and polytactic orchestral music in Part One, and in Part Two, discuss more recent polytemporal compositions ranging from orchestral to chamber, examining how technology, particularly click-tracks, electronic metronomes and video animated scores have helped composers realise their polytemporal ideas. The review concludes with a comparative analysis of these works to see how their functionalities compare to timecode-supported polytemporal music and establish if this methodology fills a gap in current polytemporal practice.

Next, Methodology, discusses how the methods and techniques used to generate the portfolio pieces specifically address the research questions. This is a theoretical methodology developed during the creation of the test-pieces that describes building four timecode-supported polytemporal orchestral pieces, a chamber orchestra composition and a number of timecode-supported polytemporal ensemble pieces that comprise them along with their functionalities and mediation as the practice element of this investigation.

To articulate these aspects, the chapter is divided into three parts. Part 1: About this Methodology, is apportioned into three further subsections: 3.1 Introduction, which sets the context and overview of the methodology; 3.1.2 The Research Questions, that lay out what the

tests described in 1.1.16 What is Being Tested? and 1.1.17 How Near to Determinate are Near-Determinate Outcomes? involve, including the subjective criteria used to produce results; and in 3.1.3 The Compositions as Research Objects, a detailed look at materials — the components — that constitute the test-piece assemblages themselves. Next, in 3.1.4 Self-Borrowing, a very brief overview of some of the generative processes used to create self-borrowed notation materials, and in 3.1.5 Creating Materials that 'Work' in Shifting Contexts, a range of processes designed to produce temporally independent materials that function in flexible contexts.

The second and third main parts present a two-part theoretical framework where in Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions, examines the methodology's functionalities moving through a series of subsections to describe how the term timecode-supported polytemporal music was constructed, what the term means and how the various functionalities, conditions, assemblages and actions comprising it operate as a relational process and composition methodology with the potential to generate near-determinate performance outcomes.

Part 3: Building the Model continues with 3.4 Assembling the Assemblage, which looks at how the compositional models for each piece are constructed using two primary operations: first, in 3.4.1 Temporal Realignments, and 3.4.2 Structural Inventions: Polyphony, Heterophony and Canons, how original, self-borrowed and transformed notation materials rendered as audio file recordings using Sibelius software are subsequently assembled using recursive and assimilative processes in Logic software to produce vast audio file constructions called audio file assemblages that upon playback produce a digital audio impression of the composition called the audio model, and how specific polyphonic, heterophonic and canonic constructions are generated as part of the structure of the pieces; and finally, 3.5 Consolidating with Timecode, examines the various processes necessary to build instrumental parts that exactly duplicate notation materials and the temporal relationships between them "placeheld" in the audio file assemblages to provide parts used to render the model as immanent sound in performance, thereby completing the compositional process and the building of the model.

Before 4. Performing the Model: Results and Discussion, in 3.6 Reflective Text, I have created a brief reflective text in which I discuss subjective reflections around orchestral behaviour and communication observed during performances of timecode-supported polytemporal music that would not easily fit into other areas of the thesis.

With no large-scale orchestral renditions to reference, 4. Performing the Model: Results and Discussion, draws its results from the performance of a chamber orchestra composition and several timecode-supported ensemble pieces composed for this project. The chapter ascertains if the methodology has been successful in generating near-determinate performance outcomes. To achieve this, I compare and measure the differences between the fixed, structurally significant sonic events proliferating the audio model timeline and those same, more flexibly rendered sonic events found in the live performance recordings as differentials in time.

The primary assertion of this thesis is that timecode-supported polytemporal composition extends simultaneous polytemporal distribution to each orchestral player to bring new composition and performance opportunities to composers that are currently unavailable. In 5. Conclusions, using evidence from the literature review and 4. Performing the Model: Results and Discussion, conclusions are presented around the efficacy of timecode-supported polytemporal music, its capacity to fulfil its compositional aims and if this approach does indeed offer new composition and performance opportunities not possible through other polytemporal praxis. Finally, I propose areas of application and potential further development for this approach that were not possible to investigate as part of this project.

1.2.1 The Compositions as Pieces of Music

Although created for this research project, the five timecode-supported polytemporal orchestral compositions are also pieces of art, composed for public performance. The first three pieces, *the heaven that runs through everything* (versions for large and standard orchestras) and *[and] a powerful flame came out of the earth [...]* are large-scale orchestral pieces composed in response to specific artistic and programming requirements of the orchestra designated to premiere them publicly. To this end, *the heaven that runs through everything* was designed as a companion piece to Gustav Mahler's Fifth Symphony (1902) but used a larger orchestra than Mahler required owing to the composition brief necessitating the inclusion of all instrumental doublings as well as a saxophone quintet, while *[and] a powerful flame came out of the earth [...]* was conceived to be programmed alongside Igor Stravinsky's *Le Sacre du Printemps* (1912–13) using almost identical instrumentation, and where both pieces were required to have a thirty-minute minimum duration to balance the scale of the other programmed works. Such compositional considerations were necessary to build an effective collaborative partnership with the orchestra in order to ensure performances of the compositions and as such, the scale and

duration of the pieces was, by and large, dictated by the requirements of the orchestra's artistic and programming aspirations.

While it would have been possible to write compositions that utilised smaller orchestral forces over shorter durations to test the same timecode functionalities in performance, the fulfilment of collaborative expectations produced pieces on a grand scale. In response to the epic scale of the first three orchestral pieces, the fourth to be written, *[...] which constantly generates a pulviscular cloud [...]*, was composed using a much smaller orchestra of forty-one players along with a shorter duration of twenty minutes in an attempt to increase the likelihood of performance.

Also using smaller orchestral forces and composed nearly two years after *[...] which constantly generates a pulviscular cloud [...], the unimportance of events* (2021) was something of a last-minute addition to this project. With its player line-up, including two horns, two trumpets and two trombones along with one each of woodwind, ten string players, percussion and piano, this chamber orchestra composition presents the largest number of players in live timecode-supported polytemporal performance within the timeframe of this project. Although not a large-scale orchestral performance, it does provide performance evidence significant to the conclusions of this investigation.

All of the pieces composed as part of this project are polytemporal, meaning two or more, and in the case of these compositions, most or all musicians are playing at simultaneous, independent speeds to one another much of the time. With the proliferation of these orchestra-wide independent speeds, the synchronising beat of one or several conductors would be insufficient to guide the multitude of tempi for each player. As such, the composition is designed to be player-led and performed without a conductor. Instead, it uses a system of organisation that somewhat flexibly holds instrumentalists and structure together using timecode, that is, minutes and seconds printed above every bar (or in some instrumental strands present in *[and] a powerful flame came out of the earth [...]* and *[...] which constantly generates a pulviscular cloud [...]*, timecode intermittently indicated above larger groups of bars) in all instrumental parts that mark the passage of time throughout the piece. Read in conjunction with the rolling timecode displayed on each players' loosely synchronised mobile phone stopwatch, players are able to mediate their performances so that both timecodes approximately match up throughout the performance. Called timecode-supported polytemporal music, this system

enables players to know exactly where they are, where they should be and what they should be doing at any given point along the timeline of the composition regardless of the lack of conductor, the independence of their material or the different simultaneous speeds at which they perform. As such, each player could be thought of as being their own independent conductor among many independent conductors.

This composition context and initial overview of the temporal functionality of timecode-supported polytemporal performance lays the foundation for further examination later in this commentary. Before that, I would like to orientate the reader to these compositions as pieces of music in their own right rather than solely research objects. To this end, the following descriptions are presented in the style of programme notes.

The Compositions

the heaven that runs through everything

The title for this orchestral piece is taken from the poem *The Heaven That Runs Through Everything* by Rosie Jackson. Rosie's poem won the First Prize in the Cookham Festival Stanley Spencer Competition 2017 and is a celebration of Spencer's paintings.

Spencer was a devout Christian whose faith defined his subjects and the way he painted them, creating many paintings that were not unlike altarpieces celebrating the wonderful in the everyday as perceived through his filter of Christian belief. Rosie's poem celebrates the miraculous in the everyday in Spencer's paintings, too. However, I wasn't drawn to the title for its religious significance or its reference to Spencer's paintings or the beautiful writing it contained. Instead, I was drawn to the title as it implied connectivity between all things that rather than being united through a concept of heaven, were connected through atoms, molecules and materials, structures and sounds, chemistry and physics, eco-systems and biospheres that relate to one another in multiple, complex ways to comprise the building blocks of life itself. It is this interpretation of the poem's title that reflects the building of an orchestral piece of substantial scale, generated through the combination and recombination of compositional elements related and interconnected on many levels. It is the compositional material that is 'the heaven' that runs through everything in this piece. The thirty-minute composition is for an orchestra of either ninety-four players (standard orchestra version) or a maximum of one hundred and fourteen players (large orchestra version).

[and] a powerful flame came out of the earth […]

[and] a powerful flame came out of the earth […] was conceived during a trip to Iceland in October 2018. I was particularly taken by the volcanic activity that has shaped and continues to shape the country and was keen to analogously explore some of these processes through intuitively structuring sound in an orchestral composition that unfolds across a substantial time span.

In lieu of landmasses and tectonic forces, I created two orchestras from the instrumentation of one large orchestra where the larger orchestral apportionment moves forward using almost entirely slow tempi across substantial spans of music that inhabits confined harmonic fields, creating structures akin to sonic monoliths and by contrast, the mercurial smaller second orchestral apportionment simultaneously moving forward using much faster tempi across connected shorter spans of music with less confined harmonic invention.

These orchestral apportionments and their contrasting characteristics are defined beyond mere tempo differentiation: they are two separate pieces thrown together where the larger apportionment is a recontextualisation of an extant orchestral composition, The North Sound (2005/14) onto which is superimposed the newly assembled smaller orchestral piece transformed from other heterogeneous materials to amalgamate one seamless body of new sound. It is the movement, the friction and attrition, between these two orchestras, these two masses of sound and the grinding together of their contrasting musical characters and especially the multiple polytemporal relationships — the different, simultaneously independent speeds at which these strata move — that in my mind correspond to the action and huge forces of tectonic plates colliding to throw up mountains and cause earthquakes, volcanoes and eruptions to occur over millennia, that are transformed into sonic features and events within the compositional landscape of this piece.

Emphasising these geological phenomena, the title for the piece was extracted from the passage: “and at the same time a powerful flame came out of the earth, huge and terrifying. It was so powerful and terribly great that it melted cliffs and boulders. From the flames came steam and smoke”, featuring verse thirty from the book Van Y*ƒ*landt (On Iceland) by Göris Peers, a sixteenth-century German traveller who wrote Van Y*ƒ*landt as a poem about his experience and travels around Iceland. This text sums up the awe and magnificence of the

landscape and natural process that formed it, processes I hope are reflected, in part, in the architecture and drama of the composition.

[…] which constantly generates a pulviscular cloud [...]

> A classic is a work which constantly generates a pulviscular cloud of critical discourse around it, but which always shakes the particles off.
>
> Italo Calvino[11]

The term 'pulviscular cloud', in this case, transformed in my imagination into a pulviscular cloud of sound — of sonic dust — full of particles that are in a state of constant motion and flux, resonated with my concept of the sonic flux that coalesces during the performance of *[…] which constantly generates a pulviscular cloud [...]* into forms that constitute the structure and content of this music.

In addition to the use of timecode and stop watches to help shape performances, the contrast between the independent tempi of the players and their heterogeneous materials is further emphasised by the spatialisation of the orchestra into six ensemble groups located around the performance area. Due to the use of timecode and stopwatches, these groups can be imaginatively positioned without any need to consider a line of sight with a conductor or each other. Each group comprises of different instrumental arrays with every player using independent simultaneous tempi and where each group is a colouristically distinct ensemble with no exact temporal relationship to any other.

The culmination of spatialisation, polytemporal performance and heterogeneous materials make this a music of extremes, of hyper-activity, hyper-density, quicksilver colouristic fluctuations, of perceptually complex sound combinations articulated through demanding, virtuosic instrumental part-writing that requires a great technical facility, expressive insight and emotional stamina from performers when mediating its notation and instantiating its sound. Here, performances are a gamble — a balance — between an aspiration to control outcomes through specific notation and how players mediate notation to produce what is actually heard. It is the uncertainty around how this balance will manifest as sound in performance and the sonic flux these particular uncertainties produce in self-similar, near-determinate variant iterations that excites me. And for audiences, I would suggest listeners surrender to the music's spatialised

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[11] See definition eight from the fourteen definitions of 'What Makes a Classic?', in Italo Calvino, *Why Read the Classics?* trans. Martin McLaughlin (Boston and New York: Houghton Mifflin Harcourt, 2014), p. 6.

visceral energy, its life force, textural diversity and intricate, ever-changing sonic relationships — to its coruscating effect — as it physically surrounds them without any need to comprehend what the music 'is' or 'means' beyond a pageant of entangled sound journeying through time to coalesce as music.[12]

the unimportance of events (2021)

Composed for the BBC Scottish Symphony Orchestra and Tectonics Glasgow 2021, *the unimportance of events* for twenty-two players is a chamber orchestra timecode-supported polytemporal composition where each player is treated as a soloist performing in their own simultaneous independent speed, enjoying unique temporal, expressive and interpretive freedoms.

Like *[…] which constantly generates a pulviscular cloud […]*, *the unimportance of events* is also organised into six spatialised groups with four soloists — alto flute, bassoon, violin and double bass — positioned at the front of the ensemble and successively behind them, two string quartets; piano, oboe and clarinet; two horns; and finally, percussion, two trumpets and two trombones positioned furthest away from the audience at the back of the performance space. Like all my timecode-supported polytemporal compositions, *the unimportance of events* (2021) draws its materials from a range of other polytemporal compositions, self-borrowing and transforming those materials to create an assemblage of related content that competes for attention, dissolves, coalesces, morphs and entangles itself in a fluid outpouring of constant generative activity activity.[13]

At times, the nature and relationship of sounds elicited through the performance of all five pieces may be deemed to verge on the extreme, overwhelming the ear with too much information across uncomfortably long periods. This condition is intentional: during phases of maximum polyphonic density, where all instrumental parts are performed at simultaneously different speeds in polytemporal performance, the numerous layers of independent, sometimes heterogeneous materials compete with one another for dominance, generating a sustained, intricate, complex and frenzied state throughout several phases of the composition that may prove perceptually challenging to disentangle.

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[12] A recording of *[...] which constantly generates a pulviscular cloud [...]* (2019) is available at 'Marc Yeats: Composer' website: <https://www.marc-yeats.com/which-constantly-generates-a-pulviscular-cloud-2019/> [accessed 5 December 2020]

[13] A recording of *the unimportance of events* (2021) can be accessed via the PhD Materials folder using a link found immediately after the title page of this thesis or on 'Marc Yeats: Composer' website: <https://www.marc-yeats.com/the-unimportance-of-events-2021/> [accessed 19 July 2021]

To prevent a descent into sonic chaos and establish a dramatic impact between materials, extremes of polytemporal density are contrasted with less dense and less chaotic sounding materials. This pattern of establishing phases of extreme polyphonic and temporal density followed by phases of comparatively sparse material stratification marks the cyclic journey — the narrative — obsessively undertaken several times within all the piece's durations, between perceptual obfuscation and perceptual clarity, that constitutes perhaps the most significant structural feature of the piece. Underpinning and driving this narrative is an often manic, relentless forward momentum that like a moth inexorably drawn to a flame, burns itself out in the composition's final moments where all sounds return to the silence from which they emerged.

2. Defining the Territory: A Literature Review

2.1 Context and Definitions

‘Defining the Territory’ examines the literature focused on and around polytemporal orchestral music, looking in particular at a range of totemic works from the twentieth-century that have shaped much that has followed in this field and concludes with a brief overview of polymetric works, approaches and technologies contemporary to this investigation that though not necessarily orchestral in scale, do help differentiate timecode-supported polytemporal music and what it offers composers from other polymetric approaches. To that end, this investigation examines compositions that, superficially at least, look as if they are already doing what timecode-supported polytemporal orchestral composition purports to achieve, particularly regarding the near-determinacy of its polytemporal structural outcomes but where closer examination shows there are small but significant differences between other compositional approaches and timecode-supported polytemporal music that constitute a gap in practice.

Although compositional generation and temporal functionality are connected, this investigation does not undertake an in-depth examination and description of the compositional methodologies of other polymetric orchestral pieces included here. Instead, the review focuses on a broad overview of polytempic and polytactic organisation, presentation and performance outcomes relevant to this investigation and the polymetric compositional territory shared by timecode-supported polytemporal orchestral music. In this vein, all mention of indeterminacy is specifically focused on outcomes where performers make choices to determine compositional or performative temporal elements such as tempo, rhythm, meter and duration the composer has not determined using notation or other means and does not refer to any degrees of indeterminacy or chance used by the composer at the time of composition. This review also describes if the temporal frameworks of cited pieces are notationally represented in scores and parts, parts alone or other formats entirely, if they use conductors, click-tracks, stopwatches, chronometers, internal cues, degrees of synchronisation or flexibility of performer choice and how these agents and actions shape performance outcomes in terms of their structural and temporal determinacy.

The metric and temporal conditions of the compositions described here are categorised using Rundall’s definitions for polymetric, polytactic and polytempic music laid out in

1.1.6 Polymeter, Polytactus and Polytempo: Definitions, in Chapter 1, along with what defines structurally determinate and near-determinate outcomes in 1.1.11 Temporal Indeterminacy and 1.1.12 Defining Near-Determinate Outcomes respectively.

This collection of works is not presented chronologically or grouped together as a consequence of stylistic similarities. In the first instance, works are ordered by their classification as polytempic or polytactic. Within the polytemporal groupings of Part One, there is a further subdivision of compositions that range from performance outcomes where rhythmic and temporal matter are not fully determined by the composer to works where rhythmic and temporal matter are fully determined by the composer. This ordering presents a progressive movement from performance outcomes with significant levels of temporal indeterminacy to those with determined temporal outcomes. Having said that, a number of compositions included here move between or simultaneously incorporate both conditions.

The categorisation of compositions presented in Part Two of the literature review are also not ordered chronologically or grouped stylistically but in contrast to the ordering of compositions in Part One, are grouped together along a continuum ranging from works where rhythmic and temporal matter are fully determined by the composer to works where rhythmic and temporal matter are not fully determined by the composer. This ordering presents a progressive movement away from performances with determined temporal outcomes toward outcomes with significant levels of temporal and structural indeterminacy. The review ends with a look at composers using animated notation along with its capacity to support determinate or indeterminate structural outcomes in performance.

I begin by examining polytemporal compositions, identified as such by virtue of their being more than two tempo markings in operation simultaneously at any point in their duration. As mentioned, also included among polytemporal works are pieces where performance outcomes incorporate degrees of temporal and structural indeterminacy. These works may sound metric or even polymetric, but due to elements such as tempo, rhythm and meter not necessarily being fully determined in notation, there is no way of predicting those outcomes through an examination of the notation. As Rundall explains:

> An even more unpredictable sort of potential for polymeter belongs to music that involves the indeterminate notation of individual rhythmic values, through proportional notation, for example. To the extent that a proportionally notated piece sounds metrical (if even by accident) there is also a possibility that it sounds polymetrical. There is absolutely no way to predict such an outcome by looking at a score, and no way to analyze what sort of polymetrical structure could arise. […] But it is conceivable that a listener could meaningfully experience polymeter during a performance of such a piece.[14]

Similarly, indeterminate temporal outcomes are associated with compositions that incorporate ad libitum, aleatory, graphic notation and other forms of temporally indeterminate instruction within their compositional structures. All such temporal conditions are described in the context of the pieces they operate within as the review unfolds.

In Part One, I begin with compositions with or without a specific and intentional focus on simultaneous tempo relationships such as Cage's *Concert for Piano and Orchestra* (1957–1958), *Atlas Eclipticalis* (1961–1962) and the orchestral piece, *1O1* (1988); I then move onto loosely synchronised pieces such as Berio's *Tempi Concertati* (1958–1959) and the many symphonies of Segerstam; flexible works that move between temporally determinate and temporally indeterminate formats such as Lutosławski's *Jeux Vénitiens* (1961) and his Second Symphony (1965–1967); temporally determinate polytemporal structures using temporally independent ensembles with conductors such as Ives's Fourth Symphony (1910–1920); Stockhausen's *Gruppen* (1955–57); Brant's *Antiphony 1* (1953) and *Millennium II* (1954); and Ferneyhough's *Firecycle Beta* (1969–1971); and then onto temporally determinate polytactic pieces where simultaneous notation-tempo are not present, for instance, Carter's Variations for Orchestra (1955); Davies's *Prolation for orchestra* (1958); and from the perspective of dense polyphony, Ferneyhough's *La Terre est un Homme* (1976–1979).

In Part Two of the review, I provide a brief overview of polymetric compositional techniques used more recently, a number of which incorporate the use of computer technologies and video to realise their polymetric ambition. Beginning with conducted structurally determinate compositions including Chaya Czernowin's *Slow summer Stay III (Upstream)* (2012); Conlon Nancarrow's *Player Piano Study no. 21 (Canon X)* in a 2021 arrangement by Dominic Murcott; and Evan Johnson's *die bewegung Der auger* (2013-2014); followed by Joel Kirk's click-track managed *[internal resistance to flow is named viscosity]* (2017); and then the individual player metronome-controlled compositions including Ned McGowan *Building Music* for big band and (mezzo) soprano voice (2013); and Ron Fein's *Orchestral Environment*

[14] Rundall, p. 49.

(1982) *Undulations*, (1993), *Meridian* (1995), *Ephemera* (1996) and *Periphery* (1998); to then look at the role of stopwatches in Rebecca Saunder's *Chroma*, (2003-2019); and discuss Michael Finnissy's loosely synchronised and sometimes open form works such as *'n'* (1969-72) the 5th and 7th Piano Concertos (1980, 1981), *Nobody's Jig* (1980- 81), *WAM* (1990-91) and *Quelle* (1994); as well as the temporally indeterminate Melting, Shifting, Liquid World (2019) by Holly Harding; and finally, I examine the animated scores of Cat Hope's *The Rupture Exists* (2020); and Desmond Clarke's *Bright Waves* (2021).

Following the literature review, I discuss, compare and contrast these works to identify what they offer the composer regarding temporal functionality including any potential temporal limitations with the aim of identifying gaps in current praxis. These observations are further discussed in relation to the differentiation, functionality and polymetric compositional potential offered by timecode-supported polytemporal composition to conclude how it constitutes new methodological, creative and performative opportunities for composers and performers alike that are not possible to achieve using current polymetric methodologies.

Part One

2.2 Cage

This territory is inhabited, at one extreme, by the structurally and temporally indeterminate, experimental orchestral works of Cage. As discussed, these pieces may not be intentionally polymetric even when musicians are, for all intent and purposes, performing in personal temporal frameworks even if those frameworks are frequently ametric but where the perception of polymeter may occur through the combination of multiple parts in performance. One such piece, *Concert for Piano and Orchestra*, uses the conductor as a chronometer, has no score and is performed from parts alone where these parts comprise sixty-three pages of notation generated from eighty-four distinct compositional approaches. The parts may be performed in any order and their materials rendered partially or in full at the discretion of each performer. The composition, too, may be of any duration. Any number of players are drawn from an instrumentation list provided by the composer and may range from one performer in extreme cases up to a concert for piano and orchestra, for example. There are no tempo indications in the performance materials. Instead, the notation of each part uses a system wherein spaces between notational elements are interpreted as relative to quantities of time (proportional notation) and where the amount of time between these elements is determined by the individual player.[15]

[15] Reference from the website 'John Cage Complete Works' search under *Concert for Piano and Orchestra* <https://johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=48> [accessed 6 March 2019]

The choices made by players and the performance outcomes they generate are further mediated by the unconventional role of the conductor who acts as a human chronometer bending clock-time from minute to minute, either faster or slower. When taken together, the actions of players and conductor make it impossible to anticipate the order of events as they unfold through time, as Drury explains:

> Adding yet one more level of unpredictability, Cage provides a 'part' for a conductor which translates notated time into real time. In performance, the players read the conductor (whose arms move in large circles) like a clock. Thus, a player's part may specify ten sounds to be made in thirty seconds but following the conductor's motions (the speed of which have been distorted by the conductor's part), that player is given only fifteen seconds to perform those ten sounds.[16]

Calculations made by the conductor pre-determine the duration of the piece as well as the duration of its various internal apportionments. Cage provides instructions to arrive at these calculations:

> Using a stopwatch, the conductor changes clock-time to effective time. Standing where he may be seen by all the players, he represents to them the movement of a second hand, but counter- clockwise (beginning each minute with the left arm high and descending to the left. At effective 30" the right arm continues to the right and up to effective 60". When a change in speed is approaching, he indicates this with his free hand, an upward motion announcing a faster speed, a descending one announcing a slower one. Throughout the final minute he keeps the free arm at 0, the end being indicated by the touching of the two palms.[17]

This chronomatic choreography is calculated using three time-columns found in the conductor's score. These columns comprise clock-time, effective time and omitted time, each of which is expressed in values of minutes and seconds. The duration of the score and the duration of each internal apportionment is calculated by the conductor selecting and ordering certain lines of time-values predetermined by Cage and adding or subtracting these values to obtain total values for each line and thereby each apportionment of the composition. Once the total duration of the performance is established through the sum of the calculations as clock- time, the conductor uses his arms according to the effective time simultaneously calculated to denote a faster or slower tempo for the performers within the overall clock-time framework of the piece. Described differently, the clock-time duration of the piece moves inexorably forward as a

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[16] Web reference from the website 'Stephen Drury: Writings', search under John Cage: The Piano Concertos <http://www.stephendrury.com/writings/cagepianoconcertos.html> [accessed 6 June 2019]

[17] Taken from the notes in a reproduction of the first two pages from the conductor's score of *Concert for Piano and Orchestra* in David Vaughan, ed., *Merce Cunningham: Creative Elements* (New York, NY: Routledge, 2013), p. 63.

constant value, the speed of the chronometer's arm rotations will exhibit different rates of rotation speed within that set framework, the total duration of which will equal the duration of the piece. In this composition, it is the measurement and perception of time rather than tempo that governs the performance and its outcomes.[18]

Like *Concert for Piano and Orchestra, Atlas Elipticalis* employs a conductor as a chronometer, has no master score and its materials may be performed in any order, either partially or in full within its eight-minute set duration by a complement of musicians up to and including the full orchestra of eighty-six players. Cage uses the *Atlas Eclipticalis* (an atlas of the stars published by Antonín Becvár in 1958) to establish his pitches by superimposing musical staves over its star-charts and tracing the star-point configurations onto the manuscript.[19] Pitches are clearly notated with some note heads being larger than others indicating increased levels of amplitude and organised as single notes or more frequently, groups (Cage called these, 'aggregates' or 'constellations') of up to ten pitches joined by a wavy line.[20] Duration-type descriptions are indicated above the events using a number of instructions:

> First, a pair of numbers might appear above a constellation; the first indicates how many notes out of the whole group should be played with as short a duration as possible […] while the second represents the number of notes that can be played with a longer duration. Second, a fermata indicates that all of the notes in the group are to be played with a longer duration, but no longer than one bow length or one breath. Third, the absence of numbers or a fermata means that all of the notes are to be sounded as short as possible. The player is free to combine tones from a group into chords or multiphonics whenever possible.[21]

The parts themselves comprise four large pages each divided horizontally into five systems where 'time is measured spatially across the page, and each system is marked with four arrows that point first up, then right, then down, and then left. These directions correspond to the motions of the conductor, who mimics the operation of a clock'.[22] Tempo indications are not given, instead, tempo and the duration of the piece are determined by the conductor where a system is equal to at least two minutes duration and the conductor performs one clock-cycle for each system using arm and hand signals. These instructions specify that: 'At 0", 30", and 60" he [the conductor] makes changes of their arm, at 15" and 45" changes of palm. From the last 30"

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[18] Ibid, p. 64.

[19] Web reference, 'John Cage Complete Works' search under *Atlas Eclipticalis* <https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=31> [accessed 7 June 2019]

[20] Benjamin Piekut, *Experimentalism Otherwise: The New York Avant-Garde and Its Limits*, Vol. 11. (Los Angeles, CA: University of California Press, 2011), p. 27.

[21] Ibid, p. 27.

[22] Ibid, p. 25.

to the end at 60" he uses both arms, fingers touching at the conclusion'.[23] As in *Concert for Piano and Orchestra*, the performer chooses when and which pitches to sound, in this instance, 'each musician judges when to play a particular note or group according to where it is positioned spatially in relation to these four cardinal points [the 0", 15", 30" and 45" demarcations]'.[24] As a consequence of each player placing minimal pitch materials within the duration of the piece and the conductor's structural choices potentially further limiting which materials are produced, players are often left with little material to perform throughout the piece.[25]

Cage eventually replaced the human chronometer with a mechanical one. This chronometer possessed a single long arm that through a three-hundred and sixty-degree rotation marked the eight-minute duration of the work using different coloured lights to indicate the start and stop of the piece as well as the two, four and six-minute apportionments.[26] Piekut notes that violinist Enrico DiCecco of the New York Philharmonic criticised the robotic nature of the mechanical conductor saying: 'the device may have given the impression of granting players freedom, but this was never more than "freedom within the barline," because there was no chance that the rate of the armature's rotation would ever change'.[27]

A conductor is also absent from the orchestral work *1O1* which instead uses a mechanical chronometer like a large stop-watch visible to all players and like *Concert for Piano and Orchestra* and *Atlas Eclipticalis*, has no master score, is performed from parts alone and uses elements of player choice around which material is performed and when it is sounded within its twelve-minute set duration. The large orchestra of one-hundred and one players is one of Cage's *Number Pieces* which include forty completed compositions that take their title from the number of players they involve, hence *1O1* using one-hundred and one musicians. These players are divided into three groups with each group having its own score and each group playing sounds of differing qualities with strings, flutes and clarinets playing sustained tones, double reed and brass instruments playing loud sounds that manifest through interjections at the start and near the close of the piece with both joined by an exotic array of percussion percussion instruments adding an intermittent constellation of sounds throughout.[28]

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[23] Ibid, p. 25. Piekut's comments are quoted from John Cage, *Atlas Eclipticalis*, conductor score (New York, NY: Edition Peters, 1961).

[24] Ibid, p. 25.

[25] Ibid, p. 29.

[26] Ibid, pp. 36–37.

[27] Ibid, p. 45.

[28] Web reference from the website 'John Cage Complete Works' search under *1O1* <https:// johncage.org/pp/ John-Cage-Work-Detail.cfm?work_ID=10> [accessed 9 March 2019]

Of particular note in *1O1* is the introduction and use of what Cage terms 'time brackets'. Time brackets are a notational device that confines player choice within certain parameters along the timeline of a piece but within which the player has complete freedom to render their material, as Popoff describes:

> A time-bracket is basically made of three parts: a fragment of one or many staves, lying under two time intervals, one on the left and one on the right. Time intervals themselves consist of two real-time values separated by a two-way arrow. The staves contain one or more sound events without any duration indications. A time-bracket is performed as follows: the performer decides to start playing the written sounds anywhere within the first time interval on the left, and chooses to end them anywhere within the second one. These parameters are thus left free to the performer, provided he respects the time-bracket structure.[29]

Unlike *Concert for Piano and Orchestra* and *Atlas Eclipticalis*, there is no spatial or proportional relationship concerning the distance between the placement of notes in the manuscript and implications for time as duration. Instead, time brackets indicate all parameters for sound production excluding duration with the duration of sounds only being established after they are rendered as time is flowing through the composition. Unlike conventional metered notation where duration is pre-determined by the composer to build compositional structures, time brackets and the concept of time-as-flowing offers little indication about structural outcomes although the limits of this structural flexibility, though substantial, are confined by the parameters of the time brackets and the unique placement of materials within them. As Weisser says: 'What time-brackets are capable of in this regard is in ensuring predictiveness on a very remote and distant scale global in its proportions'.[30]

Considering the structurally indeterminate pieces discussed here, it is impossible to determine whether *Concert for Piano and Orchestra*, *Atlas Eclipticalis* and *1O1* are ametric or polymetric in nature. As each piece is associated with a selection of features such as no master score, performance through parts alone, an array of aleatoric, proportional and graphics notations, no tempo indications, time brackets, no synchronisation or very loose synchronisation between performers, a conductor or chronometer that distorts or enforces clock-time to further mediate performance outcomes, wide parameters of performer choice concerning which materials to perform, in what order and with which instrumentation and for which duration, all of which produce highly flexible, indeterminate sonic and structural results, it is likely any

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[29] Alexandre Popoff, 'John Cage's Number Pieces: The Meta-Structure of Time-Brackets and the Notion of Time', *Perspectives of New Music* 48.1 (2010), 65–82 (p. 67).

[30] Benedict Weisser et al., 'Notational Practice in Contemporary Music: A Critique of Three Compositional Models (Luciano Berio, John Cage, and Brian Ferneyhough)' (PhD dissertation, City University of New York, 1998), p. 145.

rhythmic perception of these pieces will fluctuate between ametric and polymetric from moment to moment.

2.3 Berio, Segerstam, Lutosławski and Boulez

Different from *Concert for Piano and Orchestra*, *Atlas Eclipticalis* and *1O1,* Berio's *Tempi Concertati* is an unconducted, through-composed, fully notated piece presented in score format that moves between synchronous, loosely synchronised and asynchronous materials that generate confined aleatoric performance outcomes. This sixteen-minute piece is for flute, violin, two pianos and four orchestral groups of antiphonally placed players that are coordinated in performance by the flute player who is centrally placed so as to be visible to all players. Coordination is also shared with the violinist and either of the two pianists who together use a range of signals and gestures to manage the performance in accordance with its duration and tempi parameters. The work is only unconducted in performance: Berio instructs that all rehearsals are to be undertaken with a conductor, presumably to embed the tempo relationships between the solo flute and the ensembles to a sufficient degree to be robustly executed in performance with the conductor absent and the flute and other soloists providing sufficient structural guidance to more or less replicate the temporal relationships established during rehearsals.[31] Although not stated by Berio in the performance instructions, it is reasonable to assume that the removal of the conductor in performance generates a degree of visual theatre that affords somewhat more flexible and unpredictable temporal relationships between soloist and instrumental groups, bringing an improvisatory quality without jeopardising the overall structural integrity of the piece. As described on the Centro Studi Luciano Berio page for *Tempi Concertati*:

> Concertati, because the relation between individual tempo (of the soloists, and above all of the flute) and collective tempo (of the four small instrumental groups) is not always given: sometimes it must be prearranged and coordinated by the individual performers, on the basis of a repertory of signals (real gestures or elements of the musical structure) which implies on the part of each performer constant and careful attention to the others. It is a question of 'perceived' signals in the widest sense of the word: they can act by their presence and also by their absence, creating continuous interferences between individual and collective action.[32]

At the start of the piece, tempo relationships are unified between the soloist and the four

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[31] Taken from the English translation of performance instructions prefacing the score of Luciano Berio's *Tempi concertati: per flauto principale, violino, due pianoforti ed altri strumenti* Vol. 13205 (London: Universal Edition, 1962).

[32] Reference is taken from the website 'Centro Studi Luciano Berio' searching *Tempi Concertati* (author's note) <http://www.lucianoberio.org/node/1501?706855542=1> [accessed 13 July 2019]

instrumental groups. From bar 161, the ordinary rhythmic notation is superseded by proportional notation where spatial distribution is conditioned by the prevailing tempo for all parts. Bars 71–110 and 320–365, though still synchronised by the flautist become ametrical, primarily because the flautist is instructed that the bar and beat gestures they initiate do not need to keep a strict tempo. Additionally, Berio uses notational signs and symbols to progressively relax synchronisation between players and the prevailing tempo.[33] 'The "polytempo" [in these passages] is more or less asynchronous as all performers enter an individual tempo space, without indications or markings'.[34] Within these ametric, aleatoric episodes, the independent temporal delivery of proportionally notated materials, even within a signified global tempo, is executed by the players polymetrically and is most likely perceived by the listener as polytemporal music.

Also asynchronous, Segerstam's orchestral works of the past decades are unconducted, fully scored polytemporal pieces. However, despite his many symphonies (three-hundred and forty-two as of March 2021) and vast compositional output, Segerstam's music is the subject of little scholarly investigation.[35] Nevertheless, Koposova's study of Segerstam's polytempic pieces shows he uses a form of aleatoric counterpoint (counterpoint that is flexibly determined by the actions of the performers) developed by the composer called 'free-pulsation' in which his musical materials interact flexibly in time within overall confined structures, often organised through five to eight blocks of exactly notated material that together form the overall structure of the piece.[36] Segerstam explains: 'This is the way that my score pages are; the things that are on these pages can be put a little bit left or right in time and still make sense harmonically. How I find these kind [*sic*] of Lego bits I can't explain, but I hear it that way'.[37] Segerstam developed free-pulsation between the mid-1970s and the late 1990s, by which time the approach was incorporated into his symphonic writing.[38] The free-pulsation symphonies are somewhat rambling, sonoristic, often moderately paced single-movement works of circa twenty-minutes duration that are notationally condensed within five or six pages of A3 score manuscript. Performed without a conductor, free-pulsation music instead uses built-in conducting mechanisms to coordinate the pieces and confine aleatoric counterpoint using a technique prefigured in works by Lutosławski such as *Jeux Vénitiens* and his Second Symphony, for

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[33] Taken from the performance instructions in the score of *Tempi concertati.*

[34] Thoegersen, p. 115.

[35] Listed on the 'Music Finland' website as of March 2021, Segerstam had composed 342 Symphonies, the latest addition being "*Musical perseverences..." ("Marslander Mail...")* composed in 2020 <https://core.musicfinland.fi/works/symphony-no-342> [accessed March 2021]

[36] From the Abstract of Irina V. Koposova's '"Freely-Pulsating Composition" of Leif Segerstam as an Individual Aleatory Project', *Problemy Muzykalnio Nauki-Music Scholarship* 1 (2018), pp. 16–22.

[37] Bruce Duffie, 'Composer/Conductor Leif Segerstam: A Conversation with Bruce Duffie' in 'Bruce Duffie Interviews' (2009) <http://www.kcstudio.com/segerstam.html> [accessed 16 July 2019]

[38] Koposova 'Freely-Pulsating Composition'.

example, which are discussed shortly. As Segerstam explains:

> My scores have in-built conducting mechanisms. February [an eighteen-minute orchestral work composed in 1996] had six; the first was the percussion slapstick together with the concertmaster, and then everybody knew that now the piece started; let's play the first portion until letter A, where then the next trigger for everybody to recognize was sforzando in the double bass. And the double bass had to wait for everybody to finish, except those that didn't have a pause at the end of that portion of the music, and that was the pianists and some of the percussion.[39]

'Segerstam's music also attempts to release musicians into the present tense — what Segerstam calls the "now point" of listening to one another, reacting to what we are hearing around us', as Service describes it.[40] Segerstam describes the now point thus:

> Music is in time, but you shouldn't stop and find out because then you lose the time, because time doesn't exist and that is what we use to make a reportage of what happened. Then we stop the time and we measure things in time. Of course you have metronome markings, you have tempo markings, but music is a continuum where things move. The now point can be broader than just a very picky one. It can be something that already has a lot of tentacles to the coming time, or is dragging with itself flashbacks of the so-called past time![41]

Similar to aleatoric music in general and redolent of Cage's time-brackets but particularly the notion of time-as-flowing, all Segerstam's free-pulsation music has the capacity to generate performances that are never exactly alike, that can adjust themselves to what Segerstam describes as 'the now point of the real now, when the now is [here]'.[42]

In-built conducting mechanisms used as cues for blocks of material are clearly defined by Segerstam. What is not defined but is clear from examining free-pulsation orchestral scores, for example, on page one of Symphony No. 288 (2015), along with the video recorded performance of the same symphony, are the levels of internal synchronisation within and sometimes between sections of the orchestra.[43] For example, the aleatoric counterpoint notated in free-pulsation orchestral music scores exists primarily between orchestral sections:

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[39] Duffie, (2009). A PDF score of *February* (1996) may be viewed and downloaded at the 'Music Finland' website <https://core.musicfinland.fi/works/february> [accessed 19 July 2019]

[40] From an article by Tom Service, first published in *The Guardian* on Thursday 17 November 2011 <https://www.theguardian.com/music/tomserviceblog/2011/nov/17/leif-segerstam-prolific-finnish-composer> [accessed 16 July 2019]

[41] Duffie, (2009).

[42] Ibid.

[43] A downloadable score of Symphony No. 288 is available from the 'Music Finland' website <https://core.musicfinland.fi/works/symphony-no-288> [accessed 16 July 2019]. A video of Symphony No. 288 can be viewed on YouTube here: <https://www.youtube.com/watch?v=faMFoG314tc> [accessed 16 July 2019]

woodwind, trumpets, horns and strings in opposition but seldom within those instrumental families themselves where often, as in Symphony No. 288 for instance, the horns are written unison a4, the trumpets unison a3, and the woodwinds aligned vertically for rhythmic synchronisation with the strings rarely showing inter-sectional division and where pitch division does occur, it is frequently homophonic. This synchronisation is also evidenced in the performance video where at multiple points throughout the piece, the synchronisation of players is clearly seen with the section leader laying down the tempo and beat for the remaining section players as a localised conducting activity.[44] These synchronising actions within sections are apparent in all Segerstam's orchestral performance videos as well as implied within the homophonic organisation of notated materials within Segerstam's scores reviewed as part of this investigation.

The confinement of polytemporal interaction to predominantly sectional relationships restricts the potential for aleatoric counterpoint and polytemporal relational outcomes across and between all instruments of the orchestra. Such limiting of polymetric relationships affords a temporal and aural clarity to Segerstam's music that can make his orchestral compositions sound highly unified and very similar to one another as if each were part of a vast meta- symphonic compositional cycle that as the subtitle to Symphony No. 288 implies, is 'letting the FLOW go on'.[45]

The Polish composer, Lutosławski, creates fully notated orchestral works that are presented in score format and performed via parts but unlike Segerstam, does use a conductor to coordinate performances and manage synchronised sections of music as well as the aleatoric counterpoint generated by his compositional approach. Like Segerstam, Lutosławski restricts his aleatory to certain rhythmic freedoms while maintaining a firm hold over the pitch and harmonic materials. Such rhythmic and temporal invention can be seen, for example, in *Jeux Vénitiens* and the Second Symphony. In *Jeux Vénitiens*, 'Lutosławski prefers to juxtapose blocks in which time is exactly coordinated between instruments playing in the same tempo and meter and blocks consisting of a collective temporal 'ad libitum' in which pitch, dynamics and orchestration is prescribed but the synchronization between all the parts is not'.[46] The preface to

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[44] Examples of section leaders cueing remaining section players can be seen at time points: 0'59" (violoncellos); 1'06" (trumpets); 1'56" (violins); and 4'59" (trumpet 1 cueing the entire brass section) with more examples throughout the video of Symphony No. 288 <https://www.youtube.com/watch?v=faMFoG314tc> [accessed 16 July 2019]

[45] PDF of Symphony No. 288 from the 'Music Finland' website <https://core.musicfinland.fi/works/symphony-no-288> [accessed 16 July 2019]

[46] Mark Delaere, 'Tempo, Metre, Rhythm. Time in Twentieth-Century Music', in *Unfolding Time: Studies in Temporality in Twentieth-Century Music*, ed. by Darla Crispin (Leuven: Leuven University Press, 2017), e-book p. 38.

the score describes how this temporal ad libitum or 'time fields' as Delaere describes them, should be managed by the conductor:

> The ad libitum sections are not to be conducted. The beginning of each section is marked with an arrow which corresponds to the downbeat of the conductor. In the ad libitum sections all the rhythmic values are approximate. In consequence, the placing of the notes one above the other in the score does not necessarily mean that they are played simultaneously.[47]

These sections of temporal ad libitum are polymetric in nature in as much as each player is instructed to play as a soloist: 'Each musician should play his part with the same freedom as if he were playing it alone; the rhythmic values serve only as a guide', where the musicians are occupying their own temporal space, even if this independent temporal sense is only a slight deviation from the overall tempo range signified by the composer and where frequent cues to begin and start material given by the conductor limit and confine the scope of these individual temporal spaces so as to maintain the overall structure of the piece.[48]

Lutosławski's thirty-minute long Second Symphony again uses confined ad libitum aleatoric sections, where, in the first part of this two-section work called 'Hesitant', the material flows in a fragmentary progression and in the second section titled 'Direct', the fragments are brought together seamlessly to generate great forward momentum.[49] As with *Jeux Vénitiens*, the Second Symphony displays tight harmonic control with various degrees of rhythmic freedoms throughout manifest as substantial tracts of notation that are written without barlines and where vertically aligned notation in the score is not representative of synchronisation between the parts in rendition and where these sections are only apportioned by cues to start, stop or transition material as instructed by the conductor.

At various points and particularly at the end of ad libitum sections, players are required to repeat sections of their material until signalled to stop by the conductor as a device to transition or quickly move into the next section. These areas of repetition are indicated by wavy lines in the score and parts. From a practical perspective, such free repetition generates a collection-point, allowing all players to complete their ad libitum material, join the repeat sections at somewhat different entry-points and continue playing until the conductor indicates migration into the transitional material or following section as a unified instrumental whole.[50]

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[47] Ibid, p. 38.

[48] Cited from 'Order of Performance' section one, from the music score of Lutosławski's *Jeux Vénitiens*, Nr. 5012 (Celle, DE: Edition Moeck, 1962).

[49] Charles Bodman Rae, *The Music of Lutoslawski* 3rd edn (London: Faber and Faber, 1999), p. 102.

[50] Ibid, pp. 75–79.

The musical material rendered by individual players through this 'controlled aleatory technique [that] relies for its rhythmic sophistication on the complex combination of relatively simple individual parts', particularly articulated through the personal temporal spaces of *all* instrumentalists within the ad libitum passages, generates an aleatoric counterpoint of great complexity producing significantly denser polyphonic and temporal outcomes than those rendered through the more restricted aleatoric counterpoint resulting from the confined sectional relationships present in Segerstam's symphonies.[51] However, as a consequence of Lutosławski's penchant for pitch control, some ad libitum passages can become static owing to their reliance on a fixed harmonic complex even though this harmonic stasis may eventually modulate to different harmonic areas.[52]

As well as ad libitum writing, there is explicit polytempo throughout the first section of the Second Symphony, for example, between rehearsal points 1–2, showing simultaneous tempi of crochet = ca. 132, 176 and 105; between rehearsal points 4–5, showing simultaneous tempi of crochet = ca. 150 and 100; and simultaneous tempi between rehearsal points 21–22 with crochet = ca. 100 and 80. The section between rehearsal points 21–22, for example, also includes terms that affect the speed of individual player's delivery of material within their assigned notation-tempi such as 'poco lento' and 'lento' followed by 'vivace' and 'a tempo' to provide localised tempo fluctuations between instruments in addition to the tempo differentials between instrumental voices making the Second Symphony a polymetric work that uses polytempo as part of its managed, aleatoric rhythmic and temporal frameworks.[53]

Like *Jeux Vénitiens* and the Second Symphony, Boulez's orchestral work, *Rituel: In Memoriam Bruno Maderna* (1974–75) uses a score and parts and a conductor to govern the overall structure of the piece but also to cue free ametrical sections that involve loosely coordinated polymeter within the even-numbered sections of the composition. Similar to the Lutosławski pieces, the score of *Rituel* shows vertically aligned and somewhat unaligned instrumental lines that do not exactly represent or correspond to what will be heard in the rendition. This discrepancy between what is graphically fixed in the score and what is actually produced as sound is made clear in the performance instructions that preface the score where Boulez instructs the musicians to 'not attempt to synchronise with each other but continue to play, unconducted independently of the other groups at a specified tempo'.[54] Huscher writes:

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[51] Ibid, p. 77.

[52] Ibid. p. 84.

[53] See Lutosławski, Second Symphony, (London: Chester Music/PWM, 1967) pp. 1–9. An online score preview is available from the publisher at <http://www.musicsalesclassical.com/composer/work/7710> [accessed 18 July 2019]

[54] Rundall, p. 48. Rundall also translates and quotes the performance instruction located in the score from the

> In the even-numbered sections, however, the conductor only cues each group of instruments to begin playing; the groups then continue independently, so that each appears to be going its own way. (The percussionist attached to every group maintains the tempo for his or her players, but no one coordinates all the performers.) There is freedom and flexibility in these sections—the exact course of the music will be slightly different in each performance.[55]

The orchestra is divided into eight groups that are antiphonally placed as far from the conductor as possible. The work itself has fifteen alternating sections that are divided into two types of material: sustained chord-like blocks of sound where instrumental group entries are directed by the conductor and more fluid, rapid passages of unconducted music. As Huscher explains:

> Seven odd-numbered and seven even-numbered sections alternate before the large concluding paragraph; there are seven ensembles plus the brass group (of fourteen, or two times seven); seven gongs and seven tam-tams (positioned at the rear center of the stage) play an important role; a single seven-note chord permeates the score from the very opening. This rigidly schematic aspect of Rituel, however, is offset and complemented by the fluidity and freedom of the unconducted passages, and by the sheer sonorous beauty and eloquence of the music.[56]

Rundall asserts that 'since the material written for each instrumental group is strongly metrical [with clearly audible beat levels] and since the instrumental groups perform in a temporally uncoordinated manner, there is a strong likelihood that any given performance would sound polymetrical'.[57] As with all loosely coordinated, unconducted orchestral music where performers are instructed to play in their own temporal space, to some extent at least, it is impossible to predict the exact configuration or nature of polymetric outcomes during a performance. With the percussionists directing somewhat independent tempi during the unconducted sections, it is likely outcomes will be polytemporal.

Independent tempi and polytactic invention along with the simultaneous combination of heterogeneous musical materials were already part of the compositional practice of Ives at the start of the twentieth century. Stravinsky commented that Ives 'set about devouring the

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original French found in Boulez, *Rituel: In Memoriam Bruno Maderna*, (London: Universal Edition, 1975).

[55] Phillip Huscher, 'Programme Notes, Boulez, *Rituel: In memoriam Bruno Maderna*', Chicago Symphony Orchestra Website <https://cso.org/uploadedFiles/1_Tickets_and_Events/Program_Notes/ProgramNotes_Boulez_Rituel.pdf > [accessed 5 June 2021]

[56] Phillip Huscher, 'Programme Notes, Boulez, *Rituel: In memoriam Bruno Maderna*', Chicago Symphony Orchestra Website <https://cso.org/uploadedFiles/1_Tickets_and_Events/Program_Notes/ProgramNotes_Boulez_Rituel.pdf > [accessed 5 June 2021]

[57] Rundall, p. 48.

contemporary cake before anyone else had even found a seat at the same table'.[58] Part of that 'cake' involved Ives's compositional experimentation with the concept of multidimensional and non-linear musical time that according to Delaere, is one of the most significant developments in composition since the 1900s, as he explains:

> By multidimensional and non-linear musical time I mean the superposition of several time layers, each moving at its own speed and more or less directionless. Beautiful examples are to be found in American art music from the beginning of the twentieth century onwards, especially in music by Charles Ives. The best known instances in Ives's music are, of course, *The Unanswered Question* [1908], in which three layers of texture, pitch collections and time are superimposed, and the Symphony no. 4 [composed 1910 to the mid-1920s], in which sections in polytempo call for two conductors.[59]

2.4 Ives, Stockhausen, Ferneyhough and Brant

Ives used scores, parts and conductors to produce temporal results that range from highly determinate to somewhat indeterminate as in *The Unanswered Question*, where Ives's foreword says of the trumpet part, '[t]his part need not be played in the exact time position indicated' and uses phrases that imply an indeterminacy of instrumental entry, for example, '[t]he flutes will end their part approximately near the position indicated in the string score; but in any case, "the Last Question" should not be played by the trumpet until "The Silences" of the strings in the distance have been heard for a measure or two'.[60]

In Symphony no. 4, simultaneous combinations of polytactic and polytemporal musical layering proliferate, notably in movement IV, the last movement of the symphony, where the percussion section maintains an independent though proportionally related tempo from the rest of the orchestra throughout the movement. Polytempic and polytactic relationships also abound throughout the first movement of the symphony, as Brooks describes:

> The opening is in 6/4, but the meter can barely be sensed because of the ametric rhythms employed; at [rehearsal mark] 2, the meter changes to 6/8 (3/4), but other overlaid metric patterns continue to obscure it. […] Moreover, the metric ambiguity is accomplished in three distinct ways […]. The beginning is characterized by what is in effect metric "chromaticism"; although there is a single referential pulse and meter, the actual rhythms used are not directly related to it. After 2, the rhythms do relate clearly to metric patterns, but these are so diverse that not even the notated 6/8 dominates the texture. At the end a single

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[58] Igor Stravinsky and Robert Craft, *Retrospectives and Conclusions* (New York, NY: Alfred Knopf: 1969), p. 30.

[59] Delaere, 'Tempo, Metre, Rhythm. Time in Twentieth-Century Music', in *Unfolding Time*, pp. 13–43 (p. 28).

[60] Quoted from the foreword of Ives's, *The Unanswered Question: for chamber orchestra* (New York, NY: Southern Music Publishing Company, 1953).

> triple pulse is extended and compounded in a changing and unpredictable fashion.[61]

Brooks continues:

> Often a collection of quite distinct metric patterns will share a common underlying pulse, while others proceed independently. The pulse of the distant choir, for instance, is virtually unrelated to the other rhythmic activities throughout most of the movement. Then again, at rehearsal 7, the 3/ 4 in the upper strings and the 7/16 in the distant viola share a common quarternote pulse; the trumpet and chorus employ the same eighth-note but compound it differently; while the flute and the bass of the piano proceed at quite a different pace.[62]

Ives did not want his music to be a fixed, static entity or his compositions to represent completely finalised creative processes. He wanted the music's diverse array of components — eclecticism, quotation, acoustic and temporal experimentation, etc., — and crucially the relationships between these elements to generate musical networks rather than obvious musical arrows that acted as aural 'tour guides'. Ives instead invited the listener to privilege certain musical aspects and navigate individual aural pathways through the compositions and their often heterogeneous components, resulting in significantly different listening experiences upon each rendition.[63] It is this experimentation with multidimensional and non-linear musical time and the invitation for listeners to substantially change their perceptions of a given composition that relates Ives's pioneering polytactic and polytemporal compositions to works highlighted in this literature review and positions his work and thinking as a significant progenitor of much that was to follow in the development of polymetric composition.
Around forty years after the composition of Ives's Symphony no. 4, Stockhausen's composition, *Gruppen für drei Orchester*, apportioned one-hundred and nine orchestral players into 'three nearly equally scored orchestras [that were] placed around the audience in the form of a horseshoe, each of which [was] directed by its own conductor [to] enable a synchronous realization of up to three different temporal layers running at different speeds'.[64]

Decroupet explains that this polytempic synchronicity was the realisation of Stockhausen's theory of musical time, formulated around 1955 and often discussed in relation to the chromatic scale of tempi that are significant in other Stockhausen pieces conceived around

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[61] William Brooks, 'Unity and Diversity in Charles Ives's Fourth Symphony', *Anuario Interamericano de Investigacion Musical*, 10 (1974), pp. 5–49, (pp. 12–13).

[62] Ibid, p. 26.

[63] Ibid, p. 6.

[64] Imke Misch, Frank Hentschel and Jerome Kohl, 'On the Serial Shaping of Stockhausen's Gruppen für drei Orchester', *Perspectives of New Music*, 36.1 (1998), pp. 143–187 (p. 150).

this period such as *Zeitmaße*, for example. To expand serial thinking into tempi, Stockhausen first considered a series of pitches in terms of proportions (intervals) rather than a sequence of objects. These proportions, in turn, required an alternative consideration to establish durational chromaticism where the series proportions would dictate pitch durational values. Stockhausen extended the use of proportions based, for example, on those found in the natural harmonic series to generate a range of tempi that were produced using serial processes that further conditioned pitches governed by durational chromaticism to shape time on a structural level including the proportionally governed meter of bars and the number of bars of similar meter in combination along with their proportionally based tempi and the ratio structures that governed their polytemporal overlaps and layering.

Stockhausen realised that for these tempo relations to be perceived and effectively delivered in performance there had to be periodicity expressed through metric relations where the tempo and meter were established — repeated — at some length, a radical consideration at a time when repetition of any kind was considered problematic within serial procedures. It is this metric and tempo relationship that Stockhausen brought together in *Gruppen*, connecting tempi with one-hundred and forty-five group structures, each with its own tempo, meter, duration, pitch range and timbral construction so that through periodicity, tempi could be established, recognised and contrasted between performing groups with all elements generated under serial organisation.[65] As such, *Gruppen* belongs among the first post-1950 pieces in which physical, surrounding space was included as a structural dimension:

> Gruppen is based on the decisive idea of integrating the musical space-time dimensions in the sense of a principle which brings about coherence and has an effective serial control, not only on the parametrical, but also on the larger formal level. Consequently, the various spatial dispositions of the sounding bodies enable first and foremost a synchronous realization of up to three musical processes, each of which elapses at its own speed.[66]

It is the synchronous unfolding of the polytemporal materials distributed among the groups and three conducted orchestras that facilitates the highly controlled, determinate, polytemporal outcomes of the piece as it moves through its variously superimposed and overlapping temporal frameworks using tempi ranging from 60 BPM through to 120 BPM. This 60:120 (1:2) ratio was subdivided logarithmically to generate a cycle of eleven approximately equal-feeling duration-intervals that resulted in the twelve tempi values known as chromatic

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[65] Pascal Decroupet, 'Rhythms – Durations – Rhythmic Cells – Groups. Concepts of Microlevel Time-Organisation in Serial Music and their Consequences on Shaping Time on Higher Structural Levels', in *Unfolding Time*, pp. 69–93, p. 82 and pp. 170–171.
[66] Imke Misch et al., p. 144.

tempi used in the score where one tempo is associated with one particular pitch. These tempi are 60, 63.5, 67, 71, 75.5, 80, 85, 90, 95, 101, 107, 113.5, and where 120 BPM is double the initial value of 60 BPM. There are also several other augmented tempi values appearing in the score where notational values have been halved, for example, from crochet beats per minute to quaver beats per minute or quaver to semiquaver beats per minute but where the proportion between the units has been maintained as with crochet = 63.5 doubled to quaver = 127 BPM and 75.5 crochet BPM doubled to 151 quaver BPM.[67]

Despite the pitch, rhythmic and temporal complexities of the work, Stockhausen manages the polytemporal material relationships generated through the simultaneous temporal layering of the orchestras in such a way as to keep the distinctiveness of his material and textures clearly audible at all times. There are multiple instances of the three orchestras in polytempic relationships, for example, where the first large tempo breakdown occurs at score number twenty-eight with the tempi 113.5 and 90 BPM running simultaneously and at score number forty-two, where there are three independent simultaneous tempi comprising 107, 85 and 113.5 BPM, for example, but there are also many examples where only one orchestral group is performing at a time or orchestras share the same tempo as is the case in much of the music preceding score number forty-eight.[68] Shared tempo is also apparent in the inserts or 'Einschub' where Stockhausen added three longer sections of music onto the original four sections in which he almost completely relinquished serially controlled predeterminations, structuring the music in such a way that the three orchestras combine into a single sounding body.[69]

However, producing the required exact synchronisation between the three orchestral groups in performance was no easy matter, as the conductor Norman Del Mar recounts:

> The reports of the separate entries of the orchestras after so many seconds and in different tempi proved to be nothing but the truth. As a result, the barlines rarely coincided, though everything was laid out and calculated with the neatness and precision of an architect's blueprint. All the periodical pauses between entries in any one orchestra were given to the nearest half-second [and] tempi calculated by means of inter-related ratios to the nearest half degree. […] When the combined rehearsals came a new problem arose. This was the actual difficulty of recognizing the sounds made by orchestras other than one's own and reconciling them with the hieroglyphics on the score before one. In such wholly athematic music consisting almost entirely of pops and gurgles interspersed with spasms of veritable pandemonium it was all too easy to look down at the score after an extended period of watching Carewe's beat and find there

[67] Ibid, pp. 152–156.
[68] Thoegersen, pp. 110–111.
[69] Imke Misch et al., p. 145.

> nothing that could be immediately associated with what one's ears were receiving.[70]

More recently, in June 2018, Duncan Ward, one of a team of three conducting *Gruppen* with the London Symphony Orchestra, told Jo Johnson in an interview:

> The coordination between the three conductors is probably the most distinctive and challenging aspect to this piece. Often the three orchestras are playing in completely different (and constantly fluctuating) time signatures and tempi, but at all times whilst conducting your own part you are having to be visually aware and reacting to what the others are doing in order to keep it all in sync. It's chamber music for conductors I suppose. Perhaps the strangest feeling in conducting the piece is not being quite as engaged with the musicians of your orchestra as you would normally be. In Gruppen 97% of your brain cells are tied up with the visual coordination between the conductors, and the constant micro-adjustments required in navigating your own orchestra's path to ensure a successful performance.[71]

Ward continues:

> The radically different aspect of preparation necessary for Gruppen, however, is that the conductors need to practice by themselves without any other musicians present. Three conductors sat in a room frantically waving their hands at each other in silence is a strange sight indeed, but absolutely crucial to the success of this piece. Stockhausen recommends six such sessions of two hours each![72]

Although attitudes to and familiarity with *Gruppen* have changed across the intervening decades since Del Mar's conducting account, it is clear that the challenges in 'jointly steering the unwieldy ship that is the three orchestras combined' remain.[73]

In comparison to the scoring of *Gruppen*, the notational density of Ferneyhough's *Firecycle Beta: Symphonic Torso for Two Pianos and Orchestra with Five Conductors* indicates this antiphonal work prioritises sonic and temporal density over perceptual clarity. As Ferneyhough writes in the foreword to *Firecycle*:

> The title of the composition refers to the Heraclitean theory concerning the periodic destruction and reconstitution of the universe in and through fire (symbol of eternal flux as well as of purity). The form corresponds analogically to this principle in its employment of large-scale cycles of material and method which have a common origin in an original page since deliberately destroyed. These various types of cycle

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[70] Norman Del Mar, 'On Co-Conducting Stockhausen's "Gruppen"', *Tempo*, 59 (1961), pp. 15–23 (pp. 15, 21).

[71] Reference taken from the website 'London Symphony Orchestra'. Search under 'Conductor Duncan Ward on Stockhausen's *Gruppen'*. <https://lso.co.uk/more/blog/977-conductor-duncan-ward-on-stockhausen-s-gruppen.html> [accessed 30 May 2021]

[72] Ibid.

[73] Ibid.

> interlock and overlap on many levels simultaneously, thus generating an overall structure of high density and relative perceptual unpredictability.[74]

Ferneyhough continues: 'In effect, *Firecycle* is a double piano concerto, although one in which the pianos are less soloists in the conventional sense than emblems of the antiphonal concept'.[75] 'The orchestra is divided up into four basic sub-groups, two of strings and two of heterogeneous groupings of various instruments centred on two pianos'.[76] The groups are antiphonally placed with all conductors having a line of sight with their specific groups of players as well as each other in accordance with the composer's instructions in the score.[77] According to Fitch, the influence of Stockhausen's *Gruppen* for three antiphonal orchestras 'which emphasises orchestral colour in the concept of "groups" is palpable throughout the work. Ferneyhough contrasts quasi-pointillistic local textures (such as the violas, *soli motto secco*) with the "mass effect" of the strings notably when multiple glissandi appear'.[78] Again, like *Gruppen*, *Firecycle* uses groups of instruments to articulate specific materials wherein 'Ferneyhough conceptualises horizontal and vertical compartmentalisation in the piece: the instrumentation and naming of sections according to their inherent procedures represent the horizontal dimension, and the vertical refers to harmonic 'classes' and the antiphonal exchanges between the two orchestras'.[79]

From the polymetric perspective, *Firecycle* features sections and passages of tempo unity between all groups, for example, throughout 'Alleluiah IIa' and 'Alleluiah IIb'.97 However, as Fitch observes, the score also includes

> indeterminate notation in many sections, such as the appropriately titled Sequence (assuming that the 'class of procedure' indicates a sequence of self-contained materials separated by pauses ad libitum at the conductors' discretion). 'Alleluia IVb' and the 'Amen' both include cells to be repeated numerous times, in an order determined (in the case of the former) by performers and up to five conductors (one principal conductor, one for each orchestra, and two performers taking on a conducting role as necessary to co-ordinate groups).[80]

The ad libitum sections (the principles of which are already familiar from the aforementioned works of Lutosławski and Boulez) as indicated in 'Sequence IIa' of *Firecycle*

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[74] Foreword to the score, Ferneyhough, *Firecycle Beta: Symphonic Torso for Two Pianos and Orchestra with Five Conductors* (London: Ricordi, 1980).

[75] Lois Fitch, *Brian Ferneyhough* (Bristol: Intellect, 2013), p. 305.

[76] Foreword to the score 'Concerning Instruments', Ferneyhough, *Firecycle Beta.*

[77] Foreword to the score 'Layout of Orchestra', Ferneyhough, *Firecycle Beta*.

[78] Fitch, *Brian Ferneyhough*, p. 306.

[79] Ibid, p. 306.

[80] Fitch, *Brian Ferneyhough*, p. 306.

(pages 25–29 of the score) show a collection of tempi indications, as on page 25 of the score, applying to various instrumental groups that range from quaver = 50, 56 and 60 BPM or increase and decrease in tempo from, for instance, 50 to 55 to 46; 40 to 52 to 56; and 74 to 36 BPM, initiated by conductors or performers to either overlap or run simultaneously, generating dense, complex polytemporal relationships throughout and where a degree of colour, pitch and structural clarity is facilitated through the antiphonal organisation of the players and their respective compositional materials across the orchestra and the performance space.[81]

Antiphonal distribution was also clearly a primary concern for American composer Henry Brant (1913–2008) whose, as of 1992, seventy-six spatial pieces and fifty-seven nonspatial compositions are listed in the Carl Fischer rental catalogue.[82] For example, Brant's first spatial orchestral piece, *Antiphony 1*, written for orchestra with optional solo voices or chorus, uses five spatially placed groups and five conductors to manage polytemporality, as Harley explains:

> The spatial separation of instrumental groups highlights the contrasts of timbre, meter, key, texture, and motivic content between the five musical streams. The distant groups enter on cues and proceed at their own speed without a strict relationship to the main, more continuous layer of the music. The entries of these groups usually overlap in time: one group is still playing while another begins at a different point in space.[83]

The composition of *Antiphony 1* in 1953 predates *Gruppen* by several years. Harley asserts that '[Brant's] role in the development of "spatial music" in which sound placement and movement have a structural and aesthetic function, has been overshadowed by that of the European avant-garde, especially Karlheinz Stockhausen'.[84]

Unlike *Gruppen*, the complexity of Brant's music does not derive from complex compositional procedures but through the juxtaposition of often heterogeneous, purposefully unrelated and often simple materials that produce complex results when combined in performance, an approach prefigured in the music of Ives where heterogeneous rhythmic, melodic, pitch and temporal materials are simultaneously combined to create complex polyphony and where some of these materials are spatially distributed, as in, for example, *The Unanswered Question* and The Fourth Symphony.[85] Brant's approach to spatial composition

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[81] Ferneyhough, *Firecycle Beta* 'Sequence IIa' pp. 25–31, 'Alleluiah IVb' pp. 35–36 and 'Amen IIa', pp. 36–39 all shows ad libitum actions with polytempic relationships that generate indeterminate outcomes.

[82] Maria, Anna, Harley, 'An American in Space: Henry Brant's "Spatial Music"', *American Music* 15.1 (1997), 70–92 (p. 70).

[83] Ibid, p. 71

[84] Ibid, p. 70.

[85] Ibid, p. 73

finds an analogy in the work of others, too, for example, in the controlled aleatoricism introduced by Lutosławski in *Jeux Vénitiens*. Harley writes:

[I]n contrast to Lutosławski's work, where coordinated and uncoordinated passages are presented sequentially, Brant's *Millennium II* [(1954) for large wind ensemble, percussion and soprano] makes simultaneous use of both types of rhythmic organization. The parts for instruments on stage are coordinated; in the hall [where they flank the audience, trombones on one side, trumpets the other] they remain uncoordinated [except from section 'V' onwards, where all instruments are coordinated by the conductor]. Brant praises the absence of exact rhythmic correspondence that "permits" simultaneous contrasted meters and tempi, easily controlled either by assistant conductors, soloists, or section leaders. Extreme overall rhythmic intricacy and a sense of great rhythmic freedom are attainable by this kind of procedure; at the same time, maximum control within well-defined limits, as well as ease and naturalness in playing, is retained.[86]

Brant's many spatial compositions use notation-tempi among differentiated instrumental groups with conductors and assistant conductors to manage polytemporal organisation across sometimes considerable spatial distribution and where this spatial separation ultimately enhances the perception of frequently heterogeneous elements such as texture, tempo, meter, polyphony and contrapuntal activity'.[87]

2.5 Davies, Carter and Ferneyhough

The final collection of pieces in this review are examples of conducted polytactic works with determinate performance outcomes. They include Davies's *Prolation for Orchestra* and Carter's Variations for Orchestra. Although polymetric, these polytactic works sit outside Rundall's definition of polytemporal music and thereby fall somewhat beyond the polytemporal focus of this investigation. However, their inclusion is useful to highlight a frequently used species of polymeter that relies on rhythmic notational modifications rather than a notation-tempi modification to synchronise various polymetric structures and their associated pulse speeds into a polytactic whole. Also included is Ferneyhough's orchestral piece, *La Terre est un Homme*, not because of any overt polytactic structural elements as in *Prolation* and Concerto for Orchestra, but as an extreme example of conducted, determinate, synchronised, hyper-dense polyphony rendered from a score and parts that are comprised of equally dense and complex

[86] Ibid, p. 79.

[87] Thoegersen, p. 110.

rhythmic notation.

Although a forward-looking composition, *Prolation for Orchestra*, Davies's first orchestral work, directly links the composer's compositional practice to Medieval compositional procedures where '[p]rolation governed the relative proportion of minim and semibreve in the medieval rhythmic modal system. [In this work], prolation is extended to govern greater and smaller proportions — from periods covering hundreds of bars to the smallest 'irrational' groups'.[88] This 'rhythmic engineering of medieval music, where in 'major prolation' there were three minims to the semibreve and in 'minor prolation', two, is superseded by more complex ratios 'where the durations of whole sections and of tiny details are all geared to a set of five numbers (10:4:7:6:5). The abstractness of the [resultant] design, however, is countered by the vital energy of the music, which sweeps through all the sections and subsections to create a single symphonic movement' where layers of materials with independent pulse speeds move simultaneously forward.[89]

Different pulse speeds also proliferate the orchestral compositions of Carter where slower streams of regular pulses serve as structural foundations onto which faster and often conflicting activity including changing meters and pitch content, for instance, are superimposed upon the surface and in tension with it and where 'it is the continuous interaction between [these] different structural levels that yields a dynamic musical form.[90] For example, '[the] Concerto for Orchestra can be understood as a gigantic construction in which several temporal layers are combined to create a unique form and a clear dramatic discourse' where 'polyrhythms primarily [serve] as a means to divide the duration of the entire composition into four movements with an introduction and a coda' and where '[t]ransitions between consecutive movements occur at (near-)coincident points between these movements' and their four distinct pulse layers.[91] Coulembier elaborates:

> [The relationship between these simultaneous pulse layers] results in a very complex network of thematic/timbral/intervallic relations. In addition to the single, overarching structural polyrhythm, there are several other polyrhythms at different temporal levels, ranging from local polyrhythms (combinations of different divisions of the beat) to what Carter called short waves. These short waves can be divisions of the time-span between two or more structural pulses (as in the first and second movements) or can start in

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[88] Notes are taken from an online commentary for *Prolation for Orchestra* in 'Schott Music' (Schott: 2019) <https://en.schott-music.com/shop/prolation-no151309.html> [accessed 23 September 2019]

[89] Notes are taken from an online commentary for *Prolation* in 'Max Opus' (Max Opus: 2019) <https://petermaxwelldavies/?works_catalogue_entr=prolation-8> [accessed 23 September 2019]

[90] Klaas Coulembier, 'Static Structure, Dynamic Form: An Analysis of Elliott Carter's Concerto for Orchestra', *Perspectives of New Music* 54.1 (2016), 97–136 (p. 129).

[91] Ibid, p.127.

> medias res and lead to a particular end point (as in the coda). In some instances, the entire orchestra is engaged in the articulation of polyrhythmic superpositions to prepare or emphasize a specific moment in the discourse of the movement (e.g., at the beginning and end of the first movement, or the passage from basic pulse 1180 onwards in the coda).[92]

As in Davies's *Prolation*, proportion lies at the heart of the Concerto for Orchestra. For example, 'at the local polyrhythmic level, there are many superpositions of eighth note triplets, sixteenth notes, and sixteenth-note quintuplets (3:4:5). In addition, 'the main rhythmic character of the piano part is based on septuplets, regardless of the absolute tempo or speed.
The fundamental proportion of 10:9:8:7 is omnipresent at all levels of the composition'. These independent yet related proportion-generated pulse layers are articulated by '[t]he notated time signatures and tempi [that are] the framework for specific pulse speeds, rhythms, and polyrhythms. Changes in tempo and/or meter can mark transitions from one formal segment to another'.[93]

Powell comments that '[l]arge ensemble polyphony was worked out by Carter in three works: the Double Concerto, the Concerto for Orchestra, and the *Symphony of Three Orchestras*'. He goes on to assert that '[a]ll are in certain ways an answer, however indirect, to the spatialised polyphony of Stockhausen's earlier *Gruppen* and *Carré*, as also to the simultaneous plurality of tempi in *Zeitmaße*'.[94]

Although not a spatialised polyphony as in *Gruppen*, nor a polytemporal work, Ferneyhough's first orchestral piece, *La Terre est un Homme*, is included here as an example of extreme, synchronised, dense polyphony achieved through the sheer mass of independent parts to an extent not found in any of the polytemporal or polytactic pieces examined in this review where polyphony is engendered through the simultaneous sounding of material running within differentiated temporal strata that themselves are constructed from multiple simultaneous pulse-streams. The fifteen-minute *La Terre est un Homme,* 'is scored for an orchestra of eighty-eight players, each of whom is at times a soloist who has a part as demanding as one of the composer's solo pieces'.[95] According to Ferneyhough, punctuating this polyphonic fabric are

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[92] Ibid, p. 128.
[93] Ibid, p. 129.

[94] Larson Powell, 'The Character of Polyphony: Elliott Carter's Concerto for Orchestra', in *Polyphony & Complexity: New Music and Aesthetics in the 21st Century*, ed. by Mahnkopf, Claus-Steffen, Frank Cox and Wolfram Schurig (Hofheim: Wolke, 2002), pp. 11–37 (p. 12).

[95] Paul Griffiths, *Brian Ferneyhough: La Terra est un Homme* (London: NMC Recordings, 2018) PDF of CD Booklet Notes NMC D231 Ferneyhough La Terra est un Homme (booklet) downloadable at <https://www.nmcrec.co.uk/recording/la-terra-est-un-homme> [accessed 23 September 2019] p. 9. In disagreement with Griffith's instrumentation total, this author's calculation finds the required instrumentation as specified in the score totals 89-players. There is also a possible extension of up to 6 additional string players making a maximum total of 95 players.

'seven sections, every other one reflecting on the one before, except that the seventh was never composed, leaving the last bar of the sixth, for percussion with piano and harps, as conclusion'.[96]

Fitch, on the other hand, refers to the piece being 'in three parts (the second and third parts beginning at letters L and Z respectively)', wherein:

> [A] basic premise is the accretion of simultaneous variation phases whose overlapping generates an increasingly complex 'super polyphony' in which instrumental groups, pursuing particular rhythmic, articulation and pitch patterns, act as 'überparametrics' [overarching or governing parametrics]. Instrumental layering (principally wind and strings) is clearly distinguishable to begin with but less so in the middle of the piece (around page 24 of the score), before moving apart again into highly coloristic groups for the final part.[97]

In either case, the presence of super polyphony throughout, as a sonic manifestation in performance or as signified in score notation, is undeniable (Powell writes how Mahnkopf describes hearing *La Terra est un Homme* with its 'fiercely dense polyphony of up to forty- two voices at one point').116 As Cummings observes: 'the score is a four-foot-high marvel to behold, and while every page is caked in the most incredible testament to Ferneyhough's invention run riot, [it is] just as much an apogee of penmanship.[98] According to Griffiths, this super polyphony and maximal 'density' is present from the composition's outset from where the work is immediately in crisis, and this state is perpetuated, even through sequences in which there is less going on. In how it relentlessly renews its own turbulence, and in how we are bound to interpret this turbulence as the result of the compositional maneuvers undisclosed, the music is at once magnificent and disturbing.[99]

Cummings again remarks that it is the 'instruments combining to form what the composer has called "life forms in permanent movement and realignment", characterised by techniques and behaviours that are often unique to that entity' that creates an intensely organic composition, where 'trying to glimpse the details of these forms within such a seething sonic behemoth may seem futile, particularly as the orchestra feels so entirely integrated, inextricably linked and united towards a common action'. Although *La Terre est un Homme* is certainly monolithic, according to Cummings, it is no monolith: 'simply to glaze one's ears and follow

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[96] Ibid, p. 9.

[97] Fitch, *Brian Ferneyhough*, p. 213.

[98] An online article by Simon Cummings, 'Ferneyhough Week–La Terre est un Homme' (5 against 4: 2013) <http://5against4.com/2013/01/14/ferneyhough-week-la-terre-est-un-homme/> [accessed 31 May 2021]

[99] Paul Griffiths, *Brian Ferneyhough: La Terra est un Homme*, p. 10.

the generalised contours of its surface would be to miss the astonishing wealth of detail in [its] deeper musical fabric'.[100] Despite these relentlessly extreme levels of polyphonic density, Ferneyhough unsurprisingly recommends that a proper performance of *La Terre est un Homme* is one that gives its distinct strata or layers the most independence.[101]

Part Two

2.6 Czernowin, Nancarrow (Murcott) and Johnson

Beginning with recent polytemporal compositions that incorporate conducted temporally independent groups, Chaya Czernowin's *Slow summer Stay III (Upstream)* (2012) is for an ensemble of sixteen players divided into two groups of eight players each. Czernowin says that '[t]wo conductors are needed because the groups are temporally independent, except for a unison tutti in the middle and the "crossing points," which are cued by both conductors'.[102]

Czernowin says of her composition:

> My pieces *Streams* and *Lakes* are a part of a series of 'sister pieces' called *Slow Summer Stay*. Both are written for the same mixed octet and use mostly the same material, which is all about movement (Streams) or stillness (Lakes) in and out the passage of time. The materials are organized so differently that they shift their meaning in this sense when they move from *Lakes* to *Streams*. The culmination of the series is in the piece *Upstream*. This is a piece for two octets where *Lakes* and *Streams* are placed over each other with some changes. The simultaneous / non simultaneous presentation and cueing of the two pieces creates a loose palindromic cannon.[103]

Throughout its fourteen-minute duration, all rhythmic, pitch and expressive matter are determined through notation and presented within a conventional score format that uses related instrumental parts in performance. The temporal operation of the piece follows the tradition of organising polytemporal performance using conductors assigned to various temporally independent but coordinated ensemble groups discussed previously in the earlier works of Ives and Stockhausen, for example, though no explanation of how the two conductors synchronise

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[100] Cummings, 'Ferneyhough Week–La Terre est un Homme'

[101] Powell, 'The Experience of Complexity', p. 3.

[102] From the Library of Congress Concert Series 2012-2013 online PDF programme notes <https://blogs.loc.gov/music/files/2015/05/LOC-1213-Chaya-Czernowin-Slow-Summer-Stay-II-Lakes.pdf> [accessed 12 February 2022]

[103] Notes are taken from an online commentary for *Slow Summer Stay* in 'Schott Music' (Schott: 2022) <https://en.schott-music.com/shop/slow-summer-stay-no276606.html> [accessed 12 February 2022]

their timelines were given in the score or performance notes.

A novel technological solution to synchronising two conductors so they may simultaneously conduct temporally independent ensemble groups was seen in the London Sinfonietta's April 2021 concert at the Queen Elizabeth Hall, London**,** in which Dominic Murcott's arrangement of Conlon Nancarrow's *Player Piano Study no. 21 (Canon X)* for the London Sinfonietta and player piano was performed. The critic Arthur Keegan-Bole explains:

> The piece is predicated simply on an upper voice beginning very fast and slowing down, and a lower voice beginning slowly and speeding up so much that the final 12 seconds of music contain no fewer than 1,028 notes. For an ensemble to tackle two simultaneously occurring tempi is extremely difficult, but the solution for this arrangement worked brilliantly. Two Baldur Brönnimanns, one conducting the upper voice, the other the lower, appeared in a pre-recorded video projected for all to see. Apart from this making the players able to follow their scores, this was visually stunning and neatly outlined this simple musical process that produces this extraordinary effect.[104]

The player piano, two conductor videos and in relation to these, the two live ensembles, would need sophisticated levels of synchronisation for this performance to operate as intended. It is the level of technology supporting synchronisation between these elements and what is determined in notation that enable determinate structural outcomes in performance and make the composition's polytemporal intentions clearly audible and feasible to deliver.

Not using 'video conductors' or several 'live' conductors, Evan Johnson's 2013-14 composition, *die bewegung der auger* for nine-players uses one conductor to manage a range of simultaneous polytemporal streams. This is an ambitious undertaking for any conductor. However, in his notes for rehearsal and performance, Johnson explains that 'in general, the work is conceived so as to minimise the *necessary* role of the conductor', with 'smaller subgroups linked by tempo and meter in Sections I and II [having] only occasional instances of cross-subgroup simultaneity or reference'. To emphasise the point, Johnson states that 'the first three sections (at least) are in principle performable without a conductor at all'. This premise is based upon the ability of the musicians themselves to deduce their specific tempo in relation to a tempo established by one of the subgroups, presumably under the guidance of the conductor. Nevertheless, and somewhat contradicting this 'in principle', claim, Johnson goes on to say, 'a good deal of time and energy should be allowed as well [by the conductor] for more

[104] Cited from an April 2012 *Backtrack* online article 'London Sinfonietta Perform Conlon Nancarrow' by Arthur Keegan-Bole <https://bachtrack.com/review-london-sinfonietta-nancarrow-southbank> [accessed February 2022]

"horizontal" rehearsal process of collaborative work within subgroups on issues of coordination, balance, and gestural unanimity.

Johnson summarises the role of the conductor in this composition thus:

> Aside from ensuring overall coordination and (more actively) helping to maintain overall dynamic balance […], the conductor's role is left relatively open. He or she may, for instance, choose to lead one "referential" subgroup as a stable reference point for others; restrict his or her activities to cuing entrances and simultaneous events across subgroups; or even passively "supervise."[105]

Responsibility for accurate temporal differentiation is distributed between the conductor and players to varying degrees throughout the piece. If players and conductor are able to operate at high levels of fidelity within the established temporal framework, performance results will sound polytemporal and present a high degree of relationship between sonic realisation and what is determined in the score through notation.

2.7 Kirk, McGowan and Fein

Dispensing with the use of conductors altogether, Joel Kirk's composition, *[internal resistance to flow is named viscosity]* (2017) for baritone voice, trumpet in C, tenor trombone and bass clarinet in B♭ is a polytemporal work where all four performers move at different speeds to one another through the work's eleven-minute duration. Temporal organisation is managed through individual click-tracks. Click-tracks are synchronised through software such as Logic Pro, Reaper or Ableton, etc., and routed through a separate output to each player using extension cables as necessary. Players receive their click-track audio through headphones and will hear the click alternating between high and low tones marking each bar. Audio impulses are indicated in red in the score and part notation and are used as the basis for further pulse subdivision as necessary by the players.[106]

In the performance instructions to the score, Kirk tells us that 'to maintain absolute score-accuracy, some alterations have been made to the standard notation in order to remove extra space that would usually be required by time signatures, accidentals and extended techniques', assumedly so that graphic proportional relationships can be maintained between all

[105] Cited from the performance notes viewed in a PDF score of *die bewegung Der auger* downloadable from <http://www.mediafire.com/file/7fzfqecwjbqdvbj/die_bewegung_der_augen_%255B2014_version%255D.pdf/file> [accessed 11 February 2022]

[106] Notes taken from the performance instructions to the score. An audio recording of the composition and downloadable PDF of the score are available from the composer's website, 'Joel Kirk Composer' <https://www.joelkirkcomposer.com/internal-resistance-to-flow> [access 10 February 2022]

four voices on the page.[107] He also explains that he has used grace-notes to express notation where his generative processes create rhythms that are impossible to play or ridiculously complex to notate (where they require 1/128th-notes and beyond, for example) thereby notationally approximating such values.

The intense focus of rhythmic resolution is evident throughout the score. For example, the piece starts with four independent notation-tempi indicating semiquaver = 104, 122.5, 156 and 87.5 BPM respectively, and continues to use notation-tempi throughout to differentiate the independent speeds of its four instrumentalists. In addition to temporal and metric differentiation, page one shows nested tuplets of 9:11/10:13/25:18 and on page two, 13:12/14:13/15:14/20:19. Such rhythmic notation proliferates the score which itself is presented like a continuous piano roll cut up to make manageable sequential pages where notated events are precisely proportionally spaced in relation to one another according to their rhythmic subdivisions, polyrhythms and contrasting tempo.

If the fidelity of musicians synchronising notation, click-track and required pulse subdivisions together with rendering their materials as signified is possible to the degree of precision suggested by the notational resolution, this method of supporting polytemporal rendition will produce structurally and temporally determinate polytemporal results. However, the challenges in achieving such levels of accuracy should not be understated.

The polytemporal music of Ned McGowan and Ron Fein have also bypassed the use of conductors all together, opting instead for each player to have access to an electronic metronome which is set to a particular tempo throughout the composition and strictly adhered to by the performer. In McGowan's *Building Music* for big band and (mezzo) soprano voice (2013), inspired by Ligeti's 1962 composition, *Poème Symphonique* for one hundred metronomes, McGowan writes in his performance instructions that

> [e]ach musician, (except for voice) has their own tempo (which is different from all the other players) and must have an electronic metronome on their stand (on silent mode) to constantly show their tempo. All the rhythmic passages should be played exactly in that tempo.[108]

The score for *Building Music* presents the material for each instrumental line, clearly indicating the assigned notation-tempo, but the score fails to show any relational information on

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[107] Ibid.

[108] Cited from the performance instructions in the preview score of *Building Music* available from the composer's website 'nedmcgowan.com'. An audio recording is also available at this location. <http://www.nedmcgowan.com/music/chamber-ensemble/building-music2013/> [accessed 8 February 2022]

a metrical level as graphic proportional relationship between notational elements across the timeline are absent. Therefore, the score gives very little conceptual impression of what the music may sound like. Nevertheless, if players can reproduce their materials with sufficient fidelity to the specificity of their independent metronome markings, the sonic outcome will be both polytemporal and structurally determinate, though the exact nature of this determination is not possible to verify with a score.

In a similar vein although bringing personal metronomes together with a conductor for temporal organisation, the composer Ron Fein wrote a series of polytemporal works for small orchestra in the 1980s and 1990s in which each part is ascribed a different independent tempo. Fein called his polytemporal approach 'non-cooperative ensemble' or 'non-cooperative music'. Compositions were notated in score format and a conductor beating a consistent tempo of 60 BPM throughout, provided an ongoing temporal framework that players would follow during rests until such time as they were cued back into the composition and to their independent tempi via a range of hand signals. Independent tempi were maintained through the use of small, silent metronomes on each player's music stand. A single tempo was fixed for each instrument and remained unchanged throughout the composition. The instrumental part notation was not metered with players counting duration beats for notes and rests alike, using their metronomes for guidance.

The overall intention was to generate a very fluid, continuous music that obscured verticality and limited the indeterminacy of outcomes. Non-cooperative works include *Orchestral Environment* (1982) *Undulations* (1993), *Meridian* (1995), *Ephemera* (1996) and *Periphery* (1998). Unfortunately, the efficacy of orchestral non-cooperative music remains untested as no orchestral pieces have so far been performed.[109]

2.8 Saunders

Moving away from personalised player metronomes to the use of individual stopwatches for global structural coordination in performance, Rebecca Saunder's *Chroma*, (2003-2019) is an unconducted polytemporal collage piece for twelve to sixteen players and multiple sound sources including music boxes and record players with performers organised as soloists, groups or a collage of up to sixteen players who move through and are spatially distributed within a performance space. The composition has a duration of twenty-one to thirty-nine minutes and has

[109] Further information about these works can be found at the composer's website: 'robfein.net' <http://www.ronfein.net> [accessed 15 January 2021]

been produced for very different venues where the architectural condition of those spaces determines how Saunders arranges the component parts of the piece as described here,

> *Chroma* […] is a work concerned with the search for and manipulation of single sounds, sound structures, soundscapes and their movement and dispersion in the performance space. Although meticulously composed in the finest detail, *Chroma* is an open-ended concept that is composed anew for each venue. No version likens another, just as no performance space is the same as another.[110]

Each musician has their own score, and each presents their 'gestures' (compositional material) within which there may be a degree of rhythmic freedom signified through spatial notations, but more often through materials indicating meter and tempo. Saunders calculates how long each gesture will take to execute and then coordinates all the parts as an extensive timeline that functions as the score by '[pinning] all the scores to the walls of her room and graphically [organising] them as though they were pictures [helping] her to determine the relationships that exist between the different ensembles'.[111] Gestures are numbered and organised into sequences punctuated by relatively long pauses (from five-seconds to several minutes), enabling musicians temporal flexibility in execution and also an opportunity to begin the next gesture at the time indicated. The whole is organised through pre-determined timings governed by stopwatches. The use of stopwatches ensures the global structure of the piece is executed as designed but does not directly influence the coordination of detail on a localised level.

2.9 Finnissy and Harding

Not using stopwatches or metronomes for temporal organisation, Michael Finnissy composed a range of pieces between the late nineteen-sixties to the mid nineteen-nineties that operate using loose coordination between players. As Pace explains,

> [s]ome pieces, such as *'n'* (1969-72) for any 1-4 instruments, the 5th and 7th Piano Concertos (1980, 1981), *Nobody's Jig* (1980- 81) for string quartet, *WAM* (1990-91) for piano and treble/bass instruments, or *Quelle* (1994) for four saxophones, have no score, only separate parts which the players follow independently; synchronization is thus very approximate and to a great extent up to chance.[112]

[110] Ibid.
[111] Notes taken from the online programme in 'Berliner Festspiele' for a musicFabrik performance of *Chroma XV* in March 2011 <https://www.berlinerfestspiele.de/de/berliner-festspiele/programm/bfs-gesamtprogramm/programmdetail_18134.html> [accessed 2 February 2022]
[112] Ian Pace, 'The Panorama of Michael Finnissy (I)', *Tempo*, 196 (1996), pp. 25–35.

In other pieces where there is a score such as *Lord Melbourne* (1980) for soprano, clarinet and piano, vertical alignment between the players is only roughly indicated. Pace explains that

> Finnissy often considers musical time as a series of intervals to be filled by topologically distorted phrases or fragments, rather than accretions of metrical units. In *From the Revelations of Saint John the Divine*, an unspecified melodic instrument is introduced towards the end, whose part is independent of the main score.

These pieces may at times be perceived as ametric but due to the strong rhythmic characterisation of the materials they comprise, it is likely the temporal relationships between them will be perceived as polymetric but in all cases, due to the temporal and structural indeterminacies present, metric and structural relationships and outcomes will be impossible to predict.

More recently and also exploring loose coordination between players, Holly Harding's unconducted thirty-two-minute composition, *Melting, Shifting, Liquid World* (2019) for string ensemble, solo electric viola and an electronic part heard by the audience through bone-conducting headphones, a technology that enables all three components to be heard simultaneously, explores among other aspects of spatiality, the individual temporal spaces of players to create a morphing installation where, as Harding herself explains,

> [q]uite a lot of the textures are built out of repeated loops of material in your own tempo [performed in the player's chosen tempo], so that creates this layered effect, and that was also partly born out of logistical challenges of working in space. You can't write for an ensemble in the traditional way when you're spreading them out because they can't hear each other; co-ordination becomes an issue; synchronisation becomes an issue.[113]

Players move around the space communicating with and responding to each other in such a way that the rendering of notated material in their individual parts is influenced by the largely plaintive, slow moving dynamic sonic environment in which they are produced. With three simultaneous musical elements and players freely operating within their own tempo, the temporal indeterminacy of this piece is likely to fluctuate between perceptions of ametrical or during episodes of greater rhythmic characterisation, perhaps when oscillating sine tone beating patterns found in the tape part produce pulse tempo in disagreement with other heard sounds surrounding the listener, as polymetric or polytemporal music. With no score that notationally represents and determines the exact temporal relationships of each player's material to every

[113] Cited from an April 2019 online interview in Crosscurrent Spotlight <https://tl-life.com/2019/04/18/crosscurrent-spotlight-melting-shifting-liquid-world/amp/> [accessed 5 February 2022]

other player's material, such temporal relationships and outcomes are impossible to predict precisely outside of a broad range or set of goals set by the composer and initiated by performers, but such outcomes can be described as most likely polytemporal if not temporally or structurally determinate.

Harding's composition uses technologies in the form of bone-conducting headphones and an electronic viola. Other technologies such as networked click tracks, electronic metronomes and digital stopwatches have also been mentioned as solutions to the management of polytemporal streams in performance when conductors have either been an inappropriate, impractical or unrealistic proposition. In recent decades, the use of video scores has become more prominent as a means to support new polymetric outcomes.

2.10 Hope and Clarke

Most of Cat Hope's works use a form of rolling graphic notation called animated notation in lieu of a traditional score and are read from a video file or on iPads networked over the internet or a local network using the Decibel ScorePlayer app during performance. These performances can take place as remote or situated events. Talking about her composition, *The Rupture Exists* (2020) for six players and sub tone, Hope explains:

> Clouds of coloured dots intersecting with each other are impossible and chaotic, but proceed softly and slowly, signalling in an animated score. Performers try to be "together" by emulating each other's sounds, as synchrony is impossible. They perform with an electronic playback of low tones and white-noise designed to reflect both the invisibility, clarity and complexity of data clouds. Accuracy is a concept for one, not the group - sometimes this is exposed, but mostly, it resides in the cloud.[114]

As asynchrony and latency are built into this composition's structural outcomes and with material being delivered slowly and across long lyrical phrases with players interpreting the animated notation, itself presenting no conventional rhythmic or metric information, from within their own temporal fields, it is likely the music will sound ametric throughout due to the lack of strong rhythmic or pulse characterisation. This cloud-like status is intentional and the temporal indeterminacy it generates in keeping with the composer's intention for the piece.

[114] More information about *The Rupture Exists* along with other Hope animated notation works including all downloadable materials and instructions necessary for performance can be found at Cat Hope, (2020): *The Rupture Exists*. Monash University. Composition. https://doi.org/10.26180/5f741b3e4c4c6

Desmond Clarke takes a somewhat different approach to Hope in the use of notation videos. Clarke is a composer interested in works using fixed and live-generated video scores that explore the boundaries and overlaps between notated and improvised music. In a September 2021 interview with Arc Project Music, Clarke talks about recent pieces like *Bright Waves* (2021) for multitracked saxophones and trumpets, in which he explores acoustic phasing between instruments where player performance has been supported using video scores that as Clarke explains 'control [the] micro temporal variation in real time [between instruments] which is obviously hard for the players but is a really interesting thing to explore and is something that I'm looking to take forward'.[115]

Clarke goes on to explain that

> the idea of the video score is interesting as well because it is something that appears free if you were to stretch it out. If you just put it out as a normal score it would be completely in free-time, completely aleatoric but the fact that you've got the notes moving off the page, [as in off the area of a video screen or events moving across a vertical playback line embedded in the video] makes it almost more controlled.[116]

Clarke comments that when music is notated as free-time, there is no notated rhythmic information and that players, in his experience, even when there is a density of notationally signified events, still take their time delivering that material to the extent that 'it's very difficult to get that sense of rhythmic pressure'. To achieve a sense of rhythmic urgency, Clarke believes video scores with playback lines or similar event horizons indicating exactly where an event should occur generate more rhythmic urgency in players than standard notation because 'they've just got to do it at that point'. Clarke also says that the compromise for enforcing this rhythmic urgency is a decrease in player agency around the placements of their materials in time but sees this as 'just a different way of working and [that there are] different types of freedom that the players can exercise'.[117]

The capacity of animated notation to support polytemporal outcomes in Clarke's compositions is clear. However, the degree to which it can deliver structurally determinate result as opposed to more temporally improvised responses, and whether or not improvised or determined performance outcomes are required depends upon the metric and rhythmic resolution of the type of notation used, the ability of players to interpret and mediate that notation and any degrees of latency between performer responses to video instruction as an

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[115] Text based on a September 2021 online interview by the composer in 'The Arc Project Music' as part of their Composer Spotlight series <https://www.arcprojectmusic.com/post/composer-spotlight-desmond-clarke> [accessed 13 February 2022]
[116] Ibid.
[117] Ibid.

ensemble rather than individuals as well as how all these factors sit within any anticipated level of structural and temporal accuracy determined and anticipated by the composer.

2.11 Discussion and Conclusion

The literature review was undertaken to assess current polytemporal and polytactic compositional practice, particularly though not exclusively within orchestral music, across a selection of totemic works from the start of the twentieth century through to the present day with the aim of ascertaining the extent of compositional possibility available within this field. Having developed timecode-supported polytemporal music in response to this literature review as well as my own creative aims, it is important to establish how this compositional approach is contextualised within current praxis, where it overlaps with it and what temporal features distinguish it from other approaches.

To help expedite this contextualisation, it is useful to restate my compositional aims for this project that include:

1. Independent simultaneous temporal trajectories for all orchestral players.
2. Ease of incorporating heterogeneous temporally unrelated materials into compositions.
3. The capacity to maintain near-determinate results on a local and particularly global level in performance.
4. All solutions to the above being scalable and practical to implement.

As discussed in the review, the structurally indeterminate performance approaches and outcomes found in the particular Cage, Finnissy and Harding pieces included here require many decisions around the selection and placement of sonic events throughout the timeline of a composition to be decided by players as these particular temporal and structural decisions are not specifically determined by the composer through notation. Although these composer's methods do, in various ways, support many Independent simultaneous temporal trajectories for multiple players, incorporate heterogeneous temporally unrelated materials into compositions and offer solutions to polytemporal expansion that are scalable and practical to implement, their open form or inability to maintain structurally determinate or near-determinate performance results on a local and global level in performance do not coincide with my compositional aims and as such remain a stumbling block to their adoption.

By contrast, when reviewing totemic polytemporal and polytactic orchestral works from the twentieth century that offered performance outcomes ranging from the structurally determinate to less or intermittently structurally determinate, it was clear that none of the works investigated supported independent simultaneous temporal trajectories for *every* orchestral player throughout a composition. Instead, orchestras were often divided into just a handful of conducted or player-cued polytemporal groups with content often connected through related tempos and homogeneous materials.

For example, Carter's Concerto for Orchestra utilises only four primary, proportionally related pulse streams and their associated superimposed rhythmic subdivisions. Stockhausen's *Gruppen*, for all its complex, unified compositional parameters, remains a polytemporal piece comprised of only three, synchronised, antiphonal and temporally differentiated orchestral groups. Ives's *The Unanswered Question* has three distinct temporal layers whereas his Symphony No. 4 exhibits multiple simultaneous polytemporal and polytactic overlaid groupings throughout, but not to the extent where independent temporal trajectories extend to *all* orchestral instruments simultaneously.

Brant's polytemporal music does combine related and unrelated tempi, nevertheless, *Antiphony 1* is limited to five simultaneous temporal groups with *Millennium II*, occupying two primary temporal areas, and Lutosławski's Symphony No. 2 and *Jeux Vénitiens* rarely use more than three simultaneous independent tempi. Even in the confined ad libitum sections, instrumentalists tend to cluster around very specific tempo areas that though unconducted, do not necessarily amount to distinguishable, individuated tempi for each player no matter the extent of their rhythmic displacement, and as is the case with Lutosławski's orchestral music, there is soon a return to the confinement of synchronised, more temporally unified music. A similar return is also found in Boulez's *Rituel: In Memoriam Bruno Maderna* and Berio's *Tempi Concertati* on their journeys from temporal determinacy and synchronisation to confined temporal indeterminacy, while Segerstam's Symphony No. 288, like most other of his symphonies, confines polytemporality to predominantly player-directed, juxtaposed, loosely synchronous broad orchestral instrumental sections.

The most polyphonically dense orchestral piece included in the review, Ferneyhough's *La Terra est in Homme*, with a maximum of forty-two independent parts out of a possible eighty-nine, as previously mentioned, is held up by Fitch as representing super polyphony, even though these forty-two voices represent only 47% of the total available instruments that could

potentially have polyphonic independence at any one time, suggesting other instruments are simultaneously doubling, tacet or a mixture of both.

On a considerably smaller scale, Johnson's *die bewegung der auger* uses only one conductor to manage groups of players within a small ensemble and it is my conclusion that with responsibility for accurate temporal differentiation being distributed between the conductor and players to varying degrees throughout the piece as a condition for structurally determinate results in performance, this polytemporal approach would not easily scale up to orchestral proportions even with several conductors synchronised to one another managing multiple player groupings. Of course, orchestral scaling was not the intention of this piece, and it is perhaps inappropriate to look at it from this perspective. Nevertheless, it is my opinion that there is little evidence to suggest such an approach to polytemporal management could be adapted beyond its grouping designation to support mass individual temporal trajectories effectively.

More recent structurally determinate works such as Czernowin's *Slow summer Stay III (Upstream)* in common with the Murcott arrangement of Nancarrow's *Player Piano Study no. 21 (Canon X)* see polytemporal groups limited to just two ensembles managed in ways first seen in the multi-conductor works of Ives, Brant and Stockhausen. However, in a twist to convention, the video conductors used in lieu of live conductors in the Nancarrow do open up a range of polytemporal possibilities, but the notion of creating one video conductor for each temporarily independent player in a large orchestra as opposed to groups of players, for example, is likely to prove impractical from a technical perspective.

Not used as video conductors but for animated scores, the video score approach of Hope and Clarke shows great potential for polytemporal performance. The capacity to develop animated scores that incorporate notation events moving across a playline or off the video screen at different speeds solves a number of issues around graphically representing proportional and other types of notation with simultaneously different tempo operating in real time. However, with no examples, in the first instance, of scaling up iPad or a sufficient number of networked or synchronised video screens to enable each player of an orchestra to see and read the notation of their own temporally differentiated animated video score part has practical, technical and cost implications that would need to be considered before proceeding. In the second instance, the type of notation used and its rhythmic, pitch and expressive resolution along with the player's ability to mediate such notation in real-time would very much determine the degree to which performance outcomes would be determinate, near-determinate or indeterminate structurally on a local or global level.

Determinate structural results using unrelated tempo and heterogenous composition materials are possible using Kirk's particular approach to click-track supported compositions and in principle, if every player in the orchestra were connected to their own click track, such an approach would be scalable. However, I have reservations about pursuing this method of polytemporal composition and performance within the orchestra on two counts: first, I consider the precision anticipated of the performer in determining every aspect of notation within such a rigorous and inflexible time framework unappealing expressively, and with each player wearing headphones, sonically isolating from each other and their instruments; and second, predict the equipment requirements and technical assistance necessary for set up and take down time along with the margin for technical error prohibitive in both time and cost.

In theory, and as a much simpler solution to providing each player with a guiding pulse, the individual player-assigned electronic metronome approach of McGowan and Fein could be scaled up to any number of players in a similar fashion to timecode-supported polytemporal music and offer determinate structural performance outcomes using heterogeneous materials with unrelated tempos. However, whilst the pulse delivery via click-tracks can vary according to the requirements of musical material, I am unhappy about the temporal inflexibility associated with the individual metronome approach, finding the fixed tempo assigned to each player restrictive from a compositional and expressive perspective and with only one tempo throughout, unsuitable for incorporating extant self-borrowed materials that themselves incorporate a rich and varied tempo profile. To incorporate such materials into a composition using this individuated fixed tempo approach would require those materials undergoing a process of notational reformatting similar to that outlined in 1.1.7 Notational Reformatting and 1.1.8 Increased Notated Rhythmic Complexity in Chapter 1, and as such would be an approach to polytemporal management I would not use.

The closest compositional approach to timecode-supported polytemporal music and the creative aims I have set out for this project are found in Saunder's *Chroma*. Saunders's use of stopwatches to manage the global structure of her collage pieces, where materials are brought together in a polytemporal, spatialised fabric, echo the aesthetics and practical considerations important to me as a composer in writing my own polytemporal music. Though Saunders's stopwatch method has not yet been scaled up to manage temporal differentiation for every player within a large orchestra, there is, in my opinion, no compositional, performative, technical or practical reason why this would not be possible.

What temporally distinguishes timecode-supported polytemporal music from Saunders's own compositional approach is the use of stopwatches to manage degrees of structural resolution on the local and global levels rather than just the global level. This distinction stems from a fundamental compositional difference between the two. Timecode-supported polytemporal compositions originate from a computer model where relationships between structure, tempo, rhythm, pitch and expression are precisely fixed and determined notationally. It is then through the act of performance and player mediation, particularly of tempo within timecode frameworks, that confined degrees of temporal indeterminacy are introduced and it is this indeterminacy that in turn disrupt the fixed vertical rhythmic notational relationship established in the model. With sensitive player mediation of timecode frameworks, the effect of temporal indeterminacy is confined to localised detail and it is this indeterminacy that generates a slightly blurred sonic image when live performance recordings are compared to the computer model audio. It is this slightly blurred image I describe as a near-determinate outcome.

By contrast, *Chroma* is conceived as a collage of musical gestures that are organised as events in time and space in relation to one another. The precise temporal relationships between these gestures on a moment-to-moment basis are not established beyond when gestures start and finish. As such, Saunders's scores and stopwatch timings allow for inherently greater degrees of temporal indeterminacies between gestural detail with timings used primarily to choreograph player movements and structural flow from one area of the compositional collage to another.

Conclusion

Having examined and compared the above compositions with each other and the compositional aims set out above and through a discussion of this methodology's shared features and differences of approach situated within the context of current praxis, it is my conclusion that timecode-supported polytemporal music offers a unique approach to polytemporal composition. This unique approach is achieved through its potential to support temporal expansion to *every* instrument of the orchestra using heterogeneous, unrelated temporal materials, deliver near-determinate performance outcomes and achieve these in a practical and straightforward manner adaptable to a range of compositional aesthetics where confined yet flexible degrees of control over structural outcomes in performance are required.

3. Methodology

Part 1: About this Methodology

3.1 Introduction

The methodology chapter shows the approach taken to systematically answer the research questions set out in Chapter 1 through undertaking a practice research project where the practice element is the creation of four timecode-supported polytemporal orchestral compositions, a chamber orchestra piece and a number of ensemble compositions that embody this research and where a comparative analysis of their performance outcomes with computer-generated audio renditions of the same pieces offers evidence around how effectively the compositions have addressed the research questions.

The methodology describes the research strategy that looks at the rationale behind the research methods and the way they are undertaken to build the test-pieces. The test-pieces, in turn, incorporate the various composition methods and techniques used to generate materials and functionalities designed as the primary route to answer the research questions through the problem-solving practice of composition. To elucidate these processes, the commentary offers a step-by-step explanation of the research methods and techniques used in the construction of timecode-supported polytemporal compositions that also serves as a ‘how-to’ toolkit for composers wishing to construct their own polytemporal compositions. To this end, the methodology discusses the agencies, methods, techniques, constructions and software processes undertaken from concept to completed build that, although idiomatic of my compositional approach, remain adaptable by others interested in composing polytemporal music using this methodology.

To expedite this examination, the methodology chapter is divided into three main parts: Part 1, itself subdivided into a further three sections, includes this introduction followed by, in 3.1.2 The Research Questions, a closer look at differentiated timecode frameworks and how they are used to answer the research questions as well as discussing the methods and subjective framework within which results are analysed and situated, and in 3.1.3 The Compositions as Research Objects, present the components that constitute the portfolio pieces along with assumed performance outcomes related to which timecode frameworks materials are embedded into.

The second and third parts present a theoretical framework. Part 2, supports an analysis of the methods applied to the processes, functionality and agency of the test-pieces in Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions; and in Part 3: Building the Model, an analysis of the methods applied to the generation and assembly of notational materials that are the components of the test-pieces and how performance materials are constructed from these components.

The research process can be summarised in the following stages:

1. The development of a research problem that asks how best to expand polytemporal differentiation to any number of players using heterogeneous temporally unrelated materials while maintaining the capacity for near-determinate results in performance using the most practical means available.
2. The undertaking of a focused literature review that examines the field of polytemporal composition to highlight current functionalities and ascertain how those fit with my own polytemporal ambition.
3. Developing research questions (as identified in the introduction) that test assumptions around how the research problem can be answered using the approaches this methodology presents.
4. The creation of portfolio compositions that incorporate these polytemporal approaches.
5. Testing live performance recordings of the portfolio pieces against concomitant computer-generated renditions to ascertain their degree of structural coincidence.
6. Analysing the results of these comparisons and presenting a discussion around the findings.
7. Drawing conclusions from this analysis to ascertain if the results address the research questions, my compositional aims and fill any gaps in polytemporal praxis identified in the literature review.

3.1.2 The Research Questions

How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured?

In 1.1.12 Defining Near-Determinate Outcomes**,** I described near-determinate outcomes as a live performance sonic image rendered as a slightly blurred but entirely recognisable structural iteration of a computer-generated compositional model's audio rendition of the same piece. I go on to state in 1.1.16 What is Being Tested? that the capacity of timecode-supported polytemporal composition to meet its polytemporal near-determinate performance aims is ascertained through a direct comparison between those live and computer-generated audios, in effect, assessing the live performance recording for structural accuracy when tested against the structural fixity of the computer model's audio through focused listening. I also claim that my sense of success in this matter is supported by an understanding of just how close the live performance is to the computer-generated rendition by approximately measuring the time elapsed between key sonic events in both, drawing the conclusion that the closer the live performance recording is to the computer audio rendition according to those measurements, the more successful I consider the performance to be in achieving its near-determinate status. I have chosen the time differential parameter of +/-0–2 seconds as signifying a personal sense of near-determinate performance outcomes.

As discussed in 1.1.5 Pulse Tempo and Polymeter, measuring time elapsed as distance in milliseconds using interonset intervals between events in notated or sonic matter is already commonplace in metric analysis or when calculating rates of activity tempo, pulse tempo and notation-tempo and the tempo ratios within and between these elements. Although it would have been possible to analyse key sonic event differentials between live performance recordings and fixed computer-generated audio recordings in milliseconds using specialised software, the precise, inflexible quantitative nature of those results would have been specific to those players, their particular performance and piece of music under analysis and as such, not transferable to any other performance of the same piece.

Finding the measuring of IOIs an inappropriate epistemological framework through which to undertake the analysis of what were consistently flexible outcomes, I opted for a subjective comparative analysis of key sonic events within concomitant recordings that still used time for differentiation, but where, rather than precisely measuring event differentials, elapsed

time was gauged informally by ear through careful listening and reference to the timeline of the compositions and where necessary, a stopwatch to arrive at values in seconds between the two. Although qualitative, I considered the approximated and fuzzy nature of these results appropriate to embrace the range of iterative outcomes likely to be produced through multiple performances of any of the pieces.

At the core of this research question are performance tests to ascertain the capacity of timecode frameworks to support players in rendering notation materials at specifically indicated timecode positions along the timeline of a piece, thereby supporting structural integrity in performance. Three different timecode frameworks were designed for this purpose. They are identified as foundational, phrase-initiated and block-initiated frameworks and move from periodic bar to bar signification to aperiodic signification of timecode representing a progression from the most confined to the least confining timecode support. All three frameworks are described shortly. In examining live performance recordings and comparing them to computer-generated renditions, it is how effectively timecode frameworks have supported performers in generating near-determinate outcomes rather than the overall musicality or quality of recording that are being assessed. In this context, live performance recordings of *pulviscular observation*, *pulviscular compression* and *the unimportance of events* (2021) are examined.

As stated in 1.1.18 Subjectivity, my assessment of performance results based on comparisons between recorded renditions and any conclusions around success or acceptability are, above all else, a subjective matter based on focused listening. Nevertheless, I have found it useful to ascertain to what extent live performances differ from the determinate fixity of the audio model to bring a notion of measure and expression to such personal qualitative values as acceptability. By measuring the difference — the deviation — all be it approximately, in seconds between key sonic events such as the starts and stops of phrases and sections of material or loud, dramatic outbursts and other sonic features along the timelines of audio model and concomitant live recordings when compared, I am able to approximate how closely they align in seconds.

These approximated measurements are achieved by identifying key sonic events in the audio model that then act as fixed reference points against which all differential measurements in seconds between the audio model and live the performance audio are assessed. These fixed reference points, called time-points, correspond to 0" values in calculations. It is the plus or minus seconds measured from the 0" values, called time differentials, that constitute the

difference between the two where minus values indicate events happening ahead of 0" time-point and plus values, after 0" time-points.

To collect these measurements, first, waveforms, as visually represented in audio files, are compared by synchronising their start positions along the timeline of Logic and observing and measuring the proximity of related key sonic events in seconds. More revealing is simultaneous playback of the same audio files where greater structural detail between recordings is easier to identify sonically through listening. Analysing recordings in this way is an informal act that provides a degree of accuracy suitable for the aims of this investigation. Such methods have their limitations, not least the unpredictable acoustic outcomes often associated with live recorded matter when compared like-for-like with the predictable, consistent yet flat dynamic output of computer-generated audio renditions and the identification and location of key sonic events between both.

Having an interest in achieving near-determinate performance outcomes using performer-mediated foundational timecode frameworks and understanding that all live performances are degrees of deterritorialization of the model, my sense of an acceptable performance is situated where the greatest levels of alignment between key sonic events in the audio model and live performance are to be found. Therefore, the smaller the perceived difference in key sonic event time-point differentials between live performance and audio model recordings, the greater my sense of performance acceptability, at least in temporal and structural terms.

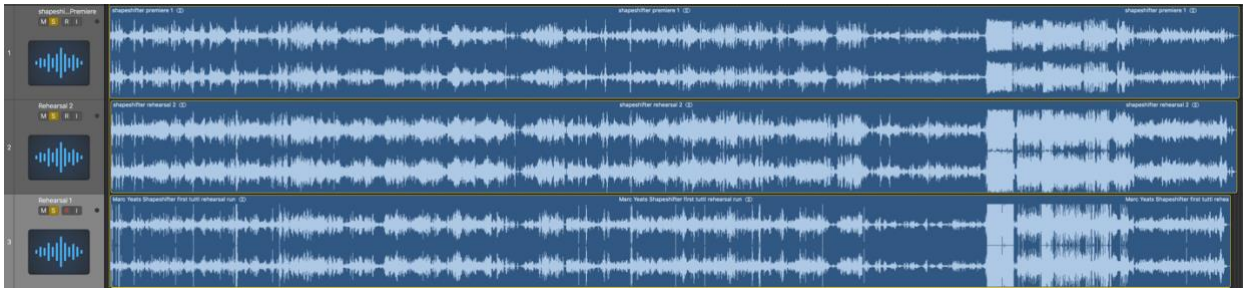
Assessing the acceptability of performance solely through the measurement of time differentials between key sonic events does not necessarily indicate the status of a performance that, because of these criteria, may feel distant from preconceived notions of near-determinate acceptability yet still present the composer with a desirable, unexpected connection between the flexible live performance of a piece and its fixed audio model output. As stated, such decisions concerning acceptability remain subjective. However, assessing time differentials in this manner does assign a communicable value to what would otherwise remain a difficult to define subjective position and as such, may offer a valuable contribution to help shape opinions around what constitutes acceptable performances based on a perceived, personal measure. It certainly helps establish if the timecode framework tests have succeeded in delivering the intended near-determinate outcomes central to this methodology’s raison d’être.

Although not framed as a specific research question, ascertaining just how effective timecode frameworks are in delivering near-determinate performance outcomes within increasingly large cohorts of players is related to a perceived sense of methodological success. Here, I am asking if the same levels of player fidelity to mediate timecode are possible to achieve within large orchestras as they are in small chamber ensembles. This question arises because it is not unreasonable to assume that levels of fidelity may fall if orchestral players are overwhelmed by the sheer sonic density produced by others during performance even though in principle, the use of timecode frameworks should mitigate against such disorientation. An analysis of performance results will show whether this assumption is correct or not.

To this end and as a basis for comparison between chamber and orchestral timecode mediated performance outcomes, my timecode-supported polytemporal composition, *shapeshifter*, is presented as an example of near-determinate performance outcomes using the foundational timecode framework within an ensemble of eight players. Although not directly part of this research project, *shapeshifter* provides useful results presented as a baseline to ascertain how well the efficacy of the foundational timecode framework may transmit from smaller to larger numbers of players.

Looking closely at *shapeshifter*, an analysis of its timecode mediation shows exceptional fidelity between the *shapeshifter* model, recordings of rehearsals and a live recording of the premiere. Having access to rehearsal and premiere recordings provides a rare opportunity to examine how players mediate the same timecode supported materials across a number of renditions and how all these renditions compare to the audio model.

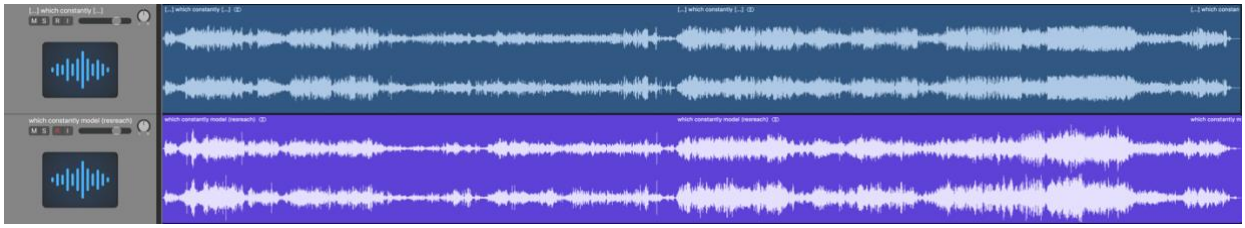
Figure 6. *shapeshifter* (2015). Rehearsal and live performance recordings compared



Shapeshifter uses the foundational timecode framework throughout all of its parts. This analysis shows that between rehearsal recording one and the recording of the premiere (as seen

in Figure 6, p. 78, where the top wave file is the recording of the premiere and the bottom wave file the first rehearsal recording), timecode fidelity ranges across a maximum of +/-0–2" but for most of its duration, a +0–1" deviation from identical key sonic events in the premiere recording. For rehearsal recording two (the middle wave file in Figure 6,) and the premiere recording, this time-point differential reduces to +/-0–1" and frequently, +0–1" throughout, showing a remarkable level of timecode mediation fidelity and interpretive consistency among the players within each iteration of the piece. Upon listening to all three recordings simultaneously, it is clear the differential between timecode positions of identical key sonic events produces a slight heterophonic effect but in all recordings, the differences between each iteration are very slight, producing near-determinate outcomes.

Figure 7. *shapeshifter* (2015). Model and premiere recordings compared



These levels of fidelity are apparent in comparisons of the premiere recording and the audio model rendition (top and bottom waveforms respectively of Figure 7, p. 79). Owing to the discrepancy between the relatively flat audio model dynamic output and the expressive live performance full spectrum dynamic output, comparisons between the waveforms of the model and the live performance recording do not reveal a great deal of information away from indications of gross structural coincidence. However, listening to the audio of both simultaneously reveals a very high degree of timecode mediation fidelity between the model and live performance recordings, again, between +/-0–1" throughout, demonstrating a near-determinate outcome and acceptable rendition.

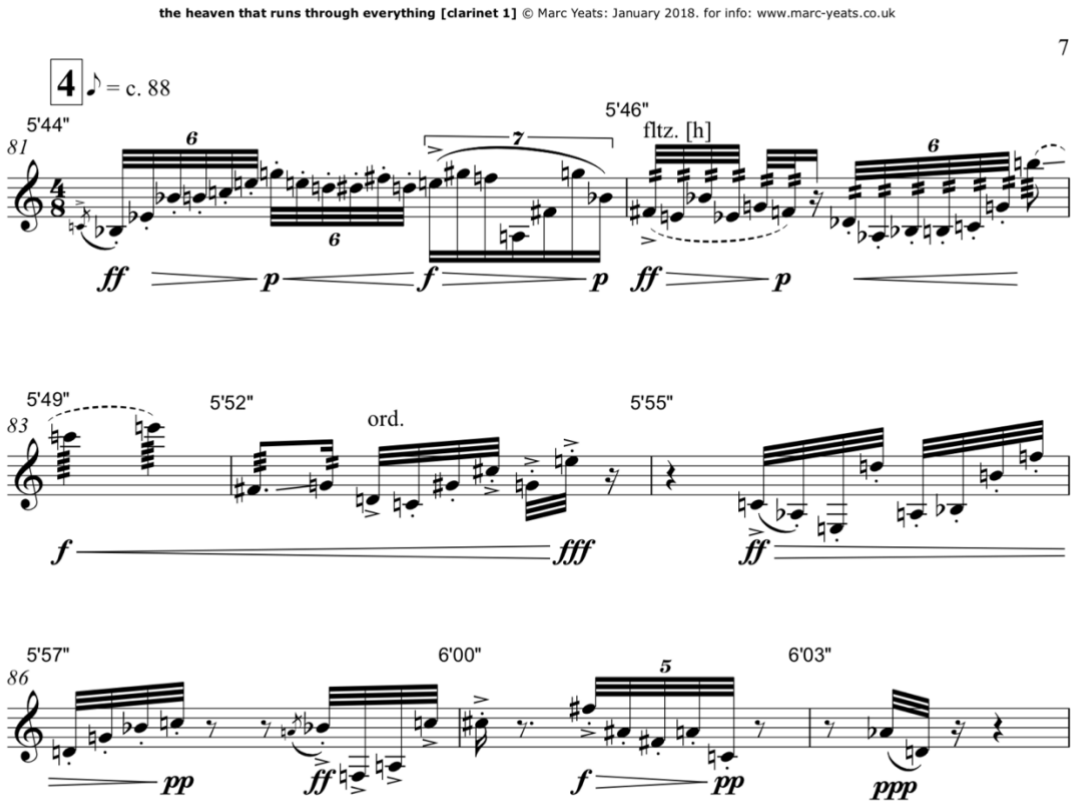
Which timecode frameworks best support near-determinate performance outcomes?

Owing to the absence of large-scale orchestral performances as described in 1.1.19 Performances, and particularly with no live performance of *[...] which constantly generates a pulviscular cloud [...]*, in which all three timecode frameworks operate simultaneously, it has not been possible to test phrase-initiated and block-event timecode frameworks. Only the foundational timecode framework has been tested through performances of *pulviscular*

observation, *pulviscular compression* and *the unimportance of events* (2021), therefore it is impossible to answer research question two as intended.

Despite the lack of performance evidence being drawn from all three timecode frameworks, it is the functionality and efficacy of the foundational timecode framework that has proved critical to this methodology. All other timecode frameworks were to be examined in relation to degrees of deterritorialization away from the greater temporal confinement offered by the foundational timecode framework with their flexible impact anticipated to produce outcomes of greater temporal and structural indeterminacy.[118] Such results would have helped define the parameters of what I considered an acceptable performance outcome. Nevertheless, my primary purpose in testing timecode frameworks in performance was to achieve what I considered near-determinate outcomes and in that regard, the testing of the foundational timecode framework has provided sufficient evidence for me to draw conclusions about its efficacy.

Figure 8. The foundational timecode framework. Clarinet 1 from *the heaven that runs through everything* (2018), bars 81–88

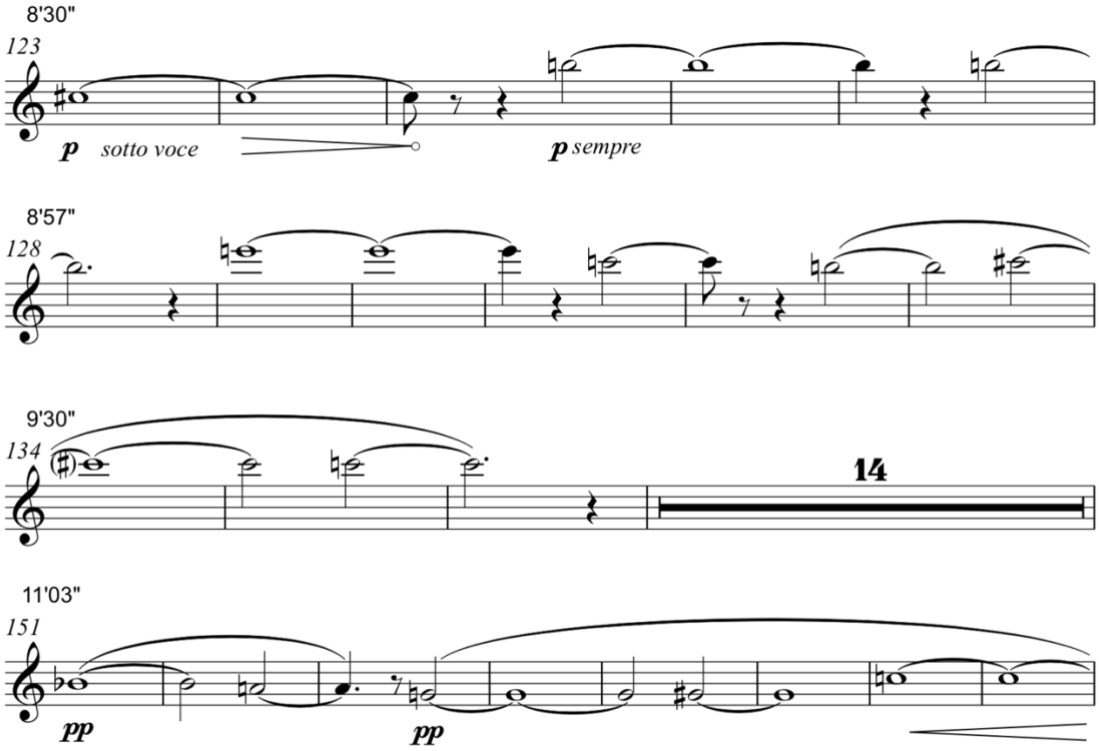


[118] Due to the collaborative obligations outlined in 'The Compositions as Pieces of Music' I decided to not remove the foundational timecode framework from any compositions as this would generate substantial levels of structural indeterminacy in performance. In such circumstances, deterritorialization would be significant, leading to performance outcomes closely associated with other forms of composition built around significant temporal and structural indeterminacies, duplicating praxis already identified in the literature review.

It is still useful to describe phase-initiated and block-initiated frameworks along with the foundational timecode framework as all are used in varying combinations among the portfolio compositions. To this end, some of the portfolio pieces use simultaneously contrasting timecode frameworks in different instrumental layers. This approach supports the testing and analysis of somewhat less confining timecode frameworks and their more structurally indeterminate performance outcomes against concomitant computer models without jeopardising the overall structural integrity of pieces in performance. It is the distinction between the functionalities of these frameworks that determines expectations around the resolution of structural determination, how each is measured and subsequently, how notions of acceptability are qualified.

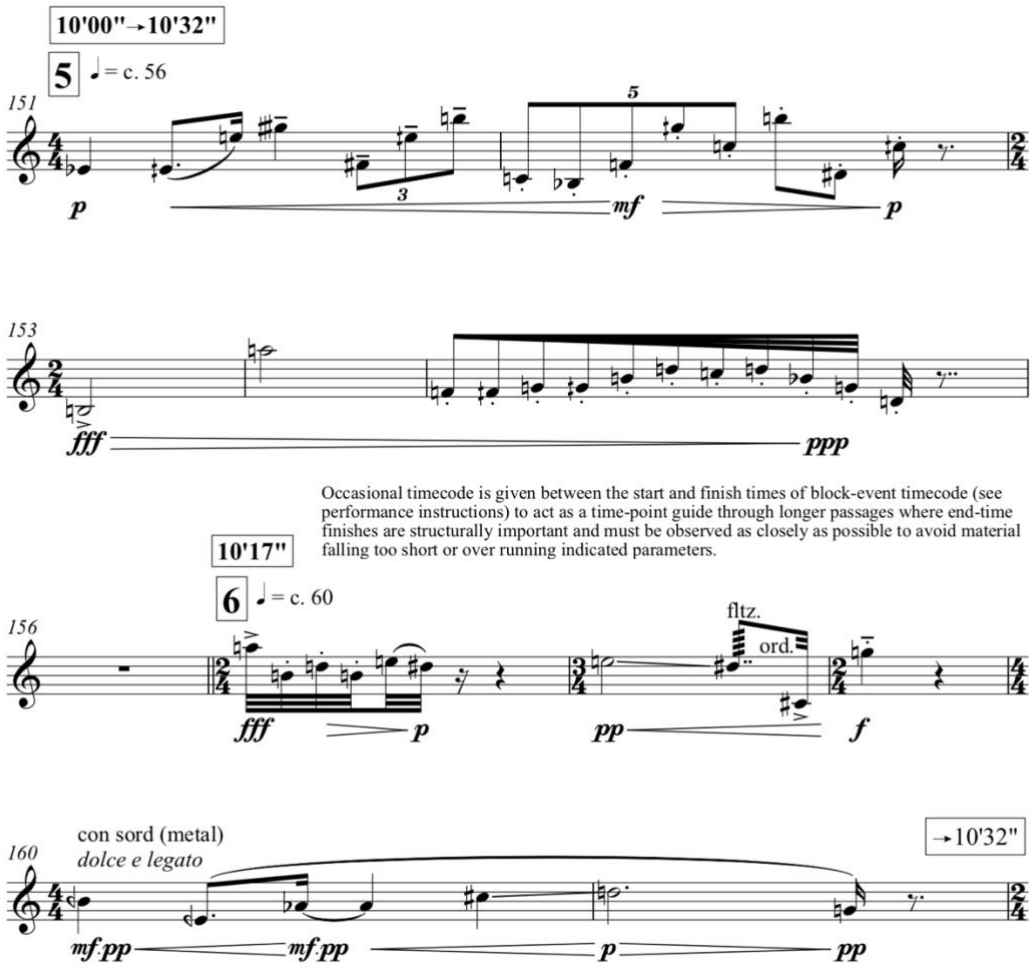
The foundational timecode framework, illustrated in Figure 8, p. 80, is signified by timecode-points (timecode-points being the position where timecode is signified above the barline) positioned directly above every barline throughout the composition. This signification represents the most confined timecode framework found in the test-pieces as it provides the most frequent periodic reference points for player orientation across the timeline of the piece. It is present in each of the test-pieces and is assumed that outcomes rendered using this timecode framework will provide the greatest coincidence between live performances and the audio model — the most acceptable rendition — offering flexible, near-determinate performance outcomes for composers.

Figure 9. Phrase-initiated timecode framework. Flute 3 from *[and] a powerful flame came out of the earth […]* (2019), bars 123–158



Second, ‘phrase-initiated’ timecode, illustrated in Figure 9, p. 81, is signified by the aperiodic positioning of timecode-points, often, though not necessarily, initiated at the starts of phrases. This signification only identifies at which timecode-points phrase material commences. With fewer timecode-points, phrase-initiated timecode generates an opportunity for more flexibility in rendition than the foundational timecode framework. It is found in *[and] a powerful flame came out of the earth [...]* and *[...] which constantly generates a pulviscular cloud [...]*, operating simultaneously to other strands using the foundational timecode framework. Outcomes rendered using this timecode framework are assumed to be somewhat more flexible in relation to coincidence between live performance and the audio model although overall, these differentials are likely to fall within the identified parameters of an acceptable performance.

Figure 10. Block-event timecode. Trumpet 2, bars 151–161, from *[...] which constantly generates a pulviscular cloud [...]* (2019)



And third, 'block-event' timecode, illustrated in Figure 10, p. 82, offers the least confining of all three timecode frameworks. Here, it is incumbent upon the performer to deliver the complete material, as far as is possible, within the defined start and finish timecode-points using only their interpretation of ongoing tempo markings as a guide to how that material is placed within the defined space, ensuring the material starts as specified and does not significantly overrun or fall short of the end-point timecode signification.[119] It is found in a number of instrumental strands in *[...] which constantly generates a pulviscular cloud [...]*, operating simultaneously to other strands using phrase-initiated and the foundational timecode frameworks. Occasionally, timecode is given between the start and finish times of block-event timecode to act as a time-point guide through longer passages where end-time finishes are structurally important and must be observed as closely as possible to avoid material falling too short or overrunning indicated parameters. It is assumed that away from start-points, this framework will offer the least coincidence between live performance rendition and the audio model, therefore producing the least structurally determinate renditions. However, across the compositional structure as a whole and taking into account the simultaneous operation of more confining timecode frameworks found in the composition, performances are anticipated to fall broadly within the extremes of near-determinate performance, at least within certain strands of the composition.

[119] Block-event timecode should not be confused with Cage's 'time-brackets', as discussed in the literature review in reference to the 1988 orchestral composition *1O1*, that allow much greater performer choice around where sounds are placed within predominantly flexible ranges of start and finish times as well as performer choice around the duration of the notated pitches themselves, the combination of which results in extremely flexible, indeterminate structural outcomes. An overview of the functionality of Cage's time-brackets used throughout *The Number Pieces*, of which *1O1* is one, can be found in William Brooks, 'Music II: From the late 1960s' in *The Cambridge Companion to John Cage* ed. D. Nicholls, from Cambridge Companions to Music, (Cambridge: Cambridge University Press, 2002), pp. 128–148 (pp. 141–142).

3.1.3 The Compositions as Research Objects

All compositions built as part of this research project are designed to test, among other factors, the effectiveness of timecode frameworks to help players render acceptable, near-determinate, dense, polytemporal performance outcomes without scores or conductors using only part-embedded timecode loosely synchronised with individual mobile phone stopwatches. The compositions are:

1. *the heaven that runs through everything* (2018), original version for large orchestra.
2. *the heaven that runs through everything* (2018), version for standard orchestra.
3. *[and] a powerful flame came out of the earth [...]* (2019), for large orchestra.
4. *[...] which constantly generates a pulviscular cloud [...]* (2019), for chamber orchestra.
5. *Cutouts for Ensemble* (2019), for ten players.
6. *pulviscular observation* (2019), for double string quartet.
7. *pulviscular compression* (2019), for nineteen string players.
8. *the unimportance of events* (2019), for seventeen players.
9. *obscure sorrows* (2019), for clarinet and violin.
10. *the unimportance of events* (2021), for chamber orchestra.

These pieces fall into three categories: first, the orchestral test-pieces listed 1–4 and second; compositions 5–9 that are ensemble pieces specifically composed for possible inclusion in *[...] which constantly generates a pulviscular cloud [...]* as modular compositions assembled through, among other actions, material self-borrowing; and third, as discussed in the introduction, composition 10, *the unimportance of events* (2021), a chamber orchestra piece and later edition to the collection, specially composed for a performance opportunity with the BBC Scottish Symphony Orchestra and Tectonics Glasgow in May 2021.

Of these pieces, *pulviscular observation*, its heterophonic expansion, *pulviscular compression* (discussed in 3.4.4 Heterophony and later in this subsection) as well as *Cutouts for Ensemble* are incorporated into *[...] which constantly generates a pulviscular cloud [...]*.

obscure sorrows and *the unimportance of events* (version for seventeen and twenty-two players) are not incorporated into this composition as other assemblages proved more appropriate for addition, but these excluded pieces nevertheless share borrowed materials, many of which are present in all three orchestral compositions and demonstrate the variety of outcomes generated through the combination of self-borrowed components.

Table 1. The orchestral test-pieces and their components

Title	Instrumentation	Duration	Components	Instrumentation	Duration	Transformed	
						Yes	No
***the heaven that runs through everything* (2018) large orchestral versions**	5(1.2/picc, 3/picc, 4/alt, 5/bass) 5(1.2/d'amore, 3/ca, 4/ca, 5/bass) 5(1.2/ebcl, 3.4+bcl, 5+bcl) Saxophones (optional) 5(1+sop, 2+alto, 3+tenor, 4+bari, 5+bass) 5(1.2.3+cbsn, 4+cbsn, 5+cbsn) – 8 8(1.2.3.4/picc, 5/bass, 6/picc, 7+flugel, 8+flugel) 4(1.2.3+bass, 4+bass) 2(1+euph, 2) – 2 harps – tmp+4 (vibraphone, gongs, tam-tam, glockenspiel, crotales, cymbals, tambourine, maracas, wood & metal blocks, cowbells, gong, bass drum.) – strings: 16,14,12,10, 8 as Violin 1: Soloists 1, 2, 3, and Violins 1a, 1b, 1c, Violin 2: Soloists 1, 2, and Violins 2a, 2b, 2c, Viola: Soloists 1, 2, and Violas a, b, c, Violoncello: Soloists 1, 2, 3, and Violoncellos a, b, c, Double bass: 1 – 8	30"	*The Anatomy of Air* (1997 rev. 2011)	2(1.2/picc) 2(1.2.) 2(1.2/bcl) 2(1.2/cbn) – 2 2 0 0 – **timp** – strings: 10, 8, 6, 4, 2	ca. 18'00"		x
			Black Sun (2013)	2(1.2/picc) 2(1.2) 2(1.2/bcl) 2(1.2/cbsn) – 2 2 0 0 – pno – **1 perc** – strings: 10, 8, 6, 4, 2	23'00"		x
			observation 1 (2015)	**string quartet**	14.30"	x	
			observation 2 (2015)	**string quartet**	16'00"	x	
			observation 1.5 (2015)	**treb/desc rec., vln, vc.**	14.30"	x	
			observation 1.6 (2015)	**2 vlns.,** pno.	11'30"	x	
			observation 1.7 (2015)	**flt., ob., vln.**	12'40"	x	
			observation 1.7.5 (2015)	**alt flt., bsn, vln.**	7'00"	x	
			observation 3 (2016)	**double string quartet and doublebass**	15'00"	x	
			observation 6 (2016)	**picc., sop.sax**., pno., perc.	12'30"	x	
			observation 4 (2016)	**string quartet**	17'00"	x	
			observation 5 (2016)	**string quartet**	18'30"	x	
			observation 7 (2016)	**picc., ob., tpt., hn., vla., db., perc.**	12'00"	x	
			observation 1.8 (2017)	**bass recorder, ob., vln.**	12'30"	x	
***the heaven that runs through everything* (2018)** standard orchestral version	4(1.2/picc, 3/picc, 4/Alt) – 3(1.2/Ca, 3/Bo) – 3(1.2/ebcl.3/bcl) – 3(1.2.3/cbn) – 4.4(1.2.3/picc.4/picc) 3.1 – 2 harps – Tmp+4 (vibraphone, gongs, tam-tam, glockenspiel, crotales, cymbals, tambourine, maracas, wood & metal blocks, cowbells, gong, bass drum.) – Strings: 16.14.12.10.8 as Violin 1: Soloists 1, 2, 3, and violins 1a, 1b, 1c, Violin 2: Soloists 1, 2, and violins 2a, 2b, 2c, Viola: Soloists 1, 2, and violas a, b, c, Violoncello: Soloists 1, 2, 3, and violoncellos a, b, c, double basses: 1 – 8	30"	*The Anatomy of Air* (1997 rev. 2011)	2(1.2/picc) 2(1.2.) 2(1.2/bcl) 2(1.2/cbn) – 2 2 0 0 – **timp** – strings: 10, 8, 6, 4, 2	ca. 18'00"		x
			Black Sun (2013)	2(1.2/picc) 2(1.2) 2(1.2/bcl) 2(1.2/cbsn) – 2 2 0 0 – pno – **1 perc** – strings: 10, 8, 6, 4, 2	23'00"		x
			observation 1 (2015)	**string quartet**	14.30"	x	
			observation 2 (2015)	**string quartet**	16'00"	x	
			observation 1.5 (2015)	**treb/desc rec., vln, vc.**	14.30"	x	
			observation 1.6 (2015)	**2 vlns.,** pno.	11'30"	x	
			observation 1.7 (2015)	**flt., ob., vln.**	12'40"	x	
			observation 1.7.5 (2015)	**alt flt., bsn, vln.**	7'00"	x	
			observation 3 (2016)	**double string quartet and doublebass**	15'00"	x	
			observation 6 (2016)	**picc.,** sop.sax., pno., perc.	12'30"	x	
			observation 4 (2016)	**string quartet**	17'00"	x	
			observation 5 (2016)	**string quartet**	18'30"	x	
			observation 7 (2016)	**picc., ob., tpt., hn., vla., db., perc.**	12'00"	x	
			observation 1.8 (2017)	**bass recorder, ob., vln.**	12'30"	x	
[and] a powerful flame came out of the earth […] (2019)	5(1/picc.2.3.4/picc, 5/alto/picc) 5(1.2/ca.3.4.5/ca) 5(1.2.3.bcl1.bcl2) 5(1.2.3.4+cbsn 5+cbsn) – 8.5(1.2.3.4.btpt) 3.2 – Tmp (2 players)+1(bd) – Strings: [16 (1 soli).14 (1 soli).12 (1 soli).10 (1 soli).8]	31'44"	*have heard this dialogue for one* (2013)	**alto flute**	ca. 12'00"	x	
			The Anatomy of Air (1997 rev. 2011)	2(1.2/picc) 2(1.2.) 2(1.2/bcl) 2(1.2/cbn) – 2 2 0 0 – **timp** – strings: 10, 8, 6, 4, 2	ca. 18'00"	(x)	
			The North Sound (2005/2013)	**3(1.2/picc, 3/picc/alto) 3(1.2.3+ca) 3(1.2.3/bcl) 3(1.2.3+cbsn) – 4 3 3 1 –** 2 harps – perc 1 – **strings: 16, 14, 12, 10, 8**	ca. 28'00"		x
			The Dog and the Wolf (2013)	**piccolo, clarinet, bassoon, trumpet, double bass,** celesta and **percussion (1)**	ca. 13'30"		x
			Black Sun (2013)	2(1.2/picc) 2(1.2) 2(1.2/bcl) 2(1.2/cbsn) – 2 2 0 0 – pno – **1 perc** – strings: 10, 8, 6, 4, 2	ca. 23'00"	(x)	
			observation 2 (2015)	**string quartet**	16'00"	(x)	
			the heaven that runs through everything (2018) large orchestral versions	Materials incorporated include **flt 2, ob1, ob2, tpt. 1 and bass tpt.**	30'00"		x
[…] which constantly generates a pulviscular cloud […] (2019)	3 (1.2.3) 3(1+ebcl 2.3) 3(1.2/ca 3) – 0 2 2 0 – pno – harp – perc 1 (Marimba [5 octaves]; Deep, resonant bass drum; 4 Tom-toms ranging from low to high; large, deep Tam-tam; 4 differently pitched resonant wooden objects ranging from low to high or 4 differently pitched temple / wood blocks ranging from low to high; 5 differently pitched resonant metal objects ranging from low to high; High-Hat; Gong (resonant – specific or non-specific pitch); Metal Wind Chimes Strings: 7, 5, 5, 6, 2.	20'36"	*Cerberus* (2008)	**trombones 1**.2.3.**4+bass** and percussion	15'00"		x
			On a Theme of Herems (2011)	**2 oboes and harp**	various		x
			the shape distance [9] (2013)	**2 flutes**	ca. 11'00'		x
			through woods in riot (2013)	**2 trumpets, 2 trombones**	ca. 10'00'		x
			shapeshifter (2015)	**E-flat clarinet and ensemble: flute, violin, violoncello, guitar, piano and percussion (1)**	20'00"		x
			Cutouts for Ensemble (2019)	**solo violin, oboe, 2 clarinets, harp, string quartet, percussion (1)**	13'00"		x
			pulviscular observation (2019)	**2 string quartets**	11'00"		x
			pulviscular compression (2019)	**19 strings: 4, 4, 4, 4, 3**	11'00"		x

Notes: Component instrumentation marked in **bold type** indicate instruments incorporated into the titled composition. All other instruments comprising the component pieces are not incorporated into the assemblage. 'X's marked in parenthesis '(x)' indicate minimal transformations of the source materials such as repetition, deletions and reorganisation of dissected untransformed materials but does not include pitch, rhythmic, tempo or transpositional transformations which are signified by the 'x' without parenthesis.

Looking more closely at the assemblages comprising the test-pieces themselves, Table 1, shows all four original orchestral pieces, their instrumentation, duration, the component parts that constitute them (self-borrowed materials and their assemblages), their particular instrumentation, durations and whether these materials have undergone transformational processes.

Portfolio compositions and their components.

As assemblages, all pieces are built from either self-borrowed extant ensemble pieces or materials extracted from extant pieces or have been, as is the case with *[...] which constantly generates a pulviscular cloud [...]*, supplemented with new materials designed specifically as additional modules for incorporation into the piece. The modular nature of each composition plus the material agencies, methods of material transformation and compositional construction are universal to all timecode-supported polytemporal orchestral pieces composed as part of this inquiry. As such, the orchestral compositions share the same methodology, in part or in full, and in general, describing the methodology of one piece describes the methodology of all. To this end, the methodology section uses examples from across the test-pieces to illustrate the various actions and processes undertaken with any specific methodological variance being highlighted in relation to that particular composition.

the heaven that runs through everything

Table 1, shows there are two versions of *the heaven that runs through everything*: the first, for a very large orchestra (one hundred and fourteen players) and the second version for a standard orchestra (ninety-two players), produced to facilitate performance where the deployment of larger orchestral forces would be seen as prohibitive. Both versions share the same duration and use the foundational timecode framework throughout. The standard version differs from the large orchestra version through the removal of twenty-two instrumental parts.

the heaven that runs through everything is the most instrumentally and polytemporally dense, structurally ambitious composition in the collection of test-pieces. As shown in Table 1, it also incorporates the most extensive array of components by drawing self-borrowed materials from the greatest number of extant ensemble pieces of all the test-pieces.

The composition was constructed (among other reasons) to test if the foundational timecode was sufficient to support structural integrity in performance. The establishment of a foundational timecode framework that supported acceptable renditions of a piece of this scale would have enabled further experimentation around relaxing the frequency of timecode signification in subsequent compositions, helping to ascertain which timecode frameworks best supported acceptable renditions. As discussed, due to the absence of performances of these particular orchestral pieces, the testing of additional timecode frameworks was not possible.

[and] a powerful flame came out of the earth [...]

[and] a powerful flame came out of the earth [...] divides its large orchestral forces into two instrumental groups as shown in Table 2, Group A is the largest and is comprised solely of materials appropriated from *The North Sound*, a previously synchronised and conducted work for orchestra. Group A uses phrase-initiated timecode and Group B, the second, smaller instrumental group, comprised of the remaining instruments not allocated to *The North Sound*, uses the foundational timecode framework. Material from *Have Heard this Dialogue for One* (2003) for alto flute is transformed and used extensively by Group B instruments in the first half of *[and] a powerful flame came out of the earth [...]* with the second half being dominated by largely untransformed materials appropriated from the timecode-supported polytemporal ensemble composition *The Dog and the Wolf* (2013), among others.

Table 2. Material and instrumental distributions in *[and] a powerful flame came out of the earth [...]*

Title	Overall Instrumentation	Group A instrumental materials originating from:	Group B instrumental materials originating from:	Specific instrumentation incorporating Group A or B, or A *and* B materials	Transformed	
					Yes	No
[and] a powerful flame came out of the earth [...] (2019)	5(1/picc1.2.3.4/picc, 5/alto/picc) 5(1.2/ca.3.4.5/ca) 5(1.2.3.bcl1.bcl2) 5(1.2.3.4+cbsn 5+cbsn) – 8.5(1.2.3.4.btpt) 3.2 – Tmp (2 players)+1(bd) – Strings: [16 (1 soli).14 (1 soli).12 (1 soli).10 (1 soli).8]	*The North Sound* (2005/2013)		Flutes 3, 4/Picc.2, 5/Alto/Picc.3; Oboes 3, 4, 5/Cor Anglais 2; Clarinets 2, 3, Bass Clarinet 2; Bassoons 2, 3, Contrabassoon 2; Horns 5, 6, 7, 8; Trumpets 2, 3, 4; Trombones 1, 2, 3; Tuba 2; Strings (16.14.12.10.8).		x
			have heard this dialogue for one (2013)	Flute 1, Clarinet 1, Bass Clarinet 1, Bassoon 1, Contrabassoon 1, Horns 1, 2, 3, 4; Tuba 1	x	
			The Anatomy of Air (1997 rev. 2011)	Timpani; Bass Drum	x	
			The Dog and the Wolf (2013)	Flute/Piccolo 1; Clarinet 1; Bassoon 1, Contrabassoon 1; Horns 1, 2, 3, 4; Trumpet 1; Tuba 1; Bass Drum;		x
			Black Sun (2013)	Contrabassoon 1; Horns 1, 2, 3, 4; Timpani; Bass Drum	(x)	
			observation 2 (2015)	Violin 1 solo, Violin 2 solo, Viola solo, Violoncello solo	(x)	
			the heaven that runs through everything (2018) large orchestral versions	Flute 2: Oboes 1, 2; Bass Clarient 1; Bass Trumpet; Tuba 1		x

Note: 'X's marked in parenthesis '(x)' indicate minimal transformations of the source materials such as repetition, deletions and reorganisation of dissected untransformed materials but does not include pitch, rhythmic, tempo or transpositional transformations which are signified by the 'x' without parenthesis.

This group also incorporates passages where each instrumental voice progressively slows down through ritardando to reach slower tempi, the first time such a fluid temporal device has been incorporated into the foundational timecode framework. Group B materials also constitute the most virtuosic writing within this orchestral collective and include the principal players of all instrumental sections, hence, for example, as shown in Table 2, Flute 1 and 2 are part of Group B and Flutes 3, 4, and 5 belong to Group A and *The North Sound* collection of materials. Additionally, contrasting timecode frameworks help to separate the identities of each group beyond these material differences.[120]

Apart from separating material identities, phase-initiated timecode distribution was introduced into *The North Sound* group to test and observe how a formally synchronised, conducted orchestral piece would be rendered when the mechanisms to support synchronisation, particularly the removal of the conductor, left the players using only their sense of tempo, phase-initiated timecode and stopwatches, to manage the structural organisation of the piece. Such actions would test if this newly de-synchronised, heavily mediated instantiation of *The North Sound* would, in combination with Group B materials, generate an entirely new composition yet retain something of *The North Sound's* former identity as part of a large-scale polytemporal entity.

[...] which constantly generates a pulviscular cloud [...]

The fourth piece, *[...] which constantly generates a pulviscular cloud [...]*, is composed for chamber orchestra and uses much smaller forces (forty-one players), has a shorter, twenty-minute duration and is designed to bring all three timecode frameworks together simultaneously. Unlike the previous test-pieces, *[...] which constantly generates a pulviscular cloud [...]* assimilates all instrumental and notation materials 'as is', that is, as they are configured in the original ensemble compositions so that the instrumentation of these

[120] Information about all the pieces comprising *[and] a powerful flame came out of the earth [...]* can be found at 'Marc Yeats: Composer' website: *The North Sound* (2005 refreshed 2014) <https://www.marc-yeats.com/the-north-sound-2005/>, *observation 2* (2015)* <https://www.marc-yeats.com/?s=observation+2>, *The Dog and the Wolf* (2013) <https://www.marc-yeats.com/the-dog-and-the- wolf-2013-for-6-instrumentalists/>, *Black Sun* (2013) <https://www.marc-yeats.com/black-sun-2013/>, *The Anatomy of Air* (1997 rev. 2011) <https://www.marc-yeats.com/the-anatomy-of-air-1997/>, *Have Heard this Dialogue For One* (2003)* <https://www.marc-yeats.com/have-heard-this-dialogue-for-one-2003/> [all accessed 12 March 2019]. Links indicated with * have online audio recordings associated with them.

ensemble pieces become incorporated into the instrumental assemblage of *[...] which constantly generates a pulviscular cloud [...]* making a nested assemblage built from multiple heterogeneous assemblages (see Table 3, p. 89, for specific component details).

Specifically written for inclusion in *[...] which constantly generates a pulviscular cloud [...]*, *pulviscular observation* for double string quartet was recorded as a discrete performance and recording project.[121] The intention was for two recordings to be made of each quartet playing their timecode-supported materials for later simultaneous combination into another studio recording where their loosely synchronised playing would generate the heterophonic expansion of materials from two quartets into four quartets (from eight to sixteen players). It was the predicted difference in the mediation of identical materials by the same players using the foundational timecode framework that produced the heterophonic outcomes, evident when both iterations of each string quartet were synchronised to their starting points and compared in software. These combined recordings along with the addition of three independent double bass parts constitute *pulviscular compression*, bringing the complement of players to nineteen and contrasting it to the eight players used in *pulviscular observation*.[122] For *pulviscular compression* to constitute the primary body of strings (the Group 3 module in Table 3), the double bass material was repurposed from three players to two.

Table 3. Performance groupings in *[...] which constantly generates a pulviscular cloud [...]*

Title	Instrumentation	Group	Components	Instrumentation	Duration	Transformed Yes	Transformed No
[…] which constantly generates a pulviscular cloud […] (2019)	3 (1.2.3) 3(1+ebcl 2.3) 3(1.2/ca 3) – 0 2 2 0 – pno – harp – perc 1 (Marimba [5 octaves]; Deep, resonant bass drum; 4 Tom-toms ranging from low to high; large, deep Tam-tam; 4 differently pitched resonant wooden objects ranging from low to high or 4 differently pitched temple / wood blocks ranging from low to high; 5 differently pitched resonant metal objects ranging from low to high; High-Hat; Gong (resonant – specific or non-specific pitch); Metal Wind Chimes Strings: 7, 5, 5, 6, 2.	**5**	*Cerberus* (2008)	**trombones 1.2.3.4+bass** and percussion	15'00"		x
		6	*On a Theme of Herens* (2011)	**2 oboes and harp**	various		x
		4	*the shape distance [9]* (2013)	**2 flutes**	ca. 11'00'		x
		5	*through woods in riot (2013)*	**2 trumpets, 2 trombones**	ca. 10'00'		x
		1	*shapeshifter* (2015)	**E-flat clarinet and ensemble: flute, violin, violoncello, guitar, piano and percussion (1)**	20'00"		x
		2	*Cutouts for Ensemble* (2019)	**solo violin, oboe, 2 clarinets, harp, string quartet, percussion (1)**	13'00"		x
		3	*pulviscular compression* (2019)	**19 strings: 4, 4, 4, 4, 3**	11'00"		x

Notes: Component instrumentation marked in **bold type** indicate instruments incorporated into the titled composition. All other instruments comprising the component pieces are not incorporated into the assemblage. 'X's marked in parenthesis '(x)' indicate minimal transformations of the source materials such as repetition, deletions and reorganisation of dissected untransformed materials but does not include pitch, rhythmic, tempo or transpositional transformations which are signified by the 'x' without parenthesis.

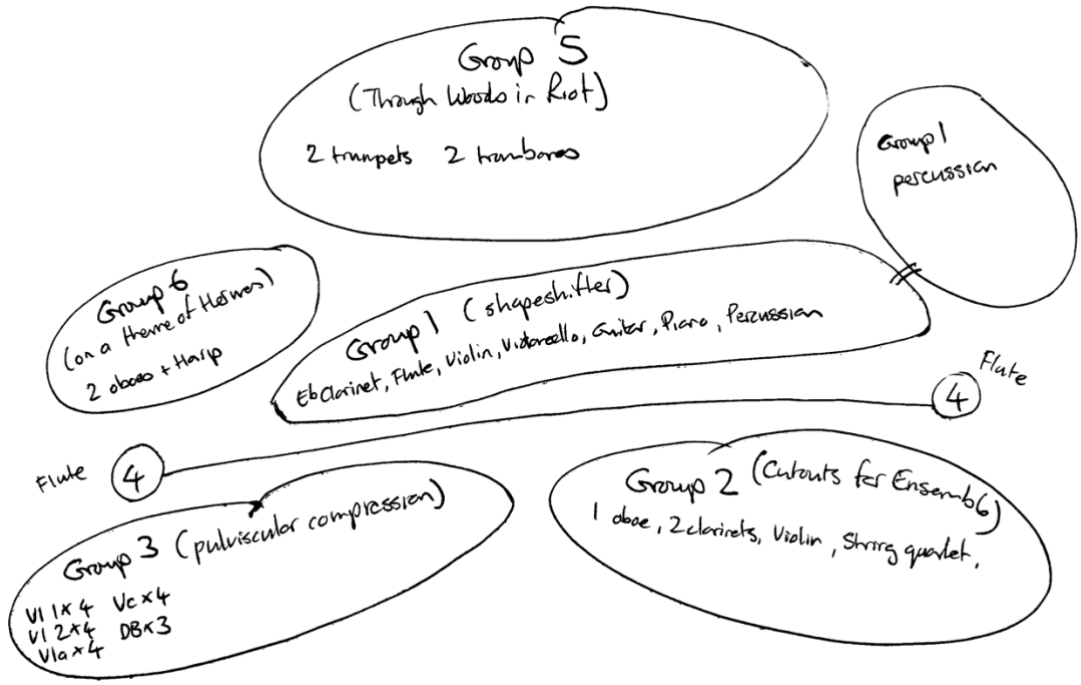
[121] *pulviscular observation* recordings were made with the Karski and Viridis Quartets at the Royal Northern College of Music, Manchester, in March 2019.

[122] A recording of *pulviscular compression* is available at 'Marc Yeats: Composer' website: <https://www.marc-yeats.com/pulviscular-compression-2019/> and *pulviscular observation* is accessible here <https://www.marc-yeats.com/pulviscular-observation-2019/> [accessed 22 July 2019]

When *[…] which constantly generates a pulviscular cloud […]* is performed live, heterophony will be generated by the simultaneous, loosely synchronised performance of identical string materials by individual players assigned to each part as opposed to the studio recording version that uses the same performer's iterative mediations.

As part of the process of assembling the test-piece and recontextualising its appropriated materials, the assimilated ensemble pieces including *pulviscular compression*, are cut up into smaller segments of material with sections retained or discarded as necessary to be distributed as blocks of material across the timeline of the piece where, in the main, those dissected blocks retain the same sequential order they possessed in the original compositions as if areas of material had been erased but the continuity of the piece maintained. The assemblage of ensemble modules is further organised into six groups (see Table 3) that are spatially situated for performance (the suggested layout is shown in Figure 11, p. 90).[123]

Figure 11. Performance layout *[...] which constantly generates a pulviscular cloud [...]* (2019)



This modular compositional approach is designed with two performance and recording outcomes in mind: the first is a standard performance iteration in which all musicians perform

[123] Information about the pieces comprising this group can be found at 'Marc Yeats: Composer' website and include online audio recordings of: *Through Woods in Riot* (2013) <https://www.marc-yeats.com/through-woods-in-riot-2013/>, *On a Theme of Hermes* (2011) <https://www.marc-yeats.com/on-a-theme-of-hermes-2011/>, and *The Shape Distance [9]* (2013) <https://www.marc-yeats.com/the-shape-distance-9-2013/> [all accessed 21 July 2019]

as a chamber orchestra, spatially organised in one location at the same time, to produce a live performance recording; and the second iteration which necessitates the modular elements — the discrete individual ensemble pieces that are combined to comprise the piece — being recorded remotely and later mixed in software to create a studio recording.

The studio recording iteration offers a practical solution for producing a mediated audio recording where performance with the chamber orchestra is not possible. In this circumstance, it may be easier for the composer to obtain performances of the ensemble modules over a period of time, piece by piece, to build towards the full complement of modular composition recordings necessary to assemble into the chamber orchestra recording that produced with care, has the potential to yield a serviceable iterative demonstration recording of the composition.[124]

During the course of this investigation, it has proven impossible to secure a live performance of *[...] which constantly generates a pulviscular cloud [...]*. However, a remote recording made using materials predating this investigation is available in the PhD Materials folder.

***the unimportance of events* (2021)**

Alongside *[...] which constantly generates a pulviscular cloud [...]*, and a later addition to the test-pieces, *the unimportance of events* (2021) is one of two chamber orchestra pieces composed as part of this project. It remains the only orchestral test-piece to have been performed during the project timeframe.

Using the foundational timecode framework throughout its twelve-minute duration and like *[...] which constantly generates a pulviscular cloud [...]*, *the unimportance of events* (2021) is spatially arranged into six groups with group one comprising four soloists — alto

[124] Although not a specific research question of this investigation, the idea to test the efficacy of timecode-supported polytemporal materials in this way — creating an assemblage of extant audio and notational materials where each modular composition is performed and recorded independently of each other for later assembly in software to create a recording of the orchestral piece — is consistent with the assemblage approach to composition practiced and discussed throughout this methodology.

flute, bassoon, violin and double bass — positioned at the front of the ensemble; and successively behind them, group two and three, including one string quartet each; group four, composed of piano, oboe and clarinet; group five, containing two horns; and finally, group six, comprising of percussion, two trumpets and two trombones, positioned toward the rear of the orchestra.

Apart from a few modifications to some of the instrumental parts, *the unimportance of events* (2021) is identical to *the unimportance of events* for seventeen players of 2019 except for the addition of five instrumental lines used to expand the instrumentation vertically, self-borrowed from a range of other orchestral test-pieces. These additions include an oboe, two horns and two trumpets. Complete instrumentation and all self-borrowed material origins are shown in in Table 4, p. 92. Links to a live video recording of this piece can be accessed from the PhD Materials folder.

Table 4. *the unimportance of events* (2021) ensemble components

Title	Instrumentation	Duration	Components	Instrumentation	Duration	Transformed Yes	Transformed No
the unimportance of events (2021)	22 players: alto flute/flute, oboe, clarinet, bassoon, 5 violins, 2 violas, 2 violoncellos, double bass, 2 horns, 2 trumpets, 2 trombones, piano, percussion	12'04"	*Cerberus* (2008)	**trombones 1.2.3.4** and percussion	15'00"		x
			On a Theme of Herems (2011)	**clarinet**	various		x
			lentern fires (2013)	**piano**	ca. 13'00"		x
			the shape distance [7] (2013)	2 flutes, clarinet, viola, harp, piano, **percussion**	ca. 11'00'		x
			observation 1.7.5 (2015)	**alt flt., bsn, vln.**	7'00"	x	
			the heaven that runs through everything (2018) standard orchestral version	**trumpets 1 and 2**	30"	x	
			[and] a powerful flame came out of the earth [...] (2018)	**horns 1 and 2**	31'34"		x
			[and] a powerful flame came out of the earth [...] (2018)	**oboe**	31'34"		x
			pulviscular observation (2019)	**double string quartet**	11'00"		x
			pulviscular compression (2019)	**double bass**	11'00"		x

Notes: Component instrumentation marked in **bold type** indicate instruments incorporated into the titled composition. All other instruments comprising the component pieces are not incorporated into the assemblage. 'X's marked in parenthesis '(x)' indicate minimal transformations of the source materials such as repetition, deletions and reorganisation of dissected untransformed materials but does not include pitch, rhythmic, tempo or transpositional transformations which are signified by the 'x' without parenthesis.

Apart from a few modifications to some of the instrumental parts, *the unimportance of events* (2021) is identical to *the unimportance of events* for seventeen players of 2019 except for the addition of five instrumental lines used to expand the instrumentation vertically, self-borrowed from a range of other orchestral test-pieces. These additions include an oboe, two horns and two trumpets. Complete instrumentation and all self-borrowed material origins are shown in Table 4. Links to a live video recording of this piece can be accessed from the PhD Materials folder.

Ensemble compositions and their components

Having discussed the orchestral test-pieces and the components that comprise them, Table 5, p. 93, shows the range of ensemble pieces composed as part of this research project along with their instrumentation, duration and the instrumentation and duration of the component pieces, themselves generated from previous self-borrowing actions, that constitute the ensemble piece assemblages designed for possible inclusion into *[...] which constantly generates a pulviscular cloud [...]*.

Table 5. Ensemble compositions and their components

Title	Instrumentation	Duration	Components	Instrumentation	Duration	Transformed Yes	Transformed No
Cutouts for Ensemble (2019)	For 10 players: solo violin, oboe, 2 clarinets, harp, string quartet, percussion (1)	13'00"	*On a Theme of Herems* (2011)	**oboe, 2 clarinets, harp and percussion**	various		x
			Cutouts (2014)	**solo violin**	ca. 12'00'		x
			observation 1 (2015)	**string quartet**	14.30"		x
			observation 2 (2015)	**string quartet**	16'00"		x
pulviscular observation (2019)	double string quartet	11'00"	*observation 4* (2016)	**string quartet**	17'00"	(x)	
			observation 5 (2016)	**string quartet**	18'30"	(x)	
pulviscular compression (2019)	19 strings: 4, 4, 4, 4, 3 organised as 4 string quartets and 3 double basses.	11'00"	*and cherries all black* (2013)	**double bass** and piano	ca. 13'00'		x
			pulviscular observation (2019)	**double string quartet**	17'00"		x
the unimportance of events (2019)	17 players: alto flute, clarinet, bassoon, 5 violins, 2 violas, 2 violoncellos, double bass, 2 trombones, piano, percussion	12'04"	*Cerberus* (2008)	**trombones 1.**2.3.**4+bass** and percussion	15'00"		x
			On a Theme of Herems (2011)	**clarinet**	various		x
			lentern fires (2013)	**piano**	ca. 13'00"		x
			the shape distance [7] (2013)	2 flutes, clarinet, viola, harp, piano, **percussion**	ca. 11'00'		x
			observation 1.7.5 (2015)	**alt flt., bsn, vln.**	7'00"		x
			pulviscular observation (2019)	**double string quartet**	11'00"		x
			pulviscular compression (2019)	19 strings: 4, 4, 4, 4, 3 **(double bass 1)**	11'00"		x
obscure sorrows (2019)	clarinet and violin	11'16"	*Cutouts* (2014)	**solo violin**	ca. 12'00'		x
			liquid music (2017)	**solo clarinet**	14'00"		x

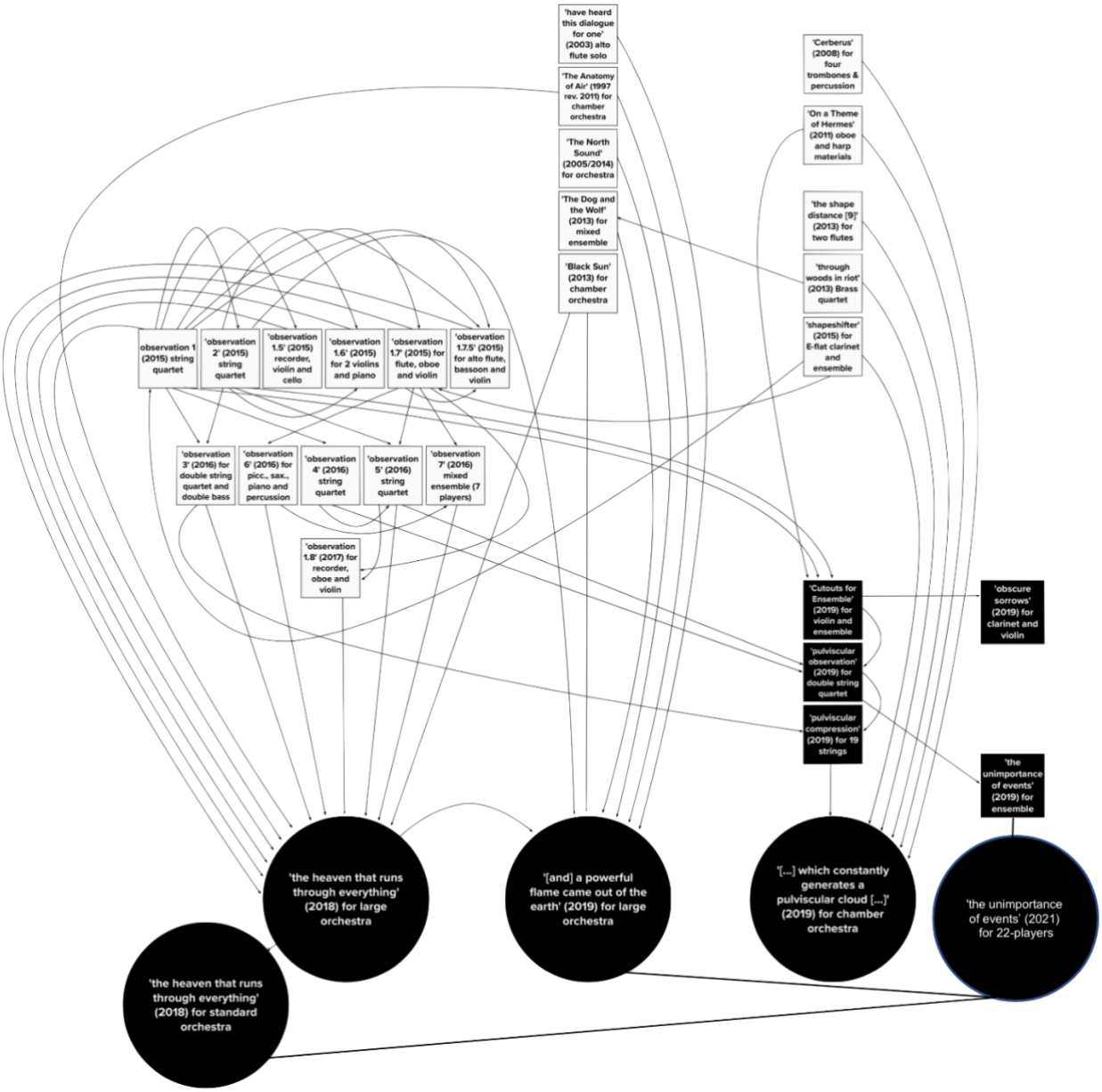
Notes: Component instrumentation marked in **bold type** indicate instruments incorporated into the titled composition. All other instruments comprising the component pieces are not incorporated into the assemblage. 'X's marked in parenthesis '(x)' indicate minimal transformations of the source materials such as repetition, deletions and reorganisation of dissected untransformed materials but does not include pitch, rhythmic, tempo or transpositional transformations which are signified by the 'x' without parenthesis.

While Table 1 and Table 5, illustrate all the test-piece components and their instrumentation in list form, Figure 12, p. 94, a self-borrowing map demonstrates the dynamic and complex relationship between the primary components and the test-pieces, showing how self-borrowing occurs between and across different generations of pieces, indicating the use and reuse of materials as a pervasive, ongoing process. While this self-borrowing map shows the relationship between materials and compositions, it does not indicate which self-borrowed materials have undergone transformational processes along the way. Reference will need to be made back to Table 1 and Table 5, for such information.

The self-borrowing map is a complex relational graphic. However, it would be misleading to assume that the organisation represented here is in any way premeditated. It is not. The graphic is constructed by working backwards through a process that unfolded across several years as a method for generating pieces on an 'as and when' basis, driven by artistic considerations and intuitive actions.

The pieces in solid black — circles for orchestral, squares for ensemble — are the compositions specifically generated for this research. The pieces in clear boxes, the earliest dating back to 2003, are the progenitors to this research, embedded through the act of self-borrowing and assimilation into new assemblages that have found their way, transformed or untransformed, into the test-pieces. The primary transformational processes are outlined next.

Figure 12. Self-borrowing map connecting all research compositions



3.1.4 Self-Borrowing

I use a range of material transformation processes dealing with tempo, pitch, rhythm, expressive matter and voicing that almost entirely focus upon the generation of new materials through acts of material self-borrowing that for me, guarantee a stylistic connectivity and consistency between all pieces I compose as well as the individual materials that comprise them. These transformative processes are neither complex nor sophisticated. They range between algorithmic and intuitive and are brought together in an idiosyncratic approach established through many years of practical composition and performance experience. At the heart of these transformations lies a recursive process that through cumulative actions across time and multiple compositions cyclically repurpose self-borrowed and transformed materials to imbue them with an inherited semiotic richness — a transmitted legacy — that is embedded in the material components comprising the test-pieces described above. Although the temporal functionality of this methodology is not contingent upon these transformational processes and describing each in full would amount to something of a detour, I would like to include a brief overview of tempo and rhythmic transformation as they have some relevance to the temporal functioning of this project.

As this methodology supports polytemporal composition, it is unsurprising that tempo is a significant parameter through which the identities of notation materials are transformed to achieve temporal differentiation. Including practical considerations that ensure newly generated tempi can be executed in relation to the specific materials and instruments they are applied to, in general, tempo transformations are based on nothing more than a subjective 'what feels right' basis while at other times, as in *the heaven that runs through everything*, tempo transformations are more organised and confined to a 2–10% reduction in speed compared to the tempi of untransformed materials. To maintain the relational characteristics of self-borrowed materials, tempo changes are frequently applied proportionally across all tempi comprising that content.

Conversely, the rhythmic configurations these materials comprise of are subject to little or no transformation outside of the tempo at which they are rendered. Transformations of tempo do not have a direct effect on the internal proportional relationships of hierarchical rhythmic configurations as their proportional relationships remain unchanged in notation if the material is subject to faster or slower tempi. As discussed in Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions, tempo changes do not alter notation,

only the duration of the materials as measured in clock-time or BPM. However, changes to tempo will radically alter relationships with other temporal structures in the piece.

3.1.5 Creating Materials that 'Work' in Shifting Contexts

Although not critical to the testing of timecode frameworks in performance per se, the notion of generating materials that work in shifting contexts is important with regard to creating compositions that succeed for me in musical terms and as pieces of art in their own right while also effectively testing timecode frameworks in performance. To this end, I would like to briefly discuss the particular advantages in applying self-similar transformative actions to self-borrowed materials in repeated operations.

Materials transformed in this manner sound 'right', as if they 'work' together whatever their vertical or horizontal placement within a given piece. It is the relational connectivity and inherited semiotic richness that supports this correspondence and enables the material to be confidently fixed within the model in the knowledge that despite the somewhat elastic but nevertheless, confined parameters inherent in player-mediation using timecode frameworks, materials will sound appropriately placed when rendered in performance.

This sense of heterogeneous elements working together and sounding 'right' is, of course, wholly subjective and it is an assumption that listeners, too, will perceive the same or any degree of sonic connectivity between materials in a similar manner to myself. However, the assumption that content relationships are indeed perceived by listeners is strengthened by the more objective nature of a range of referent, self-borrowed and recursive transformational processes that clearly point to conceptual and audible relational associations between materials. Nevertheless, despite the propensity for notation content to feel as if it works in multiple contexts, there are some combinations that intuitively feel as if they work better than others due to relational qualities revealed through the actions of combination when building the audio file assemblage that suggest further potential to enhance the architecture and identity of a piece. Chosen subjectively, it is these material combinations that become fixed elements in the model and flexibly mediated elements when rendered in performance. Such relational flexibility is an essential quality within mediated timecode frameworks if a

composition is to sound consistent, cohesive and through-composed, regardless of the degree of elasticity a performance may incur.

Aspects of rendered structural flexibility in works where parts are not linked together through a score were also important considerations for Cage who analogised the durability of such relationships in performance using the example of a skyscraper being sufficiently flexible such relationships in performance using the example of a skyscraper being sufficiently flexible to survive an earthquake rather than crumbling to the ground.[125] Looking further at a number of Cage's compositions, for example, *Thirty Pieces for Five Orchestras* (1981), and *Thirty Pieces for String Quartet* (1983), it is clear he was interested in relational pliability and developing materials and a system for their mediation in performance that 'will survive, so to speak, any relationship of the parts'.[126]

Though Cage's more open material organisation is differentiated from timecode-supported polytemporal outcomes by its extremes of elasticity and intentionally indeterminate performance goals, the ability to preserve a sense of material and structural relationships that work together in their particular immanent contexts are goals shared with this methodology. These goals and their projection or sense of appropriate or even inevitable-sounding material relationships, rendered and perceived through playback of the audio model and later, live performance, are initially established and subsequently fixed as part of the audio file assemblage build discussed later in the methodology.

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[125] "[T]here won't be a score that connects all of the parts. There won't be a fixed relation between those instruments, but rather a flexible relation between them. It resembles, perhaps, that aspect of architecture in, say, San Francisco where, because of the fault in the earth, the architecture has to be flexible and to be able to move, so when there is an earthquake, the building will simply shake instead of falling down." Richard Kostelanetz, *Conversing with Cage*, 2nd. edn (New York, NY: Taylor & Francis, 2005), e-book, p. 122. Original material provided by Bill Shoemaker, in The Age of Cage, *Down Beat Magazine* (December 1984).

[126] Cage was interested in material that worked in multiple contexts, too, though his parameters for the placing of those materials along the timeline of a piece, as described in this quote, exhibit greater degrees of performer-choice than the more tightly controlled flexibility parameters found in *the heaven that runs through everything* or any of the test-pieces: 'I'm thinking now, and have been for several years, of kinds of music which will survive, so to speak, any relationship of the parts. In a piece called *Thirty Pieces for Five Orchestras*, and in another one, *Thirty Pieces for String Quartet*, I literally made thirty pieces for each group of instruments in the orchestra and each instrument in the string quartet. Those pieces could begin anywhere at any point of time between zero and forty-five seconds, and end at any point of time between thirty seconds and one minute, fifteen seconds. The whole composition, which is a series of thirty of these, would last approximately thirty minutes. Any one segment of a piece, or any one of the pieces of those thirty, could be played in one tempo or another, because of this latitude or flexibility in the beginning and ending'. Kostelanetz, *Conversing with Cage*, p. 122. Original material provided by Bill Shoemaker, in 'The Age of Cage', in *Down Beat Magazine* (December 1984).

Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions

With the methodology introduction complete, I now examine the first part of a related two-part theoretical framework looking at how timecode-supported polytemporal orchestral music functions compositionally through player mediation to render live performances, with the second part of the framework, Part 3: Building the Model, examining how notation materials and their concomitant audio file recordings are generated and assembled to make polytemporal compositions.

By and large, explanations around functionality and build have been kept separate to clarify the actions of both in a manner that mirrors timecode-supported polytemporal compositional process where initially, an understanding of intended outcomes and the functionalities necessary to deliver those outcomes result, secondarily, in the choices and rationale around which tools and methods are required to build the compositions themselves. This somewhat artificial separation is undertaken with an understanding that functionality and build are overlapping aspects of a multi-dimensional methodological approach where 'both phenomena are contingent upon the existence of the other' and where movement between the two is seldom linear or as predictable as this separation implies.[127]

To this end, Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions presents a commentary that moves through a series of subsections to describe how the term timecode-supported polytemporal music was constructed, what the term means and how the methods, techniques, functionalities, conditions and actions comprising it work together as a new, alternative composition methodology that offers the composer wishing to write dense, polytemporal, through-composed orchestral music the opportunity to assemble pieces comprised of multiple, unrelated tempi where all orchestral voices have independent temporal trajectories that, unlike current notational temporal praxis, do not require notation to become more rhythmically complex to 'fit' multiple pulse-streams into a synchronised score format or use multiple conductors or click-tracks to manage polytemporal pieces in

[127] Prishani Reddy. 'The Differences Between Research Methods and Research Methodology' from the website 'DifferenceBetween.net' (May 2018) <http://www.differencebetween.net/science/the-differences-between-research-methods-and-research-methodology/> [Accessed 31 May 2021]

performance to deliver near-determinate outcomes.

3.2 A Unique Combination of Familiar Functionalities, Actions and Conditions

Moving to the description of what timecode-supported polytemporal music is and how it functions, it is useful to examine what words have been assembled to generate a name for this compositional methodology. The term arose through combining a compositional species — polytemporal music — that categorises compositions consisting of two or more simultaneous tempi as polytemporal, with a digital functionality — timecode — that is signified in notation as a series of numeric codes expressed through hours, minutes and seconds, generated at regular or irregular intervals by a timing synchronisation system present within notation and other software to provide a framework for temporal coordination and the logging of actions in time. As Ratcliff explains: 'Timecode is a digital signal. It carries information as a sequence of zeros (0s) and ones (1s), called "digits". These digits may represent quantities such as time or film footage'.[128]

Coordination in timecode-supported polytemporal music is achieved by all performers loosely synchronising mobile phone stopwatches at the start of performances and continually mediating timecode in relation to their stopwatches as they play, matching as closely as possible timecode positions in their notation to the rolling time displayed on their stopwatches. To achieve this coordination, the timecode uses a reliable and objective measurement of time referred to as clock-time. Clock-time is used as the unit of time-measurement displayed on digital stopwatches and other forms of chronometer.

Although timecode and clock-time are used throughout this methodology as a means of measuring and apportioning time, music performance generally relies on a different measurement of time called 'musical time' that uses the beat and beats per minute or BPM as its agreed division of time. Dobrian defines BPM as a type of time measurement that 'relies on an agreed-upon more-or-less constant unit of time known as a beat,' where '[t]he relationship of musical time to clock time is based on [...] the number of beats that occur in a certain amount of clock time, commonly beats per minute (BPM) — known as the tempo'.[129]

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[128] John Ratcliff, *Timecode: A user's guide*, 3rd edn, (Burlington, MA: Focal Press 2015) p. 27.

[129] Christopher Dobrian, 'Techniques for Polytemporal Composition' (Paper, Korean Electro-Acoustic Music Society, Seoul, Korea, 26 October 2012), PDF, Department of Music, Claire Trevor School of the Arts, UC Irvine <https://music.arts.uci.edu/dobrian/polytemporal/TechniquesForPolytemporalComposition.pdf> [accessed 17 June 2018] p. 1.

Timecode-supported polytemporal orchestral composition utilises clock-time and musical time: clock-time for the organisation of sonic events in time through timecode in notation and musical time in the mediated rendering of those notated events as sound in performance through tempo interpretation. Unlike the reliability of clock-time, musical time is malleable and flexible. It is the balance and tension between the precision of clock-time signified through timecode and the mediated expression of timecode as flexible musical time that underpins the actions of composer control and performance flexibility discussed later in this chapter and it is clock-time signified through the timecode framework that supports the player's mediation of tempo interpretation as musical time to manage the simultaneous delivery of different polytemporal streams in performance. It is this timecode framework that provides the support function referenced in the term timecode-*supported* polytemporal orchestral composition.

None of the above functionalities, actions or conditions are new to composition. Music consisting of different simultaneous pulse streams is well established. For example, according to Apel, the origins of polytemporal composition in the form of prolation canon and mensuration canon, in which a melody is performed in imitation but with augmented or diminished rhythmic values, can be traced back to compositions exploring proportion ca.1200.[130]

In comparison to the diminution or augmentation of metrical values in mediaeval and Renaissance music, timecode, on the other hand, is a recent functionality used to coordinate musical scores and performance with film that dates back to the nineteen sixties and the advent of SMPTE timecode (Society of Motion Picture and Television Engineers) that according to Davis, was developed as a type of 'timecode that enables different computers, synthesizers, and video machines to talk to each other and synchronize music to video or music to music'.[131] This cross-representation of digital documents, especially through audio

[130] 'The use of proportions, that is, of the diminution and augmentation of metrical values in certain arithmetic ratios, is a characteristic feature of the Flemish music of the fifteenth and early sixteenth centuries. Its history, however, goes back to considerably earlier periods. The first traces of this method are encountered in some of the clausulae [a newly composed polyphonic section for two or more voices sung as a descant] of the period of Perotinus (ca. 1200), in which the liturgical melody serving as tenor appears twice, the second time in half or double the values of the first appearance'. Willi Apel, *The Notation of Polyphonic Music 900–1600*, 38, The Mediaeval Academy of America, 4th edn, (Cambridge, MA: The Mediaeval Academy of America, 1949), p. 145.

[131] Richard Davis, *Complete Guide to Film Scoring: The Art and Business of Writing Music for Movies and TV*, ed. by Jonathan Feist (Boston MA: Berkley Press, 1999), p. 96.

recordings, MIDI files and digitised sheet music, is at the core of how timecode-supported polytemporal music is built and functions.[132]

Stopwatches, too, have a history of being used for synchronisation purposes. As Davis explains: 'Another method of syncing music to film is the use of the stopclock [...] (basically a large stopwatch about twelve inches in diameter) [...] but realistically, it is accurate for sync points only to a plus or minus a third of a second'.[133] The search to eliminate the response time of human performers to cues in film remains a challenge.[134] However, precise synchronisation is not required in timecode-supported polytemporal music performance. Here, the use of loosely synchronised individual mobile phone stopwatches serves to amplify a less than perfect synchronisation, a condition that would occur to a lesser extent, for instance, if all players were synchronising their playing when reading clock-time from a single stopwatch such as the one Davies describes above.

It is not the incorporation of these familiar elements within this methodology that brings about unique creative opportunities for composers and performers. It is, however, the capacity of these factors in combination to support the rendition of hyper-dense polytemporal structures in specific and unique ways that provides new opportunities to expand current polytemporal praxis. This exegesis seeks to prove its assumptions around new compositional opportunities through a thorough investigation of the mechanisms and processes embedded in this methodology manifested as music through the performance of its test-pieces. To begin this investigation, I shall discuss the central unifying role timecode plays in building compositional models and how through using timecode, stopwatches and player mediation, these models are rendered as sound.

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[132] Ewart, Meinard and Dannenberg assert that as communication between computers and software proliferates with continued digitisation: 'there is an increasing number of relevant digital documents for a single musical work comprising audio recordings, MIDI files, digitized sheet music, [and] music videos' where, '[i]n general terms, music synchronization denotes a procedure which, for a given position in one representation of a piece of music, determines the corresponding position within another representation'. Sebastian Ewert, Müller Meinard and Roger B. Dannenberg, 'Towards reliable partial music alignments using multiple synchronization strategies', *International Workshop on Adaptive Multimedia Retrieval* (2009), 35–48 (p. 35).

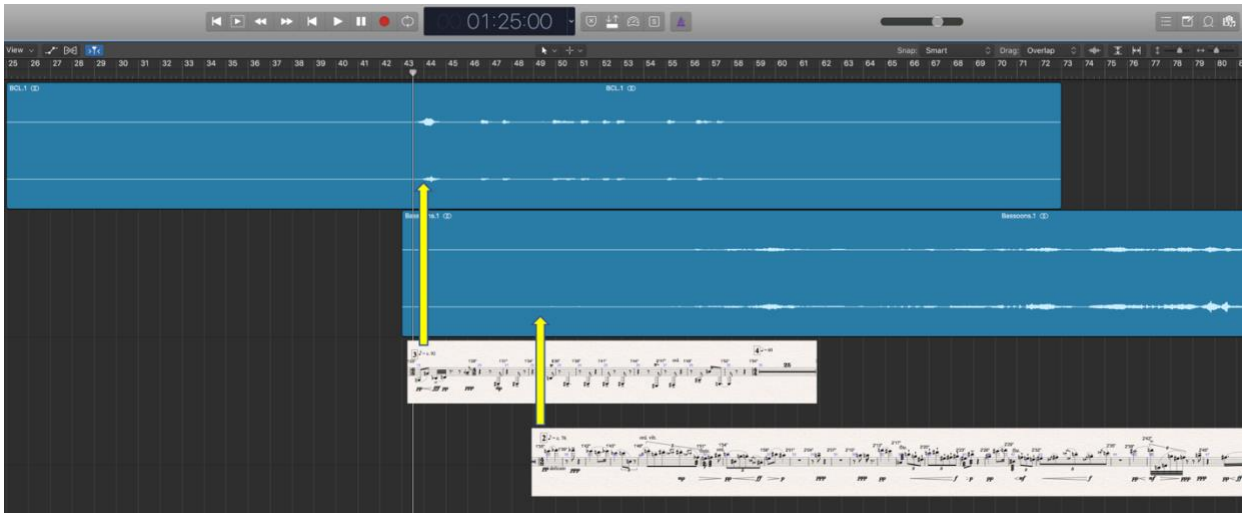
[133] Davis, *Complete Guide to Film Scoring* p. 160.

[134] 'The lag time in perception between seeing an image and responding to it spurred the development of systems capable of assisting conductors and players in producing precise timing: the click track, an audible metronome delivered to the musicians via headphones; punches and streamers, actually holes punched and lines scratched into the film at strategic points so that the conductor is prepared for important moments of synchronization; and free timing, the use of a large stopwatch to facilitate precision'. Kathryn Kalinak, *Film Music: A Very Short Introduction*, (New York, NY: Oxford University Press, 2010), pp. 126–127.

3.2.1 The Model: Audio Assemblages and Notation Networks

'The model' is a term used throughout this exegesis to describe the compositional blueprint for all timecode-supported polytemporal compositions. It comprises audio and notation components. The audio components are generated through the playback and recording functionalities of Sibelius where original and transformed materials are recorded and exported as audio files. These audio files are then imported into Logic Pro, a sequencing software, where the audio files are assembled into compositional structures called audio file assemblages. An audio file assemblage contains multiple audio files organised vertically for density and horizontally for duration. A polytemporal audio output is produced when these recordings, all containing materials rendered at different speeds, are simultaneously combined through playback. It is this computer-generated audio that is referred to as the audio model.

Figure 13. Illustrative approximation showing unpacked audio files acting as placeholders for notation materials within audio files for bass clarinet 1 and bassoon 1 extrapolated from *the heaven that runs through everything* (2018).

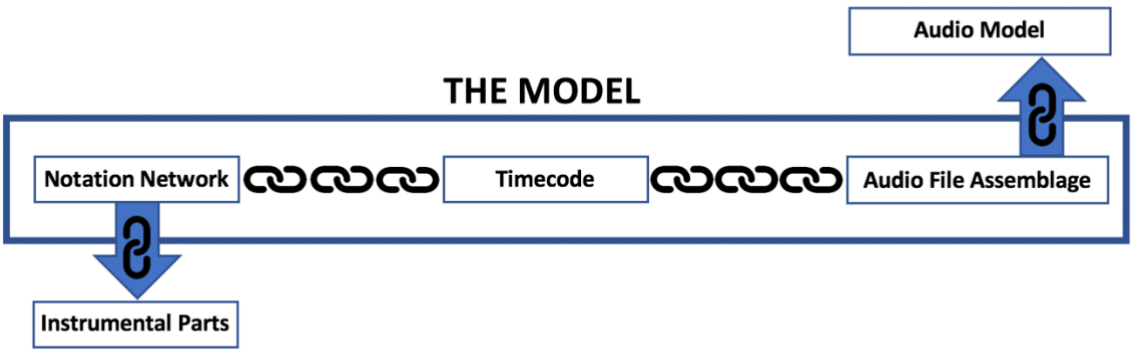


The notation component of the model, the notation network, is not visible as it would be in a score. It exists as a virtual construct of notation materials that are linked to the audio file assemblage where each audio file acts as a placeholder and audio realisation for the specific notation materials from which it was rendered (see Figure 13, p. 102). It is the organisation of audio files in the audio file assemblage that governs the exact duplication and configuration of notation materials in the notation network without displaying any of the notational information

itself. As such, the notation network is invisible. However, the relationships between the relative positions of notation materials constituting that network *are* visibly signified as positions in time through the audio file configurations that "placehold" that information and constitute the audio file assemblage displayed in the software.

Bringing these audio and notation components together as the model, Figure 14, p. 103, illustrates the timecode links between the audio file assemblage and the audio model, on the one hand, and between the notation network and instrumental parts, on the other. This timecode linkage is indicated through the placement of audio files comprising the audio file assemblage along Logic's timeline with the precise locations of audio files identified as positions in time. When the audio file assemblage is rendered to become the audio model, it shares an identical timecode profile, linking the two together exactly. With the audio files also placeholding their progenitor notation materials within the notation network, notation materials, too, share duplicate precise timeline positions with their concomitant audio files although, at this stage of the composition's generation, timecode data is not embedded into the notation materials themselves. This process is not undertaken until parts are constructed in Sibelius, as discussed later in 3.5 Consolidating with Timecode, where the addition of timecode exactly synchronises all notation signification with its rendered audio file manifestations so that the timecode positions of both are identical.

Figure 14. The model



Although the notation network is invisible, notation in the form of parts — the performance materials — that are constructed from it, are not. The parts constitute the components of the notation network but unlike the audio file assemblage, do not display any relational information about the notation network or any other parts themselves: they are the notation but not the network. It falls to timecode to provide the relational framework through which the parts are connected in time, enabling the notation within the parts to relate and function as a notation network.

3.2.2 The Model Tripartite Relationship

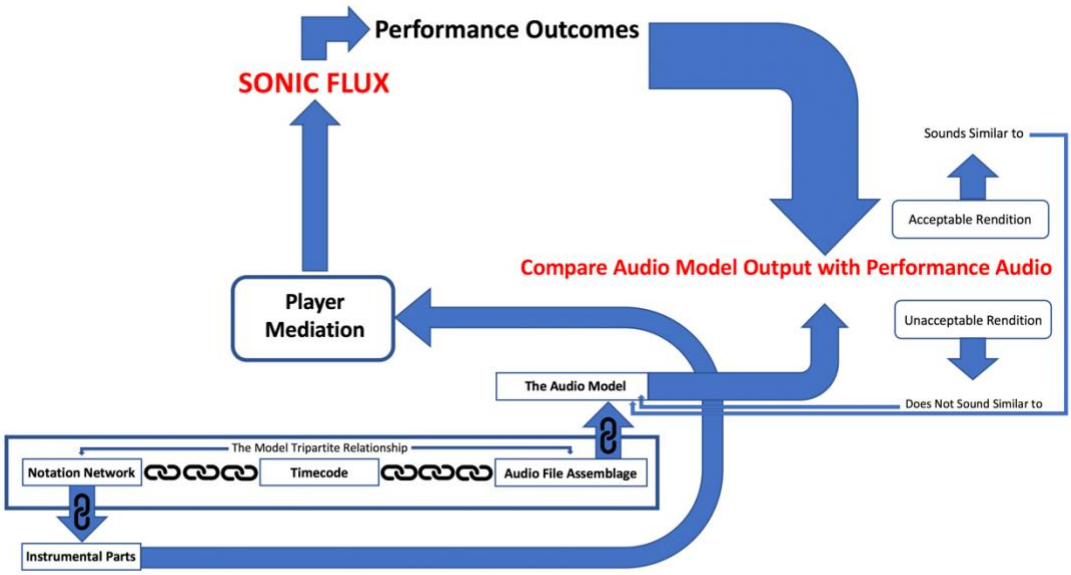
As shown in Figure 14, the notation network and its concomitant performing materials, the audio file assemblage and its audio model and the timecode that proliferates them both, constitute the three conditions of the model. They function as an assemblage termed the model tripartite relationship. In this relationship, timecode is the framework — the temporal glue — that binds these differently signified interdependent manifestations of the model together.

These three conditions are the fixed, conceptual and audio significations of the composition. By contrast, a live player-mediated performance of the model's notation materials results in a flexible manifestation of the piece that produces slightly different renditions with each performance. Using timecode again, the model tripartite relationship enables player mediation of the model through its notation materials and binds these materials to the sonic outcomes of performance. This binding — the temporal glue — enables the comparison between live performance and audio model renditions of the piece that again utilises timecode to ascertain where performances fall along the continuum between what I judge acceptable and unacceptable renditions as illustrated in Figure 15, p. 105.

It is the managed yet flexible confinement of mediated content offered by the model tripartite relationship that enables composers to feel confident performers will render their pieces within designated parameters to maintain compositional architecture in performance and timecode-supported frameworks that give musicians the confidence to flexibly reproduce those compositional structures within the same parameters to render dense, sonically complex

through-composed polytemporal music without conductors or click-tracks despite the self-directed nature of the performance.

Figure 15. Performance outcomes



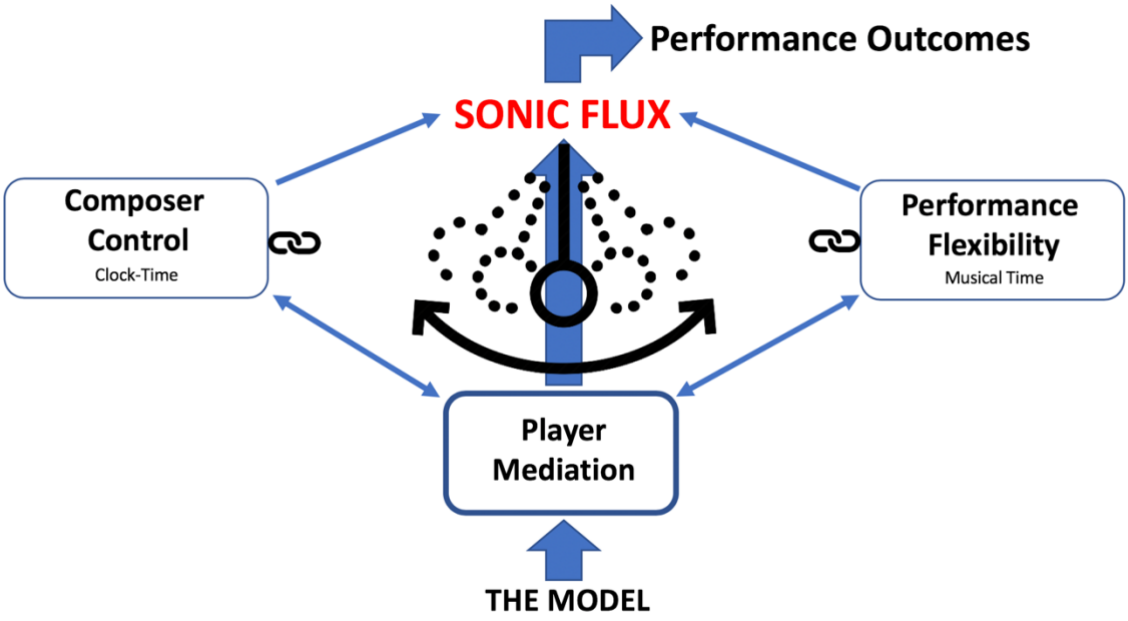
Further to the model tripartite relationship, music that results from timecode-supported polytemporal composition is instantiated through another equally important relationship, the dynamic tension between composer control and performance flexibility.

3.2.3 Mediation: Composer Control, Performance Flexibility and Sonic Flux

Composer control is transmitted through the trace, as Nattiez calls the notational surface of a piece of music, made by composers to direct and manage the placement and nature of sounds a performer produces through the rendering of such actions signified by notational signs, symbols and instructions in their instrumental parts.[135] Timecode signification adds an additional layer of composer control to notation in an attempt to support the composer's structural intentions in performance through confining player mediation to a sufficient degree that live performance renditions are considered near-determinate when compared to the audio model.

[135] Jean-Jaques Nattiez, *Music and Discourse: Towards a Semiology of Music* (Princetown: Princetown University Press, 1990), p. 16.

Figure 16. Player mediation and performance outcomes



Performance flexibility, on the other hand, defines how notation and the actions it signifies are mediated when interpreted and rendered by the performer. The effect upon the performance outcome of this secondary encoding of notation is significant in timecode-supported polytemporal music, in particular, how precise tempo markings calculated using clock-time are mediated, often approximately, by players using their sense of musical time. As illustrated in Figure 16, p. 106, it is the tension between composer control and performance flexibility, between the precision of notational signifiers and the flexibility of their mediation and rendering in real-time and the tension between clock-time and musical time that produces what is actually heard — the music, the sonic outcome, the landscape of pitches, rhythms, dynamics and expression — organised at that moment as a result of the unique plastic relationships between the mediated tempi of each instrumental part. The rendering of these plastic relationships in performance generates degrees of sonic flux brought about through the ever-changing contextual relationships rendered from notation materials simultaneously mediated by multiple performers.

As a result, the continual shifts in contextual relationships of all rendered materials within each immanent instantiation generates unique outcomes that are iterations, non-identical copies or self-similar variants of the original compositional model's sonically

rendered notation network. This flexible duplication is possible as levels of flux are effectively managed when notation materials are mediated through the temporal framework provided by timecode and it is throughout all instantiations that clock-time as timecode meets musical time as mediated tempo where, moment by moment, the player must decide which of these actions to privilege.

With performance outcomes being a consequence of the performer's mediation of notational materials filtered through the agency between composer control and performance flexibility and between clock-time and musical time, and with those outcomes potentially ranging between my sense of acceptable or unacceptable rendition, it is useful to discuss the performer's share in this relationship and how the composer supports the performer in discharging their role.

3.2.4 The Performer's Share: Mediating Clock-time and Musical Time

Notation set within a timecode framework signifies the composer's intentionality concerning the placement of sonic phenomena in time using clock-time as the common unit of measurement between all instrumental parts. It is the exact and precise nature of notation set within a timecode framework that primarily constitutes the signification (territorialization) of composer control. To this end, the performer is guided by the composer via performance instructions in each part to mediate what is signified in notation as precisely as possible within specific timecode frameworks, this being undertaken with both composer and performer aware that the performance outcomes realised through player mediation using the performer's sense of musical time will not be produced with the precision of computer software rendering an audio output from identical notational materials calculated using clock-time and timecode exactly. It is the tension between the specificity of what the composer has signified in notation and the performer's more flexible mediation of that signification that destabilises or deterritorializes the alignment between live performance and audio model to generate the rich fabric of sonic flux permeating what is heard as performance outcome.

From the performer's perspective, there is tension between adhering as closely as possible to the placement of sonic events — pitches and rhythms, for example — within the signified timecode framework and the flexibility afforded through aspects of mediation that may cause deviation from the specificity of notational timecode and tempo signification. This is the opposition between clock-time (territorialization) and musical time (deterritorialization) experienced by the performer as part of their ongoing mediation of notation materials. This opposition raises the question of primacy between adherence to timecode signification and expressive flexibility and it is this tension that reflects the continuum between composer control and performance flexibility illustrated in Figure 16.

Performance instructions available in each part state that timecode is not used to imply the use of a click-track or be seen as a straitjacket to inhibit expressive playing. Instructions explain that the reading of embedded timecode is particularly useful after longer pauses or where ongoing mediation has caused a discrepancy between the player's notational timecode position and rolling timeline displayed on stopwatches due to deviations from specified tempi. Ongoing reference to timecode and stopwatch enables the performer to compensate by playing a little faster or slower to catch up, extend or cut short material as necessary, for example, to maintain a broad synchronisation between the two.

Similarly, performance instructions do not privilege timecode above expression per se or state the primacy of clock-time over musical time. However, it is stated that timecode takes primacy at the start and finish of phrases, paragraphs, larger sections of material and the start and finish of pieces with all starts and stops being as precisely aligned with timecode signification as possible. All other notation and timecode significations between these points are subject to more flexible mediation with the caveat that performers monitor their positions relative to timecode wherever timecode-points are signified. Beyond this specification, choices around timecode or expressive primacy are a matter of balance and context to be mediated through player agency aided by a degree of musical perspicacity possessed by all experienced performers.

While appreciating that no two performances of any human-mediated music would result in identical renditions, mediation, especially temporal mediation in timecode-supported polytemporal music where individual players simultaneously interpret tempo markings using a sense of musical time, affects how pitches and rhythms, in particular, align and relate to each other in musical structures, generating the potential for a radical change to the micro and ultimately, if unchecked, the macro-architectural configurations of a composition to transform the identity of the piece itself. As Nattiez explains:

> What defines the identity of a particular musical work? Ingarden shows that this being cannot be reduced to any of the following: a given performance (since the score determines different potential performances); the here-and-now perception of a work (since each listener hears it differently); the acoustic reality (since the work's temporal profile and formal configuration are not, strictly speaking, sonorous elements); or the score (since the work will always and everywhere transcend that score).[136]

The reality of multiple renditions being generated by performers through the mediation of notation — what Nattiez calls the 'image imperfect' — can challenge the notion of the composer as 'producer' who holds sufficient 'compositional control' and 'authorship' over the performance outcome to claim any music that is heard, as entirely what they intended, entirely what was signified or entirely their own work.[137] This sense of negation of an authentic (exactly what the composer intended and anticipated) or acceptable rendition is due to any notions of authorship and control, especially regarding what is heard by the audience, being balanced between the composer's intention and the sound performers actually produce.[138] Such outcomes are possible because: 'the work is not wholly 'produced'

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[136] Nattiez, p. 69. paraphrasing Roman Ingarden, *Ontology of the Work of Art: The Musical Work; The Picture; The Architectural Work; The Film*, trans. by Raymond Meyer and John T. Goldthwait (Athens, OH: Ohio University Press, 1990), p. 90.

[137] As Nattiez explains: 'notation is indeed the trace that renders the work's identity possible. In this case, we need to realize that, from the analytical standpoint, notation is an image–imperfect but indispensable–of the notation's sonorous equivalent.' Nattiez, pp. 72–73. From this image-imperfect, the performer renders the score as a sonorous fact: 'The work's physical mode of existence is, then, divided between the score and performance. The work's ontological mode of existence is situated in the realm of pure intentionality, beyond the score, yet guaranteed, rendered possible by the score.' Nattiez, p. 82.

[138] The nature of this tripartite relationship between composer, performer and listener, as Souris points out, is an unstable one and demonstrates that due to the shared nature of authorship inherent in the relationship, any elements of composer control or direct authorship being 'transmitted' as a cogent message or instruction via the score between all three parties, are tenuous at best: 'For the musical event, there are three points of view: the author's, the performers, and the listeners. Their relation to one another is varied in the extreme, sometimes contradictory, sometimes confused'. Nattiez, p. 31. as a paraphrase of André Souris, *Conditions de la musique et autres é crits* (Bruxelles: Editions de l'Université de Bruxelles, 1976), p. 47.

unless it has been played'.[139]

This divided ontology — a work which is constituted both through a compositional idea and an immanent instantiation of that idea which is necessarily, and not only because sounding, different from, sometimes profoundly distant from, that idea — is important to note because notions of what constitutes an acceptable and authentic performance along a continuum that ranges at one extreme, from 'acceptable correspondence between graphics source and performance' or in this case, between live rendition and audio model, to the other, an 'unacceptable correspondence between graphics source and performance' predicate the success or failure of this methodology.[140] To help support an acceptable performance and best support performers' 'fidelity' when mediating what is signified in notation, instrumental parts are notated as clearly as possible.[141]

3.2.5 The Model: Plato, Flux, Indeterminacy and Complexity

Although my compositional ambition is to support the most authentic performances possible, as discussed, timecode-supported polytemporal music welcomes and anticipates levels of flux produced through the agency of player mediation where the musician's ongoing referencing of timecode throughout a performance obviates excessive temporal drift, therefore reducing the probability of large-scale structural deviation from the model and supporting the production of an acceptable rendition. There are, however, limits to how 'authentic' any acceptable rendition can be in relation to the model: although the model represents the perfect theoretical architectural organisation of the composition and provides a point of reference, the territory, against which levels of flux and temporal drift in performance may be gauged, in practice, no live performance can reproduce the identical level of fixed structural relationships extant in the

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[139] Nattiez, p. 72.

[140] In mitigating a significant loss of composer control and authorship to the interpretant it would seem imperative that the composer supports performers in rendering as 'authentic' a performance as possible, to limit the mediating effects unforeseen interpretive actions such as the flexible interpretation of tempi signifiers, bring to the sonic fact; this limitation implies a greater degree of the composer's intentionality being rendered possible through the score. In this context, according to Nattiez's paraphrase of Nelson Goodman, *Languages of Art: An Approach to a Theory of Symbols* (Indianapolis, IN: Bobbs-Merrill, 1968), p. 113., authentic performance constitutes 'any performance that executes an acceptable correspondence between graphic source and performance'. Nattiez, p. 74. The use of the word 'acceptable' is interesting here: what are the definitions of acceptable in this context and how is acceptability measured from the composer's perspective?

[141] Nattiez adds: 'as correct as this position might be [Goodman's definition of 'authentic execution'], it leaves open the question of the performer's fidelity to the work.' Nattiez, p. 74.

model. Instead, a performance will generate somewhat new, immanent structural relationships with each performance that are deterritorializations or a blurred image of the model (the non-identical mediated copies rendered from the model's notational content mentioned above). It is this blurred image, this imperfect reflection, to use a different analogy, or the deterritorialized mediated outcome that is *exactly* what is desired.

This notion of imperfect reflections of the model brings to mind Plato's theory of ideas. Here, there exists an ideal form — the essence — of a particular thing, for example, a cat or bed (or in this case, the model), that resides in heaven (or on the hard drive), that is real and unique, with all other particular (individual) cats or beds (or particular performance iterations), imperfectly partaking in the nature of that particular object (or model) to only be *apparent*, (as in a reflection of) the real form.[142]

Performance outcomes of the model are of course *real* and unique, and certainly not *apparent* in the Platonic sense; they are independent sonic facts — physical phenomenon— but they may also be viewed as imperfect reflections of the model that in and of themselves constitute an acceptable rendition of the piece where the reflection is the unique sonic reality in performance, but the model remains an unrealisable, digital fact on the hard drive. However, there are limits to which such a 'reflection' can be distorted before it ceases to 'partake in the nature' (the essence) of the form: without confining flux and temporal drift in the ways described, performances would have the potential to significantly deviate from the model — the form — and its architecture; an outcome that would constitute an unacceptable correspondence between graphics source and performance within the scope of this research.

3.2.6 No Conductor. No Score

As discussed, the sonic complexity of the test-pieces is generated in part through the flexible,

[142] 'According to the metaphysical part of the doctrine [Plato's doctrine], the word 'cat' means a certain ideal cat, "the cat", created by God, and unique. Particular cats partake of the nature of the cat, but more or less imperfectly; it is only owing to this imperfection that there can be many of them. The cat is real; particular cats are only apparent.' and 'whenever a number of individuals have a common name, they have also a common "idea" or "form"'. For instance, though there are many beds, there is only one "idea" or "form" of a bed. Just as a reflection of a bed in a mirror is only apparent and not "real", so the various particular beds are unreal, being only copies of the "idea", which is the one real bed, and is made by God'. Bertrand Russell, *History of Western Philosophy* (London: Allen & Unwin, 1946; repr. London: Routledge, 2004), e-book, pp. 115–116.

simultaneous, heterogeneous polytemporal relationships engendered through the rendering of all materials by all players. With so many different tempi in simultaneous operation and potentially each musician following their own temporal trajectories, the particular function of one or more conductors to provide synchronicity through a unifying beat to each instrumentalist is no longer appropriate to meet the temporal needs of the orchestra. It is the timecode frameworks read in conjunction with mobile phone stopwatches that provide the individual temporal support for each player that enables performance to take place. As such, conductors are not used in performance and each player is responsible for their own phrasing, expression, pulse, meter and tempo. They are now their own conductor. For similar reasons, with no universal pulse-synchronisation and each player having independent and unrelated temporal trajectories, timecode-supported polytemporal instrumental parts have been decoupled from each other and also from any score. This decision has been made for two reasons.

First, although commonplace for many orchestral works to be inscribed in a score and parts, the severe limitations of fixed, conventional scores to graphically express what are ever-changing, highly complex, real-time dynamic sonic relational permutations — the unique configurations of flux generated in every performance — would result in a score where notation would not even approximately represent the sonic flux of a performance — what is actually heard in that immanent instantiation — or any other notationally signified relational information a score might usefully convey. Additionally, if a conductor were necessary to support performance, there may be a case for some form of notational conceptualisation of the piece to enable this support to take place. However, without a conductor and for the reasons stated, no score is produced, and the music is rendered from fully notated parts alone.

3.2.7 Sonic Complexity not Notated Rhythmic Complexity

The second and perhaps more significant reason for decoupling parts from a score and each other, is that through decoupling, parts become truly independent of one another, both temporally and notationally. As discussed in1.1.6 Polymeter, Polytactus and Polytempo: Definitions, 1.1.7 Notational Reformatting and 1.1.8 Increased Notated Rhythmic Complexity, with independently assigned tempi and no synchronisation with a score, rhythmic notation

does not need to change or become more complex when the tempo is varied or when multiple parts with different tempi are layered vertically for simultaneous performance in the composition, no matter how dense this polytemporal layer-cake may become. As notational relationships between parts are not synchronised in a score, complex rhythmic and temporal relationships are only perceived when rendered and revealed as sonic relationships in performance.

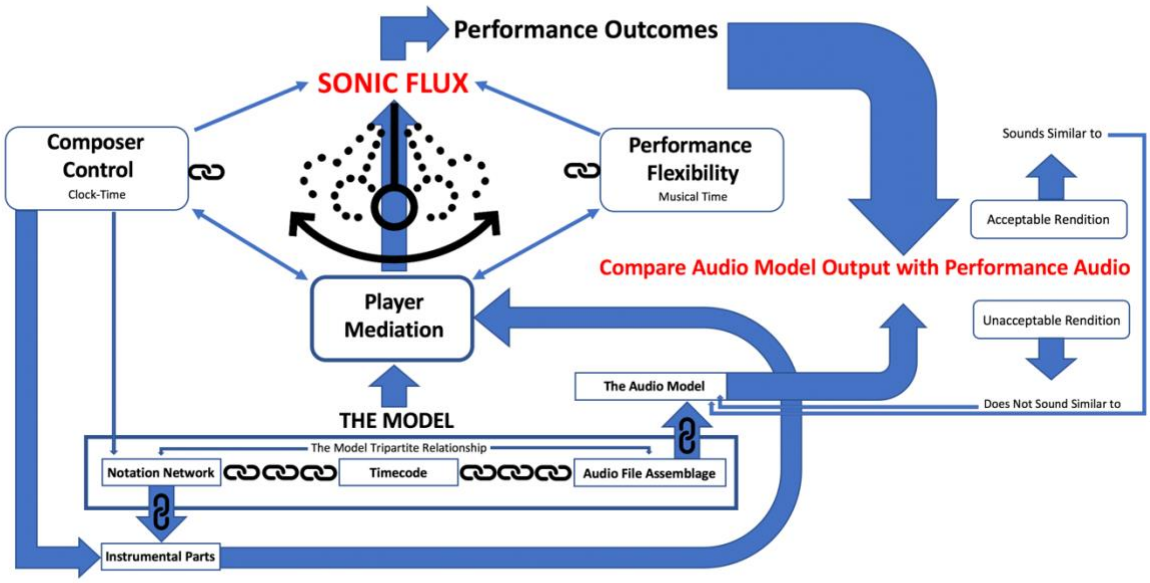
3.2.8 Synopsis

To summarise, timecode-supported polytemporal music functions in the first instance through the model tripartite relationship, a fixed relationship between a notation network comprised of decoupled parts and an audio file assemblage and its audio model that are linked through timecode to constitute the model. To enable rendition of the model, instrumental parts embedded with timecode are mediated by players during performance, coordinating as closely as possible timecode in the parts with timecode displayed on loosely synchronised stopwatches.

The mediation of notation using timecode and stopwatches generates sonic flux due to the agency between composer control and performance flexibility and the mediation of clock-time and musical time that engenders somewhat flexible outcomes around the placement of sonic objects in relation to their signified timecode positions. These actions destabilise the identity of the rendered outcome as it travels from what is territorialized in the model to what is deterritorialized in immanent instantiation. Degrees of flux are managed by the mediating activities of performers confining the placement of sonic phenomena within designated parameters as signified through timecode.

These deterritorialized instantiations and their resultant flux produce sonic entanglements that are the composition's audible surfaces as well as a manifestation of the composition's agency as sound. Such surfaces hold immensely complex sonic arrays and reflect timecode-supported polytemporal composition's capacity to support the construction and performance of through-composed music of considerable temporal density. Ideally, polytemporal performance outcomes will produce near-determinate iterations where those outcomes are situated within a parameter of +/-0–2" timepoint differential between identical key sonic events as compared between live and audio model recordings and where likewise, levels of structural determination are assessed as acceptable or unacceptable by the degree of similarity, or not, between the two.

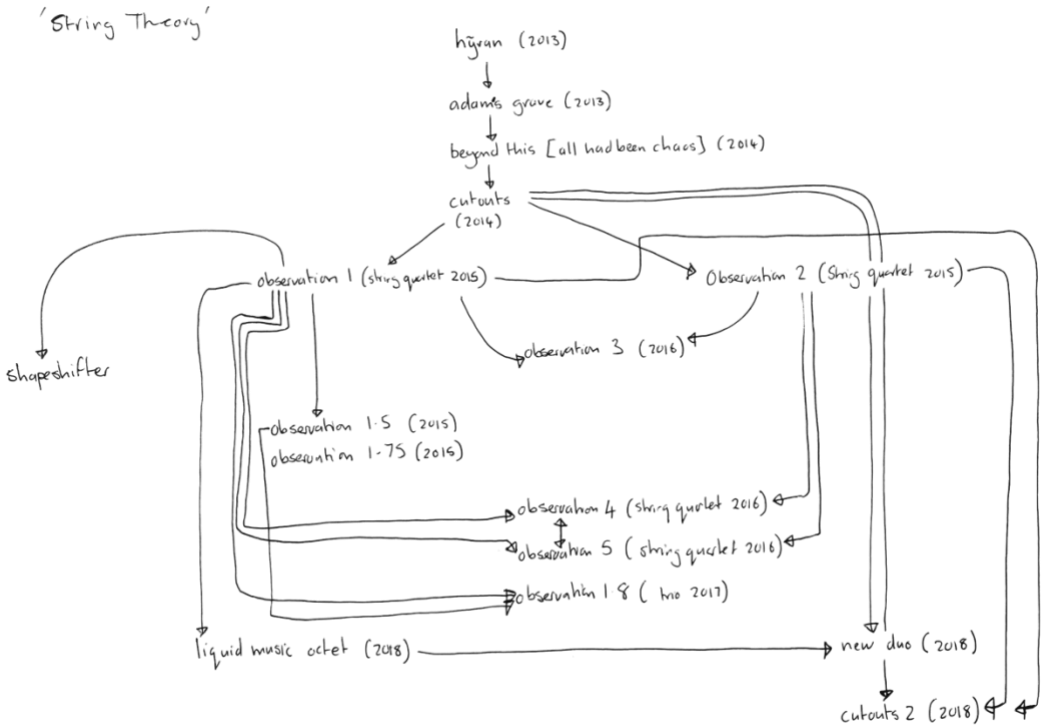
Figure 17. Timecode-supported polytemporal music functionality and outcome map



With this synopsis in mind, timecode-supported polytemporal music is characterised as conductor-less and scoreless with each musician performing in simultaneously independent tempi rendered from parts where instrumentation, structure, rhythm, pitch and expression are fully determined through notation and mediated in conjunction with part embedded timecode approximately aligned with the loosely synchronised timecode displayed on mobile phone stopwatches. Drawing these threads together, Figure 17, p. 114, shows a diagrammatic representation of how timecode-supported polytemporal music operates. Importantly, it shows the agency through which the components discussed above relate to one another, from the model through to the production of through-composed, near-determinate polytemporal pieces.

Part 3: Building the Model

Figure 18. Nested Assemblages



3.3 Introduction

'Building the Model', the second theoretical framework, describes how the model is constructed, how the materials that comprise it are assembled and how instrumental parts are generated from the model to be used in live performance. Beginning with 3.4 Assembling the Assemblage, I describe how the model is constructed through two primary operations: first, in 3.4.1 Temporal Realignments and 3.4.2 Structural Inventions: Polyphony, Heterophony and Canons, how notation materials, rendered and imported into Logic as audio files from self-borrowed and newly generated content in Sibelius, are organised using recursive, assimilative and trial and error processes to build complex audio file assemblages that are the compositional models for the test-pieces; and second, in 3.5 Consolidating with Timecode, describe the various processes necessary to construct instrumental parts from the audio file assemblage that enable the model to be rendered as immanent sound in live performance, thereby completing the compositional process.

3.4 Assembling the Assemblage

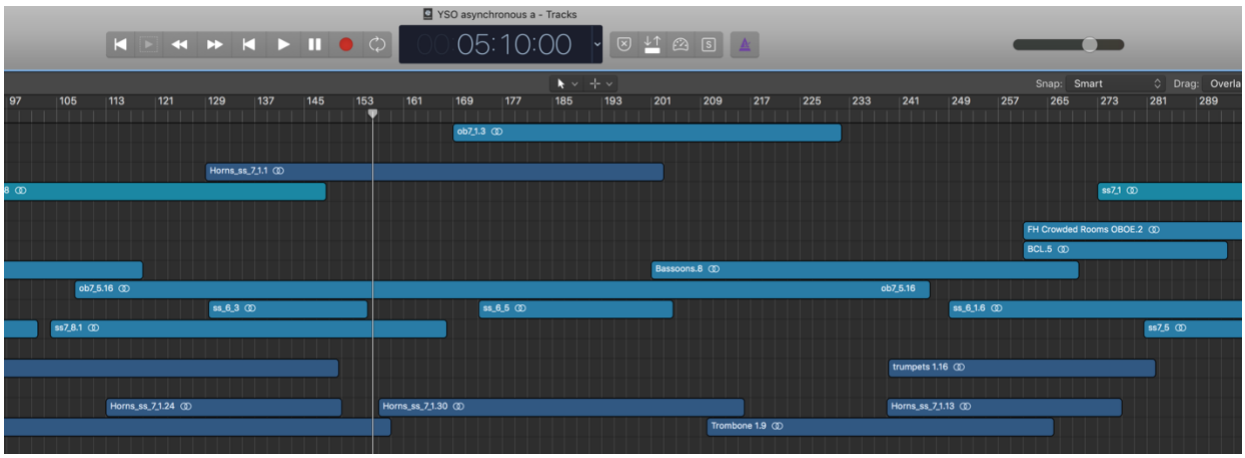
As previously discussed in Part 2: Timecode-Supported Polytemporal Orchestral Music and How it Functions, the audio components of the model — the audio files — are brought together to create the audio file assemblage. During the build, the audio file assemblage is a workspace and prototype construction until it is fixed as the finalised model. This fixing process involves two operations: first, in 3.4.1 Temporal Realignments and 3.4.2 Structural Inventions: Polyphony, Heterophony and Canons, audio recordings are imported into Logic and combined in various ways to ascertain which materials work best together to build the audio file assemblage; and second, in 3.5 Consolidating with Timecode, performance materials — the instrumental parts that facilitate the rendering of the model by musicians as a live performance — are produced as exact replications of the sonically rendered notation materials "placeheld" by regions organised in the completed audio file assemblage. It is this process that enables the model to be performed as mediated music and in so doing, move the composition from the conceptual to immanent sound. To achieve this, the timecode positions of audio files along the timeline of the audio file assemblage are synchronised with the computer-generated timecode positions embedded into new parts constructed in Sibelius until all notation and corresponding audio events in Logic have identical timecode positions along a shared timeline.

3.4.1 Temporal Realignments

To begin assembling the assemblage, audio files imported into Logic require temporal realignment. This action describes a process of play and building, of experimentation, of trial and error. It is in this phase that the audio file assemblage and ultimately the model are built in Logic, and it is in this phase that the audio file assemblage is used as a workspace in which these actions take place until the process is completed and the composition fixed. Here, imported audio files, now called regions, can be freely moved horizontally and stacked vertically along multiple tracks to establish new compositional structures that generate density and polyphony.

These realignment actions are recursive and concern the repeated addition and evaluation of regions or newly transformed or composed materials imported into the audio file assemblage that require assessment through playback. To enable this audio review, Logic facilitates synchronised playback of all regions simultaneously, no matter how deeply nested or how displaced in relation to each other regions are along the timeline nor how diverse the tempi of the recorded materials the regions "placehold" are in relation to one another. Here, each track containing one or multiple regions are played back in real-time, second by second, minute by minute as measured by the in-built digital clock (Figure 19, p. 117), providing an audio impression of the music with the real-time delivery of all tracks synchronised to the digital clock that displays the timecode positions of all the regions.

Figure 19. Digital clock timecode indicated by playhead position along the tracks. From *the heaven that runs through everything* (2018), in Logic Tracks Area



These audio reviews may lead to further notational modifications, sometimes necessitating the re-rendering of materials to be included in the model for additional review until the desired structural/compositional outcome is reached, resulting in a generative cycle of importing, playback, evaluation, modification, importing, playback, evaluation and so on between Sibelius and Logic. Actions are also assimilative because the process of building is in a continual state of adaption due to the incorporation of new materials and ideas being assimilated and affecting eventual outcomes until the compositional process is deemed complete. As a consequence, there is no sequential building of compositional structure from start to finish. The process is intuitive, messy and unpredictable.

With no score to reference and no visual indication of notational relationships across the composition, building an audio file assemblage solely on the evidence of playback in Logic is challenging. A great deal of compositional experimentation with aligning and realigning materials along with consequent audio reviews is necessary to establish which configurations — structural inventions — hold the greatest potential on a moment-to-moment basis and as longer-term architectural structures when configured in multiple ways. Any initial conceptual process that brought materials together is transferred from imagination to the computer precisely to reveal the interesting relationships through playback glimpsed using aural imagination. This process of aural imagining and software realisation enables compositional play in a rich environment of possibilities that continually reveal combinations of tempi, pitch, harmony and rhythm not otherwise conceived. As Edwards states: 'Perhaps counterintuitively, such formalization of personal composition technique allows the composer to proceed from concrete musical or abstract formal ideas into realms hitherto unimagined, sometimes impossible to achieve through any other means than computer software'. He goes on to quote German composer, Helmut Lachenmann who says: 'a composer who knows exactly what he wants, wants only what he knows — and that is one way or another too little'.[143]

3.4.2 Structural Inventions: Polyphony, Heterophony and Canons

Polyphony that arises through temporal realignments certainly falls outside of Lachenmann's notion of a composer knowing exactly what they want. At the basic level, polyphonic texture within the test-pieces is built through the addition of various layers of temporally independent self-similar materials, experimentally thrown together as regions in software, aligned in various combinations and eventually fixed to become the model but where many polyphonic relationships remain unforeseen until they are rendered through playback or live performance. With polyphony playing such a dominant textural role in the test-pieces, it is useful to examine exactly which structural relationships and inventions are described as polyphonic.

According to Frobenius et al., polyphony is defined as 'music in more than one part, music in many parts, and the style in which all or several of the musical parts move to some

[143] Michael Edwards, 'Algorithmic composition' *computational thinking in music*, 54.7 (2011), 58 (p. 67).

extent independently'.[144] Although this definition would appear to embrace almost any combination of independent materials under the umbrella of polyphony, '[m]any authors take the function of harmony as a criterion [within polyphony] so seriously' that they exclude works that do not conform to that criterion 'or consider its harmonies the product of the part-writing'.[145]

The polyphony constructed in this methodology is not mindful of harmonic functionality as randomising processes are used to furnish material lines with arrays of pitches (color) that are then attached to a number of rhythmic units (talea) that in combination produce non-tonal harmonies.[146] These non-tonal outcomes can certainly be considered a product of the part-writing and as such would be excluded from any definition of polyphony reliant on a functional harmonic contingent. Pironkoff's more open interpretation of polyphony takes a different view:

> Polyphony is always based on a multiplicity of superimposed lines; the dimension of complexity develops from the intensity of the dynamic interplay between the separate structural levels underlying a single line. Accordingly, it is mediation that constitutes one of the most important characteristics of complexity rather than superimposition, the latter leading to the subsumption of already existent qualities, as opposed to their differentiation. We should therefore recognize the fashioning of linear contours as one of complexity's foremost tasks, which will necessitate a new definition of the term "polyphony".[147]

Pironkoff explains further how Ferneyhough's music constructs polyphony through the interlocking of various simultaneous time-structures:

> Ferneyhough, for example, has rigorously thematicized the temporality of music through the interlocking of several time-structures, thus achieving a heightened linear intensity (where this linear realm is loaded with countless relationships and ambiguities) and a resulting shift from the

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[144] Wolf Frobenius and others, 'Polyphony', in *Grove Music Online* <https://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000042927> [accessed 9 June 2021] p. 1.

[145] Frobenius and others, p. 5.

[146] In Medieval isorhythmic practices, the words 'color' and 'talea' are used to designate tenor melodic and rhythmic units respectively. As Bent explains, "'isorhythm' is: '[a] modern term applied with varying degrees of strictness to the periodic repetition or recurrence of rhythmic configurations, often with changing melodic content, in tenors and other parts of the fourteenth and early fifteenth century compositions, especially motets". Margaret Bent, 'Polyphonic mensural notation, c1260 – 1500' in *Notation*, ed. by Ian D Bent, et al., in *Grove Music Online* <https://www.oxfordmusiconline.com/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000020114> [accessed 9 June 2021] p. 1. I have appropriated these terms to differentiate between pitch materials that undergo frequent change and rhythmic materials that do not, but where these processes in no way imply any adherence to isorhythmic procedures.

[147] Pironkoff, 'The Figure and its Dramaturgy' in *Polyphony & Complexity: New Music and Aesthetics in the 21st Century*, ed. by Claus-Steffen Mahnkopf, Frank Cox and Wolfram Schurig (Hofheim: Wolke, 2002), p. 1.

> level of the individual co-ordinates to the issue of their mutual interpenetration. If complexity is to be defined primarily as the stipulation of relationships, it has thus raised polyphony to the level of a new language; one could, therefore, currently speak of 'polyphony through complexity,' in this manner updating the definition of polyphony.[148]

Mediated by many players simultaneously and on an orchestral scale, it is the interlocking of multiple time-structures, the countless relationships and ambiguities within and between them plus the mutual interpenetration of notation and timecode shaping those through complexity in timecode-supported polytemporal music. As such, and somewhat expanded to relationships that forges the heard and emergent linear connectivity constituting polyphony suite multiple players, it is Pironkoff's description of polyphony that is adopted by this methodology.

3.4.3 Polyphonic Density

The changing depth of polyphonic textures – polyphonic density – is also a factor in generating polyphony through complexity in the test-pieces. Polyphonic density may vary between a few instrumental voices up to the full orchestra. However, the greater the densification of polyphony, particularly polytemporal polyphony, the more 'that experience is subject to [the listener's] perceptual and cognitive limits as they pertain to that medium'. And as London continues, 'the problem for much modern, "difficult", "complex", or "hyper-complex" music [is that] many aspects of its structure and organization are not even remotely audible'.[149] This imperceptibility of polyphonic lines, London's 'not remotely audible', is anticipated in the test-pieces at times of increased or maximum material stratification in which multiple streams of polytemporal activity — 'linear polyphony' — sound simultaneously, resulting in polyphony '[destroying] itself through its very complexity', to generate block sound-textures in which, potentially, only activity may be heard.[150] At other times, polyphonic density will be sufficiently thin for all strands to be audible.

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[148] Ibid, p. 1.

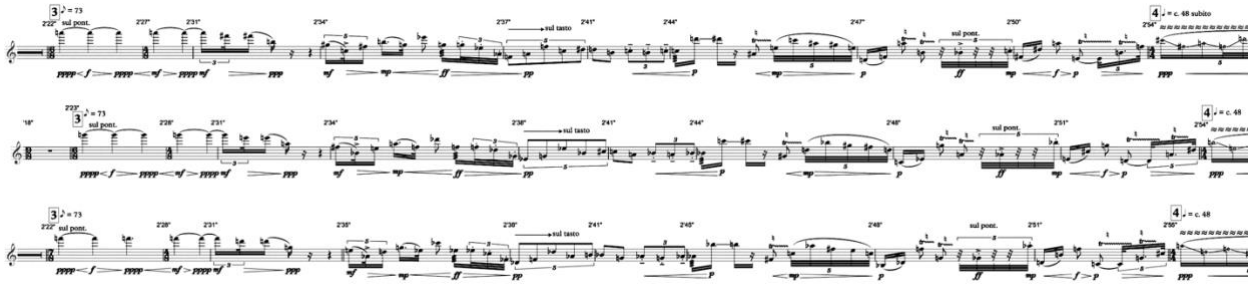
[149] Justin London, 'Temporal Complexity in Modern Music and Post-Modern Music: A Critique from Cognitive Aesthetics', in *Unfolding Time,* p. 47.

[150] In 1971, the composer Iannis Xenakis wrote: 'Linear polyphony destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers. The enormous complexity prevents the audience from following the intertwining of the lines and has as its macroscopic effect an irrational and fortuitous dispersion of sounds over the whole extent of the sonic spectrum. There is consequently a contradiction between the polyphonic linear system and the heard result, which is surface or mass'. Iannis Xenakis, *Formalized Music: Thought and Mathematics in Composition*, rev. edn (Stuyvesant, NY: Pendragon Press, 1992), p. 8.

3.4.4 Heterophony

Heterophony, too, generates degrees of material stratification and intentionally obfuscates musical lines. These degrees of stratification and obfuscation may produce very small or substantial divergencies from the original matter when instantiated in performance.[151] Such outcomes range across the two types of heterophony that proliferate timecode-supported polytemporal compositions. They are composed heterophony, where the embellishment of a single line is structurally premeditated and intentionally shared through notation among a number of parts to be mediated in performance; and uncomposed heterophony, where a monophonic line is altered through the mediation and rendering of unsynchronised multiple players, producing immanent, unpremeditated outcomes, and where both manifestations intend to 'smudge' and somewhat obscure material in performance.

Figure 20. Composed heterophony: score-to-part reconstruction. From *the heaven that runs through everything* (2018), Violin 1. 'a', 'b', 'c'



For example, it is made clear within the performance instructions of all shared test-piece string parts that exact synchronisation between players is not required where duplicate notated materials are distributed among a number of players although close adherence to timecode during performance remains imperative. Reading timecode in this way means that all players will deliver their material at slightly different speeds, different phrasing lengths, dynamic levels and rhythmic interpretation from one another. Consequently, there will be no

[151] According to Cooke, heterophony: could range from reference to minute discrepancies in singing or playing in unison or octaves (even, for instance, those produced unintentionally within the first violins of an orchestra) to the most complex of contrapuntal writing. In modern times the term is frequently used, particularly in ethnomusicology, to describe simultaneous variation, accidental or deliberate, of what is identified as the same melody. Peter Cooke, 'Heterophony', in *Grove Music Online* <https://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000012945> [accessed 9 June 2021] p. 1.

coordination of bowing between desks or sub-sections. It is this rich interplay of individual string players interpreting notation as closely as possible that will lead to uncomposed heterophonic effects generating an array of self-similar tempi described here as temporal heterophony, for instance, a feature that shares similar temporal behaviours to the ad libitum sections found in the music of Lutosławski, for example, *Jeux Vénitiens* and the Second Symphony, discussed in the literature review.[152]

By contrast, *the heaven that runs through everything* is populated with examples of composed heterophony. For example, Figure 20, p. 121, shows the reconstruction of a section of string writing that has self-borrowed materials from the string quartet *observation 1*, violin 1, and where notated heterophony is produced through two consecutive procedures: transposition followed by temporal displacement. The first part, 'a', is the original material. The second part, 'b', is a transposition of 'a' down by a whole tone and temporally displaced by a one-second delay from it. The third part, 'c', is a transposition of 'b', again down by a whole tone but here, temporally displaced from 'a' by a quaver delay and where all parts shown here share the same tempo. The effect temporally and harmonically displaces the lines from one another producing very close canonic relationships that smudge or blur the original line. As more than one player renders each part, composed heterophony will be further encoded through the agency of uncomposed heterophony, consequently increasing the smudge-factor to generate sonic outcomes of greater complexity than the notation itself suggests.

3.4.5 Canon

Frequently constructed to densify polyphonic texture, canonic inventions in this methodology do not rely on any sense of vertical harmony for their organisation. Instead, the number of

[152] The string writing in Group 3, *pulviscular compression* from *[...] which constantly generates a pulviscular cloud [...]* shows an example of uncomposed heterophony. Here, the original material composed for two string quartets is duplicated to make four quartets with two quartets sharing identical material from quartet 'a' and similarly, two quartets sharing identical material from quartet 'b'. The string players across all quartets are instructed not to synchronise with each other and to perform as soloists, mediating within the indicated timecode frameworks. The resultant music is a heterophonic expansion from eight players to sixteen, where the heterophony produced does not exist in notation but through the immanent instantiation of the materials by individual players. Similar mediated heterophony can be found among the other test-pieces, for example, in *[and] a powerful flame came out of the earth [...]* where originally synchronised and conducted string material is now heterophonically mediated by individual players using timecode.

canonic voices (named the 'dux' (the first entering or leading voice) and the 'comes' (companion or second voice)) along with the canonic length, rate and position of entries are determined solely by structural considerations. This structural approach to canonic invention sits happily within Mann et al's description where '[c]anon provides a composer with a procedure for exploring melodic and harmonic space without relying on functional harmony as a guide. Canon creates its own harmonic functionality, resulting directly from melodic and contrapuntal considerations'.[153]

These canonic inventions are assembled in situ within the audio file assemblage as part of the concomitant actions that build the model and are therefore strategically placed within the test-pieces to become part of the composition's polyphonic fabric. However, not all canonic invention is consciously generated. Unforeseen canonic relationships may also emerge as incidental consequences of general polyphonic thickening when building the model. Such material associations are possible due to the many potential canon-like connections between the self-referential, self-borrowed and self-similar variant materials proliferating the test-pieces across multiple temporal strata. With no score available to offer an overview of the test-pieces, these unforeseen canonic relationships are difficult to predict, cannot be viewed notationally and only become apparent during playback or performance as immanent sonic facts. Until then, they remain hidden.

Intentional or incidental, all perceived canonic relationships within the model appear stabilised. However, this stability is an aural illusion generated by the fixity of the audio model playback that remains identical with each rendition. It is, however, worth noting that canons, like all structures comprising the model, change the relational association of their materials further as they move from the conceptual to what is heard as canonic when flexibly mediated in performance. Similarly, the perception of referent associations between self-borrowed and self-similar variants will be inhibited when polyphonic density increases beyond a small number of simultaneous voices, again obfuscating these relationships.

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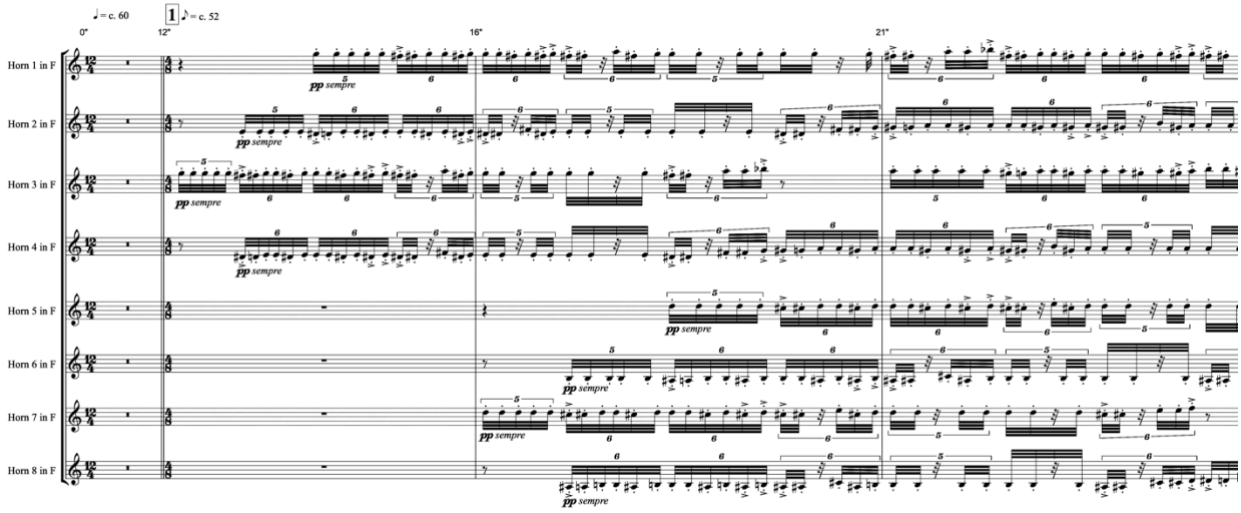
[153] Alfred Mann, J K Wilson and Peter Urquhart, 'Canon (i)', in *Grove Music Online* (2018) <https://www.oxfordmusiconline.com/grovemusic/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000004741> [accessed 24 July 2018] p. 11.

Figure 21. Part-to-score reconstructions: Horns 1–8, *the heaven that runs through everything* (2018)



Relational obfuscation is also a concern when voice entries are considerably displaced or conversely, compressed, across the compositional timeline, questioning at what extremes canonic voice entries cease to function canonically and revert to more general polyphony or heterophony. For example, at one extreme, the close proximity of canon-like entries in composed heterophonic structures can be very small, as illustrated in Figure 20, where conceptually at least, voice-entries are only a quaver apart at quaver = 73 BPM, representing a fraction of a second between entries. By extreme contrast, self-similar components of up to twelve minutes duration are used as complete canonic materials where subsequent canonic entries of the same or similar content can be initiated at any point along that twelve-minute timeline. Can these materials still claim to have a canonic relationship with the original matter, conceptually if not perceptually?[154]

[154] Though not orchestral music, it is useful to mention the composition of rhythmically complex canons by the composer, Conlon Nancarrow in relation to canonic invention in general. Nancarrow used piano rolls to operate the keys of the player piano through a system of precisely punctured paper rolls passing over a tracker-head where jets of air would pass through the puncture holes in the paper and subsequently through corresponding holes in the tracker-head to release the corresponding piano key. This form of piano roll notation enabled Nancarrow to produce mensuration or tempo canons of huge complexity that bypassed concerns around the limitations of human performance. As Thomas writes of Nancarrow's canons: 'Several perception issues arise with regard to the canons: Can the individual voices be followed? Can the tempo proportions be heard? Can a particular canon actually be heard as a canon? The answer, of course, depends on both the listener and the piece. [...] Nancarrow's canonic studies constitute a widely diverse group of pieces. In some works, canon is deployed straightforwardly, and the canonic process is quite perceptible. But in other works, the canonic process may be obscured by the complexity of the canonic line, the number of voices, the fast speed at which it proceeds, or the specific canon type used'. Margaret E. Thomas, 'Nancarrow's Canons: Projections of Temporal and Formal Structures', *Perspectives of New Music* 38.2, 106–133 (p. 110).

In the absence of clear parameters to define what degree of temporal displacement describes the limits of canonic functionality and with perceptual interpretations being inconsistent or not relevant to necessitate extreme complexity within canonic construction, it is left to the composer's intentionality to be the final arbiter around whether or not material is described as canonic.

Figure 22. Part-to-part comparison. Time-stretched or tempo canon. Piccolo/flute 2 and clarinet 2/E-flat clarinet from *the heaven that runs through everything* (2018)

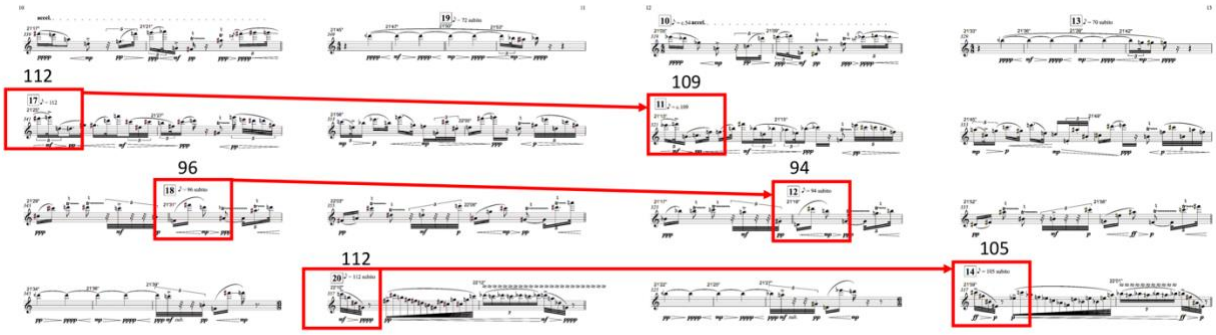
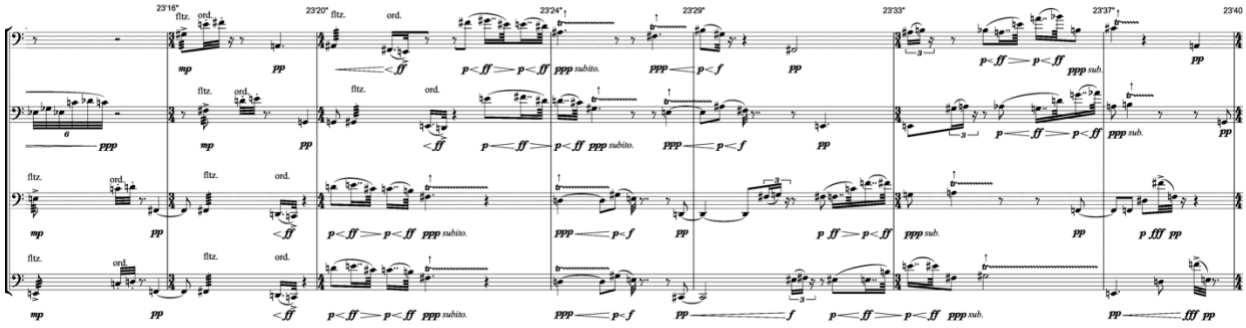


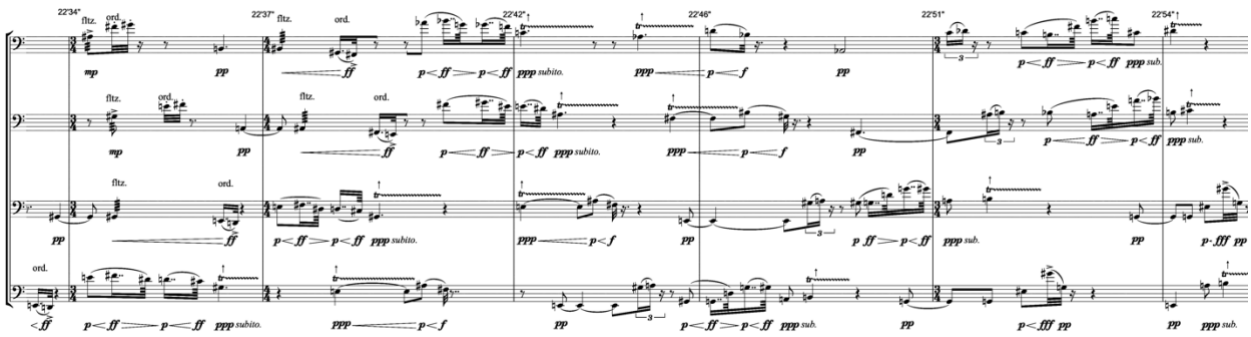
Figure 23. Part-to-score reconstructions: Bassoons in rhythmic canon. Bassoons 1 and 2, contrabassoons 1 and 2, the heaven that runs through everything (2018)



With this definition in mind, test-piece canonic constructions fall broadly into five categories: first, a standard canon where rhythmic and pith elements are imitated but lines are transposed and displaced in time from one another (see Figure 21, p. 124); second, rhythmic canons where the talea remain (largely) unchanged and displaced in imitation but the color in all subsequent voice entries are transformed (see Figure 23, p. 125 and Figure 24, p. 125); third, a tempo canon where talea remain intact and color are or are not transposed and transformed but where material entries are displaced and proceed using augmented or

diminished notation tempi (where materials have been time-stretched) in relation to the dux, with all parts situated within the same canonic network (see Figure 22), where the connected red boxes highlight time-stretched notation tempi assigned to identical materials); fourth, another tempo-type canon where the dux incorporates a range of tempo changes as part of its material that are subsequently imitated and displaced from the original material by entries of the comes and where talea remain unchanged and color are or are not transposed and transformed; and finally, the fifth canon-type that freely combines strands of all other canonic forms mentioned here into a single invention. A number of these canon types are illustrated in part-to-score reconstructions.[155]

Figure 24. Part-to-score reconstructions: Trombones in rhythmic canon. Tenor trombones 1 and 2, bass trombones 1 and 2, *the heaven that runs through everything* (2018)



Once all structural invention is complete and the architecture of the audio file assemblage established, it is recommended to set up a sixteen-second count-in bar at the very start of the audio file assemblage as a silent area where no audio files are placed. Experience composing timecode-supported polytemporal music for ensembles has shown the value of leaving a four to twelve-second count-in bar at the start of compositions to allow players to settle between synchronising stopwatches and beginning to play. For orchestral pieces, a longer

[155] Although textually describing the various forms of canon found in these compositions is useful, an enhanced overview of canonic relationships is better served through the visual medium of notation examples. However, as explained, the test-pieces have no score from which to extract multi-stave examples of canonic or any other kind of notation-signified relationship. Therefore, all multi-stave notation illustrations are part-to-score reconstructions. These reconstructions must be taken with a pinch of salt as the player mediated renditions of these same materials using the flexibility of timecode frameworks will deviate in numerous ways from what is indicated in fixed notation. Additional to the potential for mediated deviation in performance, consideration should also be given to the context in which these materials are performed. Presented here perceptible, even after flexible mediation, but their perceptibility is likely to be compromised by the varying levels of polyphonic density that frame their rendition, privileging what sounds are and are not perceived clearly.

sixteen seconds count-in allows sufficient time for the orchestral leader, for example, to conduct in the synchronisation of stopwatches for all players from the front of the orchestra, return to their seat and focus before beginning to play.

Figure 25. Highlighted region positions before the creation of the count-in bar. *the heaven that runs through everything* (2018)

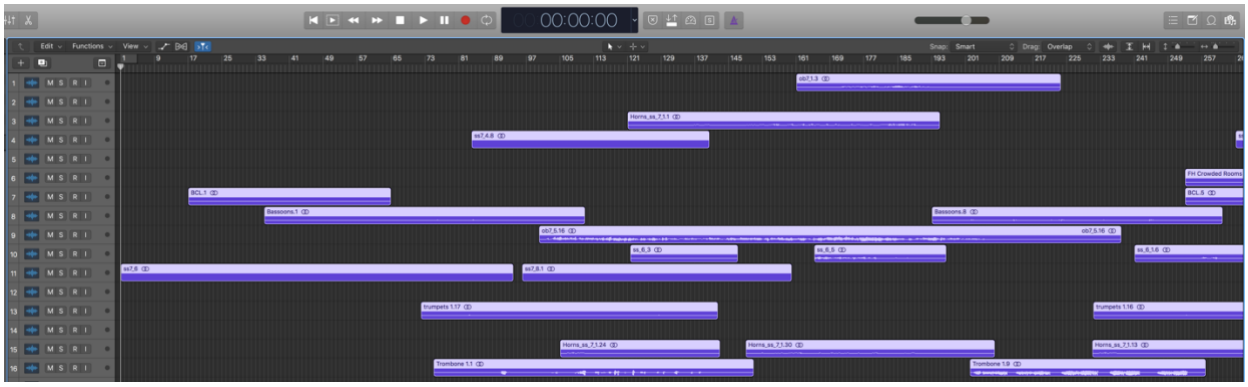
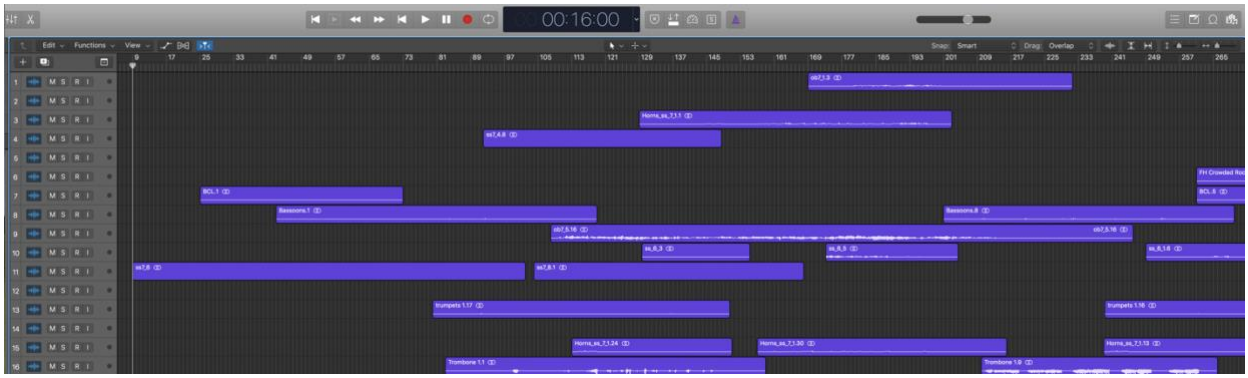


Figure 26. Region positions after the creation of the count-in bar. *the heaven that runs through everything* (2018)



This operation is easily undertaken in Logic by selecting the first positioned region(s) along the audio file assemblage timeline, entering the ‘Edit>Select’ menu and choosing the ‘All Following’ option. When selecting the first timeline positioned region(s) using this functionality, all subsequently positioned regions are highlighted (Figure 25, p. 127). It is then possible to drag all regions in a single action that preserves the fixed relationships in time between them. Once completed, the start location of the first timeline positioned region is 0:00'16" (Figure 26, p. 127). This migration of regions has now created the count-in area that represents the period of time lying between the synchronisation of stopwatches by all players at the beginning of the piece — timecode 0:00'00"— and the start of sonic activity at 0:00'16".

With the building of the model and the compositional structures that constitute it complete, it is now necessary to construct the performing materials — the parts — that enable the live performance of the test-pieces to take place. This process is described as consolidating with timecode. What follows is a step-by-step description of how, using information "placeheld" in the Logic audio file assemblage and notation materials in Sibelius, performance materials are assembled.

3.5 Consolidating with Timecode

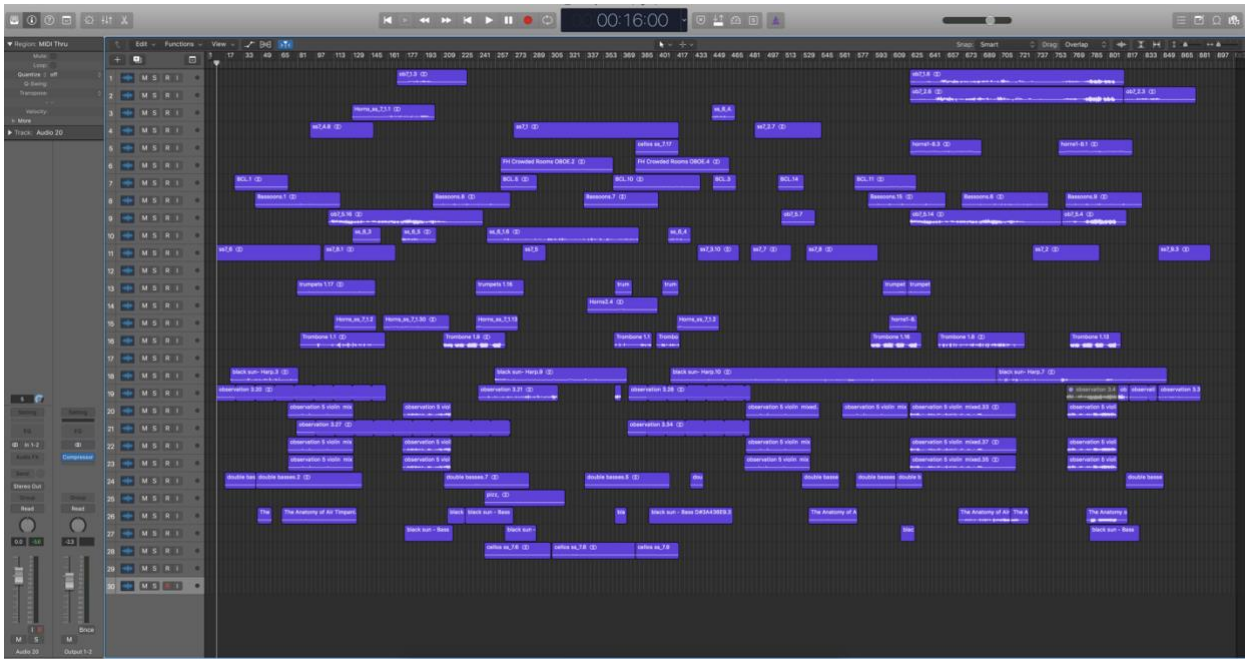
Once the audio file assemblage is finalised in Logic it is possible to begin the process of making instrumental parts in Sibelius. At this stage, before parts are constructed, notation materials are held in separate composition files (as transformed or original materials) and are unconfigured to one another. To enable the building of parts, new Sibelius files are created for each instrument of the orchestra into which notation materials are later imported and organised. When brought together into parts and linked through timecode, these notation materials will duplicate exactly the order and position of any given collection of audio files and tacet spaces arranged along an instrumental track comprising the audio file assemblage. In addition, this action will precisely link and duplicate every sonic phenomenon in the audio model with its signifying progenitor notation materials in Sibelius.

As can be seen in Figure 27, p. 129, an audio file assemblage holds a great many regions. These regions are automatically assigned file names when exported from Sibelius as audio files. Using the sequence of named regions now imported into Logic and placeheld in the audio file assemblage, the process of identifying notation materials and how they are structurally configured begins.

With all regions now positioned and fixed along Logic's timeline in the audio file assemblage and the count-in bar created, the structural location of a region is described as a position in time. For sonic phenomena signified in notation to also be described as positions in time, notation materials need to have timecode embedded within them. To achieve this, the 'add

timecode' function must be initiated from the appropriate menu in Sibelius. Once initiated, timecode is generated throughout the selected material to signify clock-time passing where material duration is determined by a calculation that uses metronome markings, meters and the numbers of bars as factors. For clarity, timecode is displayed in a selected format common to Logic's timeline, digital stopwatches and part-embedded timecode that shows hours, minutes and seconds as 0:2'14", for example.[156] Once generated, the timecode-calculated duration of notation materials correspond exactly with and are represented as concomitant region lengths when imported into Logic. For example, notation with a timecode duration of twelve minutes is now "placeheld" by a region with a length equivalent to twelve minutes duration when measured against Logic's timeline.

Figure 27. Audio file assemblage (in progress) *the heaven that runs through everything* (2018)



The count-in bar described above is also duplicated notationally in all the parts through generating a single silent 16/4 bar at a tempo of crochet = 60 BPM that equates to a duration of sixteen seconds starting at timecode 0:00'00" (Figure 28, p. 130). A 16/4 bar is selected

[156] The timecode format displayed in Sibelius differs slightly from that displayed in the digital clock in the Control Panel of the Logic in as much as the hours, minutes and seconds are separated thus 00:00:00 and thus: 00:00'00" in Sibelius.

because the count-in bar signifies sixteen seconds of clock-time as measured via the stopwatch, not a metered division of musical time generated using an arbitrary collection of smaller bars. The count-in bar falls outside the start of the piece but within its timecode-governed parameter. Metered time proper commences when the piece begins at 0:00'16", with all parts displaying the relevant tempo markings for subsequent bars from that point on. For those parts with materials that remain tacet immediately after the sixteen-second count-in, it is necessary to add bars rest equivalent to the duration between 0:00'16" and the start of sounding material as shown in Figure 29, p. 130. With the count-in bar situated, it is now possible to assemble notation materials to construct each part.

Figure 28. Score extract illustrating incorporation of the sixteen-second count-in bar. Alto Flute: *the heaven that runs through everything* (2018)

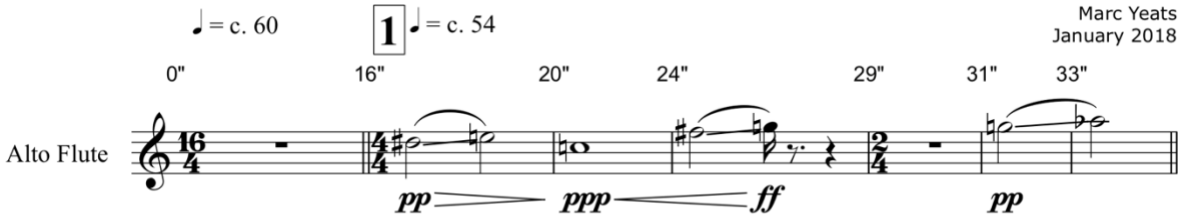
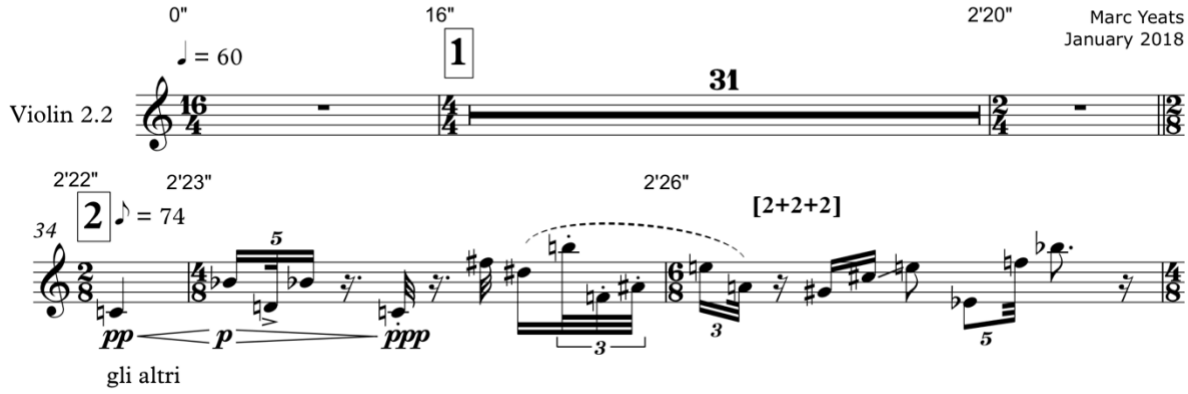


Figure 29. Sixteen-second count-in bar plus additional tacet bars. Violin 2.2: *the heaven that runs through everything* (2018)

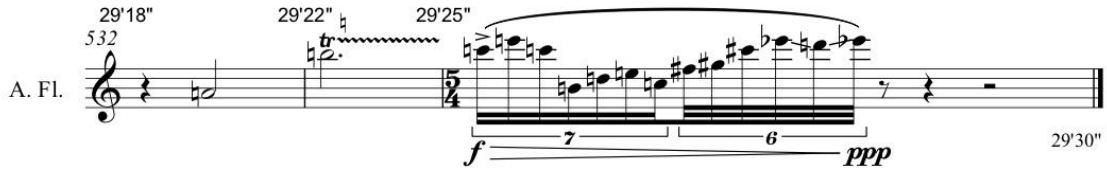


With ‘add timecode’ initiated, score-embedded timecode will be cumulatively generated to proliferate parts under construction as each new element, including tacet bars, are added to the part. When adding tacet bars or using copy and paste operations to construct a single part from a selection of free-standing notation components, timecode is automatically recalculated

and updated throughout the part with each addition or paste operation. This constant recalculation makes it essential to bring together instrumental part components sequentially as organised in the audio file assemblage. Sequential construction facilitates cross-referencing between region timecode positions along the timeline of the audio file assemblage with progenitor notation materials, providing ongoing verification of exact temporal alignment and synchronisation between the Logic and Sibelius manifestations of the piece.

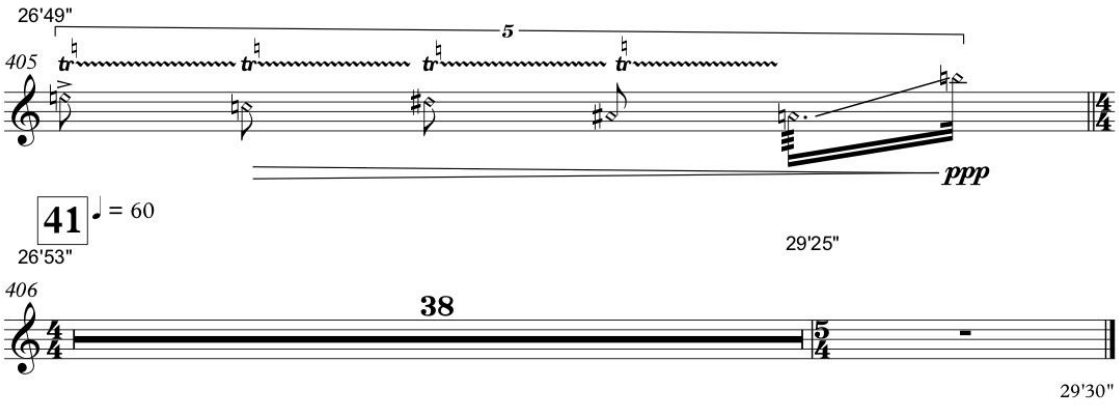
Any subsequent independent alteration to tempi within a part will affect its synchronicity within the model. If tempi are to be altered, notation materials from that revised part need to be rendered again as audio files and imported into the audio file assemblage for temporal realignment to ensure what is heard upon playback of the updated audio model correspond exactly with what is notated in the revised parts and therefore, what is likely to be produced in performance.

Figure 30. Final timecode position for one of the last voices to sound in the piece. Alto Flute: *the heaven that runs through everything* (2018)



Once the operation of consolidating instrumental parts with timecode and synchronising them with the audio file assemblage is complete, all material relationships in the model will be fixed. To ensure all instrumental parts share an identical duration within the composition's timecode-governed parameter, tacet bars equal in duration to the final timeline position of the composition's content (as illustrated in Figure 30, p. 131) need to be added as necessary to parts where the material has completed earlier than that point (Figure 31, p. 132). As a consequence, each instrumental part will have a total duration that is identical to every other and includes the sixteen-second count-in, all bars and bars rest and the composition end-time. In all, three consecutive synchronised barlines at 0:00'00", 0:16'00" and the composition end-time are shown at the double barline that concludes the piece.

Figure 31. Illustrating the addition of tacet bars to the final timecode position. Violin 1a: *the heaven that runs through everything* (2018)



To finalise the process and check all temporal alignments are as intended, all newly constructed timecode-consolidated parts are re-recorded using Sibelius to make an updated collection of audio files that are imported into Logic as total composition duration regions. These refashioned regions have individually incorporated the count-in bar and all separate regions and tacet spaces along each instrumental track to make single meta-regions that when reassembled into a revised audio file assemblage will show all region start and finish positions aligned. Once this process is complete, the model is built and the final audio model can be rendered from Logic for later use evaluating the coincidence between audio model and live recordings to establish if performance outcomes are near-determinate or not.

3.6 Reflective Text

I have created a reflective text to lay out some thoughts about timecode-supported polytemporal music and its operation that do not easily fit elsewhere in this thesis but nevertheless warrant some consideration. Predominant among those thoughts is the act of decoupling players from each other, from a score and from a conductor where that decoupling has had direct consequences upon the way an orchestra functions when performing timecode-supported polytemporal music as compared to standard synchronised, score-based and conducted music. Having implemented decoupling, it is reasonable to ask if what remains can still be described as an orchestra and to ask if the music it produces still functions as orchestral music?

Decoupling rendered the usual modes of cohesion and communication between players and players and conductor built upon predominantly synchronous relationships redundant. Operations such as supporting instrumental doubling; intricate rhythmically interlocking part-writing; tutti and solo playing; a unity of purpose between players, conductor and score; and the general buzz and excitement of working together as a single unified body to achieve what was often a known, broadly reproducible outcome, were no longer possible. From my perspective as a composer, the quid pro quo or payoff for players resulting from breaking those familiar performance communication behaviours was an opportunity for each member of the orchestra to be an independent soloist in their own right and shine as an individual with a moment in the spotlight; for players to have a greater role in determining the expressive content of their material in performance; and as an orchestra, the framework within which players alone could experience the achievement and satisfaction of rendering music of great sonic complexity and density in a multitude of spatialised contexts without a conductor. Those changes not only affected my approach to the conception and possibilities of polytemporal composition but changed the communicative, political and hierarchical power structures associated with orchestral bodies and how they could perform this music.

As stated in 1.1.14 Still an Orchestra? I take the view that orchestral music is music conceived by a composer as orchestral, and music that is executed by a body of performers identifying as an orchestra regardless of their particular mode of operation. Taken at face value, such a position asserts that timecode-supported polytemporal orchestral music is indeed orchestral music rendered by an orchestra. However, with no player ethnographic component included in this project, player's feelings about these operational changes and opinions about their activities still being those of an orchestra remain unknown.

The conclusions I had reached about timecode-supported polytemporal music's musicality and efficacy were drawn from a subjective aural analysis of performance outcomes where I have assumed that the production of near-determinate orchestral performance outcomes has, in and of itself, demonstrated a sufficient degree of functionality and communication between players to support those outcomes. In effect, successful communication is self-evident.

It is, however, entirely possible that despite performance outcomes meeting my expectations, players may take the view that their own performative experiences were less than satisfactory. Without an ethnographic investigation, such insights are impossible to ascertain with any clarity or detail. Nevertheless, drawing upon my 'sense' of overseeing rehearsals of the BBC Scottish Symphony Orchestra and the conversations and comments I had with and from the players and producers, I was under the impression that notwithstanding some initial apprehension – fear even – around what was for them a novel performance approach, the experience of playing a timecode-supported polytemporal orchestral piece was a positive one.

Also, worth comment are my observations around how each subsequent rehearsal brought with it an audibly more cohesive rendition. This cohesion moved beyond the temporal requirements of near-determinate performance into more subtle musical considerations, primarily because of the expressive and communicative components of the composition being better expressed following rehearsals, no doubt due to an evolving familiarity with the contextual relationships of materials as well as an increased sense of orientation and confidence by the players brought about by the rehearsals themselves. I have made the assumption that these incremental improvements demonstrate that regardless of the decoupling of parts, musicians were still listening to each other and contextualising their own contribution within the overall sonic fabric of the piece. Despite the changes to operational communication, players were adapting and initiating their own communicative approaches so they could still render a cohesive musical performance to the sonic standard they expect of themselves despite their changed operational circumstances.

To emphasise this and although anecdotal, I would summarise the player comments I received as: 'I'm really proud of us'; 'when I stopped playing and listened to what everyone else was doing, it sounded amazing'; I really enjoyed that. It was good to have more expressive freedom'; and, I didn't think it was possible to make music like this without a conductor'. Interestingly, I received no comments or questions about the lack of operational 'listening and responding' communication between players, necessary for synchronisation and dynamic

(volume) balance among other factors, neither did I receive comments about what players should be doing when, or feedback about any sense of individuals feeling isolated from each other despite the changes in communication between them. A number of questions and comments were fielded to the orchestral leader, too, but among the questions I received, notation, technique and dynamic interpretation were the only concerns. Feedback such as this helped me assume the performative aspects of timecode-supported polytemporal music including the consequences of decoupling parts and the rapid and straightforward comprehension of how it functioned demonstrated a ready acceptance for the approach by the very players it was specifically designed for — orchestral players.

In addition to the above observations, I was particularly interested to discover how my assumptions concerning the orchestra-wide notation and mediation of dynamics would instantiate as sound during performance with no musical director to manage and balance the volume and power of those dynamics, especially in relation to any given musical context for a particular player, through referencing a score and directing players accordingly. Although great care was taken to consider and signify those aspects and contexts through dynamic markings in notation so as to aid players when mediating and producing the balance of sounds I had conceptualised and to a limited extent, replicated through the playback of electronic notation materials in the audio model, I was aware that with no dynamic arbiter such as a conductor, no score and no practical way of signifying or communicating dynamic relationships between the players themselves, what manifested as sound in rehearsal or performance could potentially be quite distant from my expectations.

Unlike establishing time differentials between the key sonic events of live and audio model recordings through listening and approximately measuring their placement along a timeline in seconds, comparing the dynamic rendition between live and audio model recordings is unreliable in the extreme, making this aspect of aural analysis unhelpful. Electronically rendered orchestral materials do not possess the same dynamic breadth or reflect an accurate dynamic balance of orchestral instruments when compared to their live recorded counterparts. This discrepancy reflects in the dynamic range of the audio file recording being much suppressed and differently biased to certain sounds when compared to its concomitant live recording. Owing to this, the graphic representation of audio materials varies greatly, making like-for-like visual and aural comparisons of volume dynamics challenging.

With only a subjective conceptualised dynamic profiling of any timecode-supported polytemporal composition and no score to reference or signify dynamic relationships graphically, I could not verify how successful the dynamic balance of actual performance outcomes where away from those remembered subjective impressions and comparisons between live recordings and rather dynamically inadequate audio model renditions. For Cage, expectations around dynamic relationships in performance were tempered by pragmatism. When asked about dynamics, he neatly responded: 'These result from what actually happens (physically, mechanically, electronically) in producing a sound'.[157] I have adopted a similarly straightforward attitude where I accept that the resultant dynamic balance produced when timecode-supported polytemporal music is mediated by players 'is what it is' but am most satisfied when those outcomes fall within some notion of expectation.

Although players are responsible for self-regulating the dynamic balance of timecode-supported polytemporal music without requiring my presence or necessarily the guidance of anyone else as a musical director, I *was* present for the rehearsals and performance of *the unimportance of events* (2021). In this circumstance, the dynamic balance between orchestral players manifested much as anticipated with only minor adjustments necessary to the notated trombone dynamics during rehearsals. Whether the trombonists would have moderated their volume had I not commented remains to be seen, but in the worst-case scenario, were their enthusiasm not tempered, I would still have considered the dynamic balance of the orchestra largely successful and the assumptions I had made around dynamic balance outcomes largely confirmed. Interestingly, a number of players seated immediately in front and around the two trombone players did comment on their excessive volume level and asked to move further away so 'they could hear themselves play'. Perhaps those comments and actions are an indication of the orchestra self-regulating its dynamic balance? They certainly imply that despite decoupling, communication between players is alive and well.

[157] John Cage, *Silence: Lectures and Writings*, 50th Anniversary Edition (Middletown, CT: Wesleyan University Press, 2011) in 'Experimental Music: Doctrine', p. 16. This article, there titled Experimental Music, first appeared in *The Score and I.M.A. Magazine*, London, issue of June 1955. The inclusion of a dialogue between an uncompromising teacher and an unenlightened student, and the addition of the word 'doctrine' to the original title, are references to the Huang-Po Doctrine of Universal Mind.

4. Performing the Model: Results and Discussion

This analysis focuses exclusively upon results obtained through the live performance of test-pieces composed as part of this investigation. They include *pulviscular observation*, *pulviscular compression* and *the unimportance of events* (2021). These results are compared to the performance results of the 2015 timecode-supported polytemporal ensemble piece, *shapeshifter*, as discussed in 3.1.2 How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured? used as a baseline for what I consider optimal near-determinate performance outcomes. Results analysed from performances will be assessed against this baseline to establish the correspondence between both.

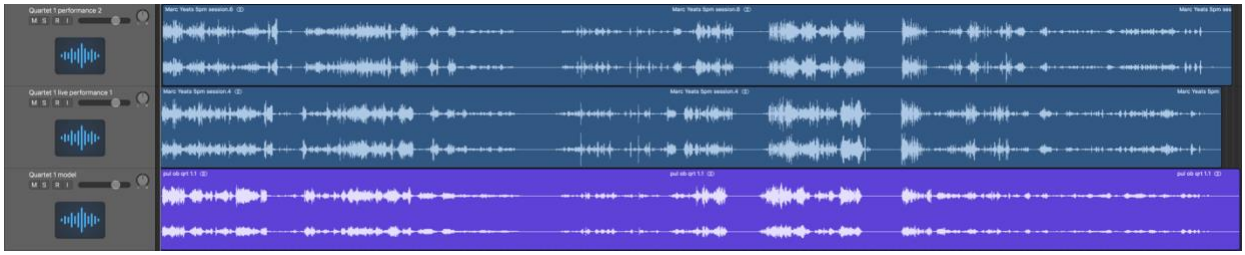
4.1 *pulviscular observation* and *pulviscular compression*

pulviscular observation and *pulviscular compression* are related free-standing compositions. *pulviscular observation* is for double string quartet and *pulviscular compression* for four string quartets (sixteen string players) and three double basses making nineteen players in all. *pulviscular compression* duplicates the string quartet materials found in *pulviscular observation* and assigns two players to each quartet part.

Without a full complement of nineteen string players, a recording of *pulviscular compression* was realised using two string quartets performing and recording their *pulviscular observation* material twice. This action was undertaken intentionally to test deviation levels between performances by the same players of identical materials rendered as non-composed heterophony, a type of heterophony found in all the orchestral test-pieces including *[...] which constantly generates a pulviscular cloud [...]* for which *pulviscular compression* was composed as the string component. When performed live with all string players, each of the nineteen parts would be assigned a performer and each instructed to play independently without any expectation of synchronisation between identical parts. The intention was to generate heterophonically varied recordings that in the absence of a live performance recording, could be used along with the inclusion of previously recorded double bass material to construct a remote recorded acoustic version of *[...] which constantly generates a pulviscular cloud [...]*.

To examine the efficacy of the foundational timecode framework, I begin by analysing the two quartets of *pulviscular observation* separately, comparing each recording of the material with the audio model rendition. Figure 32, p. 138, positions the two live recordings of quartet 1 material as the top and middle tracks with the audio model rendition of quartet 1 in purple positioned as the bottom track. Similarly, Figure 33, p. 138, shows the identical configuration of tracks displaying quartet 2 materials.

Figure 32. Model and live recordings compared. *pulviscular observation* Quartet 1 (2019) audio files in Logic



Quartet 1 shows that overall, the gross structural coincidence between the audio model rendition and live performance recordings was very good, ranging on average between +/- 0–1" time-point differential and on occasion +/-0–3" with only a few events extending beyond the parameters of what I consider acceptable performance. Closer inspection showed that key sonic event alignment between both live versions was somewhat closer than both live versions with the audio model.

Figure 33. Model and live recordings compared. *pulviscular observation* Quartet 2 (2019) audio files in Logic.

Similarly, quartet 2 comparisons between the audio model output and live performances demonstrated a good or very good alignment between gross structural features. Examining key sonic events in more detail revealed on average between +/-0–1" and on occasion +/-0–2" time-point differential with very few events extending beyond these parameters.

In both cases, waveform comparison would only elicit information around gross structural alignment. To ascertain the finer degrees of key sonic event alignment all audio tracks had to be listened to simultaneously and their discrepancies measured against Logic's digital clock. The results nevertheless provide a good indication of coincidence between performance and audio model output. Heterophonic results, too, fell within the +/-0–2" time-point differential.

Perhaps unsurprisingly, what has emerged from an analysis of these results is that standard performance outcomes and non-composed heterophonic outcomes inhabit similar time-point differential bandwidths. In both cases, what binds these performance outcomes together is the player mediation of notation where the expectation is for the highest degrees of fidelity to timecode signification in performance. What separates them is the instruction for string players conditioned to playing as one body to *not* attempt to synchronise with one another when mediating duplicate materials.

Though musically very convincing, neither quartet performance quite matched the degrees of timecode fidelity exhibited in *shapeshifter*, but discrepancies between all performances and key sonic events in their corresponding audio models were small. This slight movement away from key sonic event alignment is perhaps unsurprising given that those performing *shapeshifter* were highly experienced new music specialist performers.

4.2 *the unimportance of events* (2021)

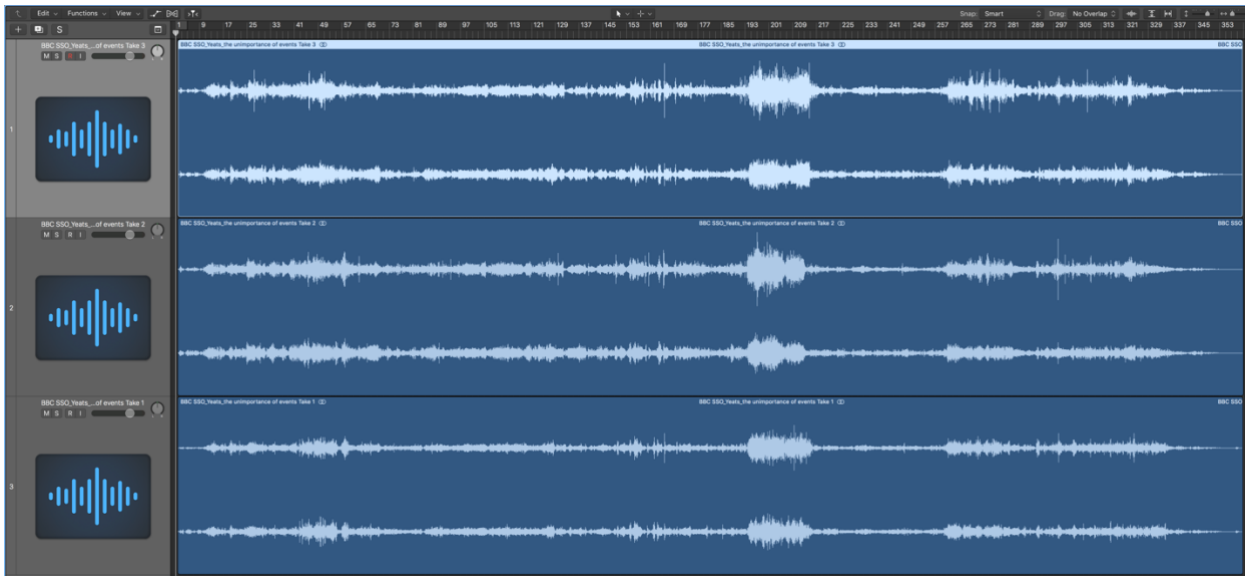
Although not a large-scale orchestral piece, the twenty-two players that comprise *the unimportance of events* (2021) and the instrumental categories they incorporate — woodwind, brass, string, piano and percussion — do constitute a chamber orchestra. The musicians, too, drawn from the BBC Scottish Symphony Orchestra, provide useful evidence of how professional orchestral players approach and perform timecode-supported polytemporal music. It is worth noting that the production team reported that in their history of working with the orchestra performing and recording twentieth and twenty-first-century orchestral music, they had never encountered a composition of such complexity that did not require the use of a conductor or conductors and instead, used player's mobile phone stopwatches for loose synchronisation with timecode distributed throughout each musician's part to achieve structural organisation in performance. Despite this unfamiliarity, the rehearsals and recording proved straightforward to manage. Emphasising this point, the orchestra reached optimum structural coherence after only one and a half hours of an allotted three-hour

recording session. I had assumed timecode-supported polytemporal orchestral compositions would be relatively uncomplicated to put together in rehearsals providing performers came fully prepared but had not imagined optimum structural coherence being achieved so quickly.

It is useful to analyse the three successive recordings produced through the session to understand why rehearsals were so productive. Examining these recordings in order and in relation to the audio model rendition will show the entry-level performance correspondence to the audio model and any progression from that position to the final recording achieved through additional rehearsals.

In examining all three live recordings of *the unimportance of events* (2021), it was immediately apparent that the correspondence between renditions was remarkable. Analysing the audio files visually, as illustrated in Figure 34, p. 140, as well as listening to all three tracks in simultaneous or paired groupings (recording one and three, one and two, two and three) revealed a timepoint differential range of +0–1" or less, producing results that exceed the baseline differentials of *shapeshifter* held as an ideal measure of near-determinate outcomes. Interestingly, these results show that there was no significant progression relating to fidelity to timecode and the placement of key sonic events as rehearsals progressed.

Figure 34. Recordings 1–3 compared. *the unimportance of events* (2021). Audio files in Logic



Recordings were made after an initial playthrough of the piece in which a few balance issues were addressed between the dynamic level of the trombones and other players. The

following three renditions were recorded successively and as revealed through analysis, each reproduced near-identical structurally ordered outcomes. The third and final recording was considered optimal and used for public distribution.

As discussed, as illustrated in Figure 34, the close similarity between each live recording of *the unimportance of events* (2021) showed an excellent degree of structural resemblance. The precision of this correspondence was similarly found between take three of the live recordings when compared to the audio model as shown in Figure 35, p. 141, where the live recording used for public dissemination, take three, is the upper track and the audio model rendition the lower.

Figure 35. Live recording 3 compared to the audio model. *the unimportance of events* (2021). Audio files in Logic Audio files in Logic

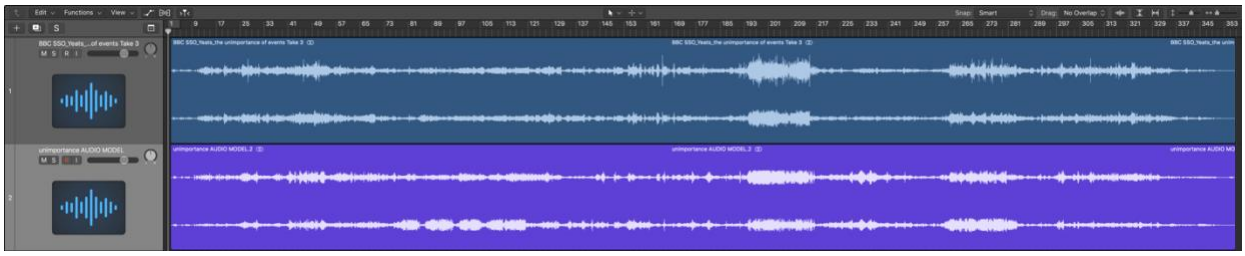
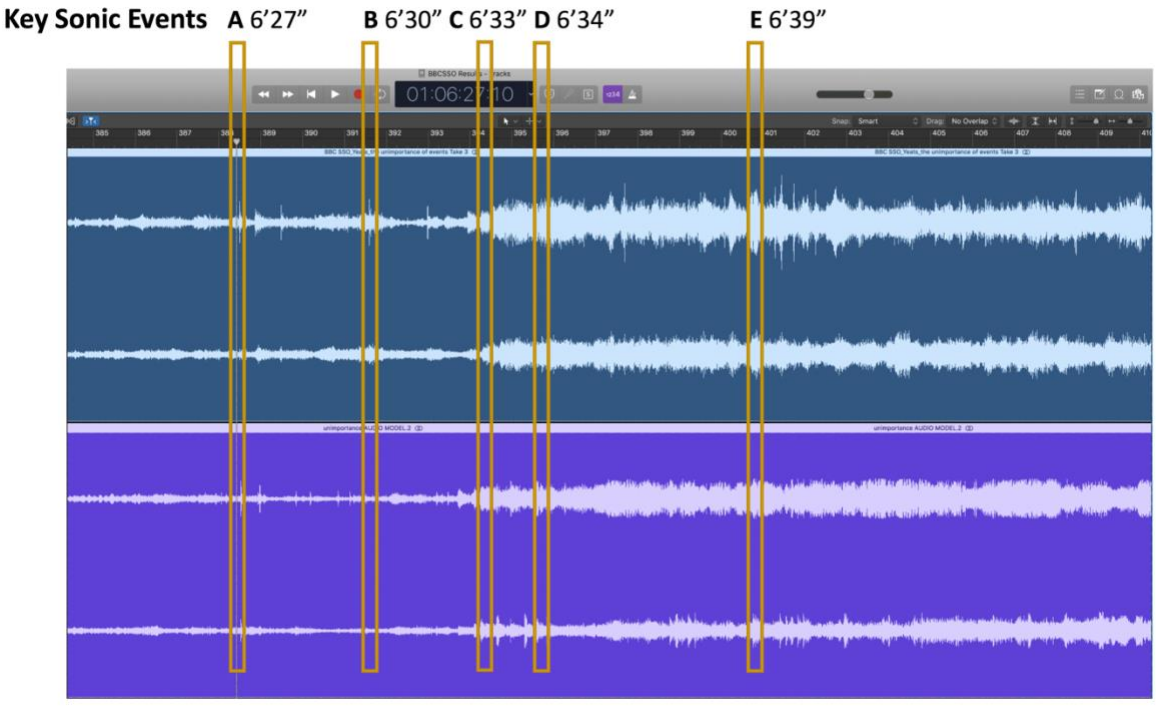


Figure 36. Key sonic event comparison between take three and the audio model. *The unimportance of events* (2021). Audio files in Logic



Looking more closely in Figure 36, p. 141, a comparison between take three of the live recordings and the audio model and zooming into a selection of key sonic events, for convenience, identified as A 6'27", B 6'30", C 6'33", D 6'34", and E 6'39", where A-E represent the event followed by the event timecode position, help illustrate how close correspondence between the two are. Here, the pale yellow vertical bands show a one-second window within which key sonic events may or may not occur. Key sonic events A and B represent particular percussion figures that are produced almost simultaneously between each audio file. Event C signifies a prominent entry for the percussion, piano and trombones, again very closely correlated, with event D showing the point where the horns enter one after the other and event E, a significant series of interlocking horn phrases, all of which are very closely correlated and located well within the one-second window appropriate for near-determinate outcomes to fall within.

Observing these correlations through a direct comparison of the audio files alone is challenging as the dynamic output between the live and audio model recordings are not equalized in such a way that reflects the real-world sound output of an orchestra when compared to that of the audio model. In all comparisons, the dynamic range of live performance recordings exceed that of the audio model. This discrepancy results in the live recording audio files having a far greater graphic resolution when signified as sound waves than the audio model. However, an aural analysis of both tracks does effectively locate the key sonic events of each, locating them precisely along the composition timeline. Figure 36, has been constructed using this approach.

Overall, the aural analysis of *the unimportance of events* (2021) showed a timepoint differential of +0–1" or less throughout. Such fidelity between the audio model and live performance outcomes illustrates the capacity of the foundational timecode framework to support near-determinate performance outcomes using timecode-supported polytemporal methodology. In this instance, the results produced have exceeded my expectations for polytemporal structural reproduction in performance.

5. Conclusions

5.1 Summary

This research project was undertaken to solve a range of compositional problems I identified as:

1. How to expand Independent simultaneous temporal trajectories to all orchestral players?
2. How best to incorporate heterogeneous temporally unrelated materials into compositions?
3. How to best support near-determinate outcomes on a local and global level in performance?
4. How to achieve the above conditions in the most straightforward and practical way?

An examination of the current literature in this field showed no single approach that addressed all of these issues fully. To find solutions, I developed a compositional methodology called timecode-supported polytemporal music that I hypothesised had the capacity to address and resolve the highlighted problems. To test this hypothesis, I created a range of portfolio pieces that when composed and performed using the timecode-supported approach would produce performance outcomes I could examine. These performance outcomes were documented as audio recordings for comparison with their concomitant computer-generated audio model renditions. In effect, live performance recordings were tested against their audio model counterparts using subjective criteria based on an aural comparative analysis. Near-determinate outcomes were identified as those where live performance and audio model recordings showed the closest alignment in time differentials measured approximately in seconds.

To test my hypothesis concerning the efficacy of timecode-supported polytemporal music's capacity to address the compositional problems above, I devised two research questions that asked:

1. How do I know if timecode-supported polytemporal music succeeds in producing near-determinate performance results and how is success defined and measured?
2. Which timecode frameworks best support near-determinate performance outcomes?

In answer to these questions and as presented in 4. Performing the Model: Results and Discussion, comparisons between live and computer-generated recordings have shown timecode-supported polytemporal composition does enable every player to have simultaneously different independent temporal trajectories from one another and in *the unimportance of events* (2021), produces a functioning polytemporal collective of twenty-two players. Here, analysis shows the near-determinate outcomes produced in all three performance recordings exceed those identified in the optimal performance baseline demonstrated by *shapeshifter*, showing that with experienced musicians, fidelity to timecode falls within the +0-1" timepoint differential range. These results show a remarkable correlation between audio model key sonic events and those identical key sonic events rendered in performance.

Unfortunately, and for the reasons previously explained, there have been no performances of the larger-scale orchestral pieces. It is therefore impossible to draw conclusions about methodological efficacy concerning those compositions. For the same reasons, it has not been possible to answer the second research question beyond the demonstrable efficacy of the foundational timecode framework as evidenced in the performance results. In the absence of more comprehensive results, it has been necessary to speculate and build assumptions about possible outcomes through projection of known ensemble and chamber orchestra results onto larger orchestral performance scenarios.

At the heart of this speculation sits an assumption concerning the capacity of the foundational timecode framework to support players in the delivery of near-determinate performance outcomes in far greater numbers than is currently demonstrated. When examining performance results there is no indication that player fidelity to timecode support is compromised by an increase in the numbers of players as similar levels of timecode supported efficacy have been demonstrated between the eight, sixteen, and twenty-two players rendering *pulviscular observation*, *pulviscular compression*, and *the unimportance of events* (2021) respectively. With no sign of fidelity to timecode mediation reducing as player numbers increase, I predict that the foundational timecode framework will support the rendition of near-determinate performance outcomes across all performer numbers, from ensemble to large orchestra. Nevertheless, this assumption requires testing through performance to be answered emphatically.

To summarise, I conclude that within the scope of the literature review and performance outcomes obtained, timecode-supported polytemporal music has demonstrated that it

1. Does enable independent, simultaneous polytemporal expansion to all instrumental players.
2. Does support the combination of heterogenous and temporally unrelated materials using a straightforward process of integration.
3. Does support near-determinate performance outcomes despite the use of part-embedded timecode, stop watches, having no conductors and the decoupling of notation materials and players from each other and a score.
4. Supports the hypothesis that this methodology will produce similarly near-determinate performance outcomes for any scale of composition or number of players.
5. Is a unique approach to creating and performing polytemporal music.

Owing to the inherent degrees of confined temporal indeterminacy, this particular iteration of timecode-supported polytemporal music does not support

1. Fully determinate structural results
2. Precise orchestral synchronisation
3. Rhythmically aligned instrumental doublings or precisely predetermined rhythmically interlocking part-writing.

5.2 Future Developments

Owing to time constraints and the specific focus of this investigation, it was not possible to explore all avenues of development the composition and performance of the portfolio pieces suggested. Some of these developments I shall explore in future compositions. Others, I hope, will be of interest to composers in general and researches expert in differing fields. The following paragraphs point to some of these areas of investigation. I will begin by looking at the compositional and performance functionalities currently not developed but supportable through further iterations of the methodology.

Blended Approaches, Remote Performance and Spatialisation

It is possible to incorporate timecode-supported polytemporal methodology into a polytemporal composition as a blended functionality where it is used in conjunction with other performance approaches to produce a hybrid composition operating through a conductor or several conductors alongside timecode-support. Such integration would enable player groups, strands or individuals to be synchronised in ways not currently explored within this methodology to support fully determinate structural results, precise orchestral synchronisation and rhythmically aligned instrumental doublings or predetermined rhythmically interlocking part-writing as transient or continual conditions of performance appropriate for tutti or segmented orchestral application.

Along similar lines but more localised and less radical in approach, the introduction of player directed text instructions into timecode-supported notation materials could include directions for certain players to synchronise their tempo and material where this is logistically and musically practical. It is also feasible to instruct larger groups of players to synchronise material where timecode frameworks share the same tempo and material is suitable for doubling or synchronised polyphony.

For composers requiring higher levels of structural determination in performance, it would be possible to network stopwatches so that they were precisely synchronised to each other. In this scenario, the temporal indeterminacies generated by the loose synchronisation at the start of timecode-supported performances would be eradicated, leaving only player-generated temporal indeterminacy resulting from timecode mediation. A simpler, less technically reliant solution would be to use a large digital stopwatch display all players could see or in a spatialised performance, perhaps several synchronised large displays.

The decoupling of parts and the use of players' own portable timecode frameworks delivered through mobile phone stopwatches also open up a range of extreme spatialisation configurations that are not dependent upon a line of sight between players, players and conductors or players and shared timing devices or expensive, time-consuming technical setups. Additionally, these spatial configurations lend themselves to remote recording and performance as a native activity adaptable for use in blended performances, combining live and remote

players where sophisticated levels of synchronisation are not necessary to achieve near-determinate performances outcomes.

The Introduction of Further Technologies

An exploration of animated notation using video scores where networked iPads or multiple video screens combine notation, timecode and a playback line could yield interesting compositional and performative results. However, as previously discussed, levels of structural determinism would be dependent upon the resolution of the notation used and how much structural, rhythmic, pitch and expressive information were determined through that notation. Although this would be a technology-heavy approach, the iPad would combine stopwatch, timecode and performance materials into one easy to manage format while simultaneously removing the need for manual page turning.

Even more technology based are ideas to explore timecode-supported polytemporal composition within augmented soundscapes. These soundscapes are also known as 'located media' or 'mobile immersive media' and use GPS (global positioning system) mapping technologies to triangulate an individual's position on the planet's surface using three or more satellite signals. Using electronic maps and software, digital media is located into a landscape and the position of this media identified through its GPS coordinates. Using the location technologies within a mobile phone, the GPS coordinates of an individual are established, and their location identified in relation to the coordinates of the placed digital media. This positioning information is used to layer and curate digital content including sound over a physical location within a mobile phone app to create a parallel sonic world.

Ralph Hoyte, an expert and practitioner in this field writes:

> 'Augmented Soundscapes' or 'located audio' (also 'locative media') means audio that triggers in Place, and only in that designated Place. The location — a land — or cityscape — is invested with audio (music, sounds, ambient, poetry, reimagined histories). The whole is downloaded as an app. You go to the designated location, open the app and use your ears to navigate the parallel soundworld, the soundscape, the soundart, the virtual auditorium.[158]

It is within this context I am interested to set in play composed soundpools of

[158] From 'augmented soundscapes' on Ralph Hoyte's personal website 'ralphhoyte.org', <https://ralphhoyte.org/augmented-soundscapes/> [accessed 17 February 2022]

polytemporal materials modelled and performed using timecode-supported polytemporal techniques that are then recorded and located — curated — in a specific place where users walk through and explore the installation. Once at the site, the user will open the app. The app will show blobs and shapes of different colours representing the curated soundpools on the phone screen. Hoyte continues:

> As users navigate to those soundpools, the sound reacts to how they behave when in it: face one direction, for example, hear one thing; face another, hear something else; enter a soundpools once, hear a particular mix; leave, then enter it again – hear something else from the stacked curated soundfiles.[159]

Within these sound files comprising of polytemporal materials, the user will walk through the composition, initiating polytemporal interactions of different materials operating at different simultaneous speeds to build a polytemporal layer cake. In effect, the user is assembling their own unique compositional experience from the multiplicity of combinations available, controlled by their physical movements through space and time. As such, this form of timecode-supported polytemporal composition will present as an open-form work where compositional assembly is shared between composer and user.

Ethnographic Investigation

A final area of investigation concerns the behaviour and functionality of the orchestra in relation to the effects of operating within a timecode-supported polytemporal musical environment. Studies into the functionalities of performers as a group and the differences in power relationships, distribution and communication as well as performance and compositional control and flexibility within an orchestra and its members would bring different, ethnographic, social and political perspectives to the functionality of this methodology. In this context, I believe an examination of timecode-supported polytemporal music through a Deleuzian lens, particularly in relation to Assemblage Theory, The Refrain, and Rhizome as discussed in *A Thousand Plateaus: Capitalism and Schizophrenia*, in a manner similar to that undertaken by Edward Campbell in his book *Music after Deleuze* would prove insightful and useful to the further development and enhancement of this methodology along social and behavioural lines.[160]

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[159] From ‘augmented soundscapes/The Temple of Hermes’ on Ralph Hoyte’s personal website ‘ralphhoyte.org’, <https://ralphhoyte.org/augmented-soundscapes/the-temple-of-hermes/> [accessed 17 February 2022]

[160] Edward Campbell, *Music after Deleuze* (London and New York: Bloomsbury, 2013).

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