

A Practice-Based Study into the Composition and Performance of Polytemporal Music

by

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Abstract

This practice-based research explores the composition and performance of polytemporal music, culminating in ten new works in audio/visual format with accompanying commentaries and notation. Research is undertaken into concepts of rhythm and pulse in order to develop new techniques for composing music in multiple simultaneous tempi, particularly methods for managing rhythmic consonance and dissonance in the compositional process. Attention is also given to the practicalities and implications of performance, investigating issues of accessibility and ensemble in reference to the use of click tracks and headphones, as well as the form and function of notation.

The approaches within this research stem from my experience as a commercial rock/studio musician fused with contemporary classical influences. As well as these musical influences, a background in visual art and design also contributes to the visual presentation of works and scores; musical works are presented in video format which is shown to enhance temporal perception, and a new form of rhythmically accurate western notation for polytemporal music is developed.

Composing and performing in a strictly polytemporal setting has at the time of writing not been widely researched, and it is hoped this work displays new knowledge and approaches important for the development of composition in this area.

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Table of Audio/Visual Examples (provided on USB stick)

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1) Creative Processes

This research is primarily concerned with the composition and performance of new polytemporal music, and as such seeks to investigate and establish principles of rhythm and pulse, using these to explore and develop compositional techniques to create new musical works. These techniques are framed by concepts of rhythmic consonance and dissonance, and are developed over the composition of ten pieces discussed in this portfolio. This results in a broad range of demonstrated methods and devices for composing in multiple tempi. Further questions on the practicalities of performance of polytemporal works are explored, with attention given to the use of click tracks and headphones, accessibility, and the impact of this on a musical ensemble, as well as investigation into the function and practical application of notation in a variety of forms.

My research begins with rigorous analysis of concepts of pulse, utilising delay to explore different rhythmic concepts. This provides a base upon which a refined method of rhythmic composition can be developed and utilised for full pieces. The culmination of this is a portfolio of complete compositions in a range of styles and instrumentations (drawing on a wide range of theoretical concerns) which are presented in multiple formats including audio and video recording, live performance/installation, and score. The works featured are listed below, broadly categorised by function.

Experimental works, which seek to examine practically specific rhythmic concepts:

- *Drum Kit*
- *Cowbells*

Workshopped pieces, which expand on previously explored rhythmic ideas to consider approaches to ensembles, specifically trialling approaches to structure and notation:

- *Maggini*
- *LABO*

Portfolio of Compositions, which display complete pieces informed by the previous experiments and workshopped concepts:

- *5:4 Guitar*
- *Fractal*
- *Translate*
- *Cycles*

- *Disconnect*
- *[in]dependence*

Accompanying these are analytical commentaries documenting the compositional processes and critically evaluating the pieces. Throughout this written thesis readers are invited to experience the works by way of printed score and audio/visual examples.

1.1) Expanded Rhythmic Cognition

Polytemporality is an uncommon and not widely researched area of musical composition, and as such new knowledge can be found both in the completed pieces and the creative processes used to produce these. In order to gain a deep understanding of the processes of composition, performance, and reception of polytemporal works, the cognition of rhythm is investigated theoretically and practically; as such, concepts of ‘expanded rhythmic cognition’ are presented. This wider term encompasses concepts of cognition in relation to the organisation and perception of rhythm, focusing on aspects of entrainment, concepts of pulse, meter, groove, and hierarchy within rhythmic structures, framed within the impact of this on listening and performance.

In order to investigate rhythmic cognition, concepts of temporality in a musical context must first be discussed. The concept of temporal consonance and dissonance as applied to rhythm is an explicit concern of composer Conlon Nancarrow. His terminology and rationale will first be discussed, providing a central catalyst to the compositional approaches within this portfolio. The term ‘temporal dissonance’ was coined by Nancarrow (Reynolds, 1984, p. 1), a key proponent of polytemporal music and major influence in how my own works are produced. Nancarrow was noted for his complex rhythmic concepts for player piano, influenced in this approach by the writing of Henry Cowell (Reynolds, 1984, p. 3). Nancarrow has been credited as playing a major role in American music and gaining respect from György Ligeti and Elliott Carter (Greeson, J.R., et al., 1995, pp. 459-460), Carter also being cited as the initial innovator of temporal modulation (Kostka, 2016, p. 117). Nancarrow’s music included such complexity that few works were physically performed, highlighting also the rationale behind the use of player piano over a human performer. Nancarrow expands on his term ‘temporal dissonance’, considering;

I don't think, say, the polyrhythm of 4 against 5 [is dissonant], where after every 4 and every 5 it comes together on the block...I do think a tempo of 4 [against] a tempo 5 is dissonant because you have a line going against another line. The former situation is coinciding on, let's say, the measure, and the latter isn't. That's what I call temporal dissonance. (Reynolds, 1984, p. 23)

Temporal dissonance can be considered a high-level term encompassing other forms of dissonance, for example metric dissonance as discussed in (later discussed in section 1.2, p. 18). This dissonance can be offset by the concept of a 'convergence point', the 'infinitesimal moment at which all lines have reached identical points in the material they are playing' (Drott, 2004, p. 540). The temporal modulation found in Nancarrow's work could link to that of Japanese gagaku (traditional Japanese court-music often dealing with temporal fluctuations, discussed further in writings by Tokita (2014) and Terauchi, (2011)) which contains a similar temporal direction, however the key difference being Nancarrow's strict and calculated approach contrasting to the intuitive interaction in gagaku, temporal changes noted to be 'felt' by performers (Susumi, 2009, p. 30). A clear example of work showcasing Nancarrow's polytemporality is his *Canon X* (1961-1965), in which two independent lines play simultaneously in separate tempi, with their tempo modulating so as to converge at a single point and cross each other in an 'X' trajectory. It can be argued that the opportunity to visually watch the piano roll during a performance, as in Hocker's video of *Canon X* (Hocker, 2010), can enhance listening accessibility, this concept forming a core element in the presentation of my work as discussed initially in relation to *Drum Kit*. *Canon X* therefore creates a similar sonic effect to Steve Reich's *Piano Phase* (1967), albeit featuring two independently modulating lines as opposed to Reich's piece, wherein one line remains temporally static (this increased complexity emphasising Nancarrow's use of automated performance). Concepts of convergence appear within my own works, most notably displayed as a structural aspect of *Maggini*.

Within wider temporality, concepts of musical rhythmic organisation can be investigated. Specifically, hierarchical notions of meter and pulse can be considered, these terminologies also discussed and defined in relation to *Cowbells* (section 2.3, p. 64) and *LABO* (section 3.2, p. 90). Considering Nancarrow's approaches to temporal modulation, questions surrounding pulse and rhythmic density can also be raised on North Indian music. As demonstrated within gagaku, Indian tāl (clap, considered to represent meter) does not strictly adhere to evenly spaced beats – these can be considered 'categorically equivalent' (Clayton,

1996). Concepts of rhythm, meter, and dynamic are dealt with by Henry, examples cited in the text in the case of qawwali (spiritual, devotional music) are ‘metres with simple and regular durational patterns, clearly articulated by vigorous and recurring stresses’, as well as tempo increase (Henry, 2002, p. 38). ‘Rhythmic density’ is also established among qawwali’s melodies at points of intensity (Henry, 2002, p. 39). A comparison here can be drawn to Nancarrow’s temporal modulation, as the rhythmic density of the piece could be considered to increase as Nancarrow’s tempi do – to again cite *Canon X* as an example, the close of this work culminates in a mass of rhythmic density. Discussion on rhythmic density can also be found in relation to *Cowbells*.

In his text, Clayton (focusing on North Indian rāg) notes ‘Indian music theory historically shows a strong preference for the accurate and unambiguous measurement of time’, deriving from ritual. Specifically, he refers to ancient Indian gāndharva (Clayton, 2008, p. 12). The accurate execution of music is designed to mimic religious ritual, often signalled by hand gestures (cheironomy) – the impact of non-verbal communication is further discussed in relation to *Maggini*, section 3.1, p. 83. The underlying desire for rhythmic accuracy in execution, notation, and communication, is conveyed throughout my portfolio, both in terms of practical application as well as handling the problems of Western notation (discussed in section 1.4, p. 32).

Clayton notes that the concept of cyclical time is very detailed, extending from basic concepts of days, months and years to spiritual or cosmological thought. He speaks of cycles as ‘the same in type, but not in detail, and processes such as salvation unfold continuously within the framework of cyclical time. Moreover, while the cyclicity of time suggests that things are essentially unchanging’ (Clayton, 2008, p. 16). Though a core concept in North Indian music, Clayton draws comparisons of cyclical rhythmic structure to Western metric concepts as well as West African rhythm (referencing Ekwueme), among other styles. This cyclical approach to rhythmic structure is heavily focused on throughout my portfolio largely via cell-based rhythmic cycles, particularly exemplified in *Cowbells*, *5:4 Guitar*, *Maggini* and *Cycles*.

Discussions on West African music handle rhythmic cognition, developing thinking to consider metric hierarchy (later expanded upon by Krumhansl in relation to *Cowbells*, section 2.3, p. 68. In his book *African Rhythm and African Sensibility*, Chernoff discusses

the integral complexity of African music, comparing the importance of this with Western music – specifically, it is considered that ‘In Western music, then, rhythm is most definitely secondary in emphasis and complexity to harmony and melody’ (Chernoff, 1979, p. 42), suggesting that the opposite is true for African rhythms. Although this can be considered an oversimplified, highly subjective, and outdated argument, Chernoff does importantly highlight the Western organisation of rhythm into ‘standard units of time’ by way of beat, meter, etc. which can prove problematic when drawing comparisons to rhythms of other cultures (Chernoff, 1979, p. 41). Agawu challenges these generalisations (referencing Chernoff amongst others), noting such studies ‘leave unchallenged the basic assumption regarding the paramountcy of rhythm’ (Agawu, 1986, p. 64). Ekwueme acknowledges also the lack of detail in this type of writing; ‘more studies seem to have been made of Ghanaian rhythm - in particular Ewe dance drum rhythms - than the rhythm of probably all other areas of Africa combined’ (Ekwueme, 1975, p. 28). Commenting on the broad form of West African pieces, Ekwueme writes,

West African musical rhythm is based on a skeleton - a background structure which we may simply call the "form" of the music. In a general way, this is reducible to an A-B form, or simply a "Call and Response" or "Call and Refrain" form, in which a soloist (or a group) makes a statement, and a chorus (or another group) makes a response. (Ekwueme, 1975, p. 31)

Agawu describes the hierarchical functions of drum ensembles, which can then draw parallels to hierarchies of rhythmic structure more widely; while he notes the difficulty in assigning the term ‘meter’ to music of this type, Agawu references instead ‘structural tension’ and ‘metric dissonance’ (not dissimilar to Nancarrow’s use of temporal dissonance) that arises in the presence of rhythmic levels. Also included are concepts of foreground, middle ground and background, potentially comparable with Clarke’s high and low-level rhythmic structures (Agawu, 1986) – Clarke’s concepts are further discussed in relation to *LabO* (section 3.2, p. 91). This concept of foreground, middle ground, and background could be translated to my compositions by way of rhythmic structure at different levels; high-level structures, bars, and beats and subdivisions.

1.2) Multitrack Recording

A core tool for developing expanded rhythmic cognition throughout the portfolio is the use of multitracking. DAW (Digital Audio Workstation software) and MIDI are used heavily in the composition and audition process, contrasting with more traditional score-based workflows where digital systems would be used to record and enhance a pre-existing performance. These systems are also utilised to ‘command’ or ‘manage’ compositions and performances, most notably discussed and demonstrated in *Translate*, and my writing surrounding this also expands to cover the sociological implications of this on ensemble (including power relationship and control structures) when discussing network theories.

The use of DAWs integrates several means of construction and analysis; material can be very easily manipulated by way of MIDI quantisation, audio editing and automation (the later forming the basis of *Translate*) to produce compositions, in particular the piano roll screen closely mirroring Nancarrow’s original pianola rolls (an example of these featured in section 2.1, p. 55). The use of digital technology and playback can also ease certain accessibility issues; parts may be programmed for absolute accuracy, or if instrumentalists are to be recorded this opens up a more flexible environment in which accessibility can be practically researched during the recording process. This can be by way of (for example) observing players’ interaction with click-tracks, or utilising technology to streamline works where cell-based rhythmic cycles are used by way of looping and overdubs; *Cowbells* and *Fractal* demonstrate this approach.

In order to derive tempi used within pieces, a calculation-based methodology is used to produce a table of available mutually compatible temporal options (in beats-per-minute) for composing upon. This is first established in section 2.1, p. 51, then forming the basis of all works in the portfolio from early experimental work until the most advanced and complex pieces. This method, used to generate potential tempi that have rhythmic relationships, functions as a means to select tempi systematically instead of arbitrarily. This method therefore could be considered a digital parallel to Nancarrow’s approaches, however maintaining accessibility by not handling highly complex or irrational tempi, which Nancarrow did in multiple works (examples being *Study No. 33* and *Study No. 37* (1966-1969)).

Throughout the portfolio several approaches to musical structure are considered. These include the following:

- Improvisation from performers, demonstrated in *Drum Kit*, and *LABO*
- Structure built on cell-based rhythmic cycles, demonstrated in *Cowbells*, *5:4 Guitar*, *Fractal*, and *Cycles*
- Performer-led open-form work, demonstrated in *Maggini*
- Machine-led rhythmic frameworks, demonstrated in *Translate*, *Disconnect*, and *[in]dependence*

As mentioned previously, expanded rhythmic cognition can be found in many divergent styles and approaches. Multiple concepts of rhythmic manipulation featured in the portfolio can be demonstrated by Swedish metal band Meshuggah, whose compositional style draws heavily from polyrhythmic techniques. Though their music exists within a single tempo, polytemporality has at times been implied within songs, an example being 0:55 of *Neurotica* (1998), where the guitar riff could be perceived as a different tempo superimposed onto the actual pulse (this is considered ‘subjective rhythmization’, a term discussed in relation to *Cowbells*, section 2.3, p. 66). The band often utilise complex rhythmic patterns (usually consisting of relatively few harmonic notes, an example being *Break Those Bones Who Sinews Gave it Motion* (Meshuggah, 2012)) played on the guitars, bass, and kick drum. This is superimposed onto a common rhythmic backbeat usually adhering to Moore’s ‘standard rock beat’ where snare placement usually occurs on beats 2 and 4 (Moore, 2001) to create a cyclical, large-scale polyrhythmic effect. Pieslak provides an analytical example of this, referring to the 2002 song *Rational Gaze*:

The guitars and bass can be grouped into four repetitions of measures in 25/16, followed by a measure in 28/16. The entire passage is then repeated. While this is going on, the cymbals create a metric superimposition: as the pedal bass (kick) drum doubles the guitar and bass rhythms, the cymbals maintain a consistent quarter-note pulse, complemented by snare drum hits on what would be beat three in 4/4 time. (Pieslak, 2002, p. 220)

The polyrhythmic nature of the two elements can evoke in the listener further rhythmic patterns by way of subjective rhythmization, particularly regarding the interplay between the guitars/kick and snare. Pieslak comments on the concept of ‘metric dissonance’ (Pieslak, 2002, p. 220), a term which expands upon Nancarrow’s broader temporal dissonance, referencing Krebs’ definition as ‘interpretative layers whose cardinalities are different and are not multiples/factors of each other’ (Krebs, 1999, p. 23). Pieslak then notes that although Meshuggah’s cyclical polyrhythmic approach utilises metric dissonance, it does not usually occur in full, commenting that, with reference to *Rational Gaze*, the ‘25/16 would have to be repeated sixteen times in order for the downbeats [of both this and the 4/4 pattern] to ultimately fall in the same place’ (Pieslak, 2002, p. 222). However, the inclusion of the 28/16 bar allows the section to repeat after eight bars of 4/4 time; this could be considered a conscious decision to avoid ‘excess’ metric dissonance and maintain a more conventional, commercial song structure. Pieslak notes:

Meshuggah, however, seems to organize the rhythmic techniques of odd meter and mixed meter into a larger structure of four-bar hypermeasures, where each hyperbeat equals four quarter notes, each hypermeasure consists of four hyperbeats, and each hypermeasure repeats four times; this prototypical hypermetric structure is common in many popular music genres. (Pieslak, 2002, p. 223)

Concepts of Hyperbeat and Hypermeasure are also displayed visually by Capuzzo in a circular format, representing well the nature of the rhythmic structure visually – this is exemplified in Figure 1, representation of the track *Dancers to a Discordant System* (2008) (Capuzzo, 2014, p. 6).

Example 6. Cyclic rhythmic/metric representation of “Dancers to a Discordant System.”
 4 hypermeasures (orange, T48), 16 hyperbeats (green, T12), 64 beats (blue, T3)

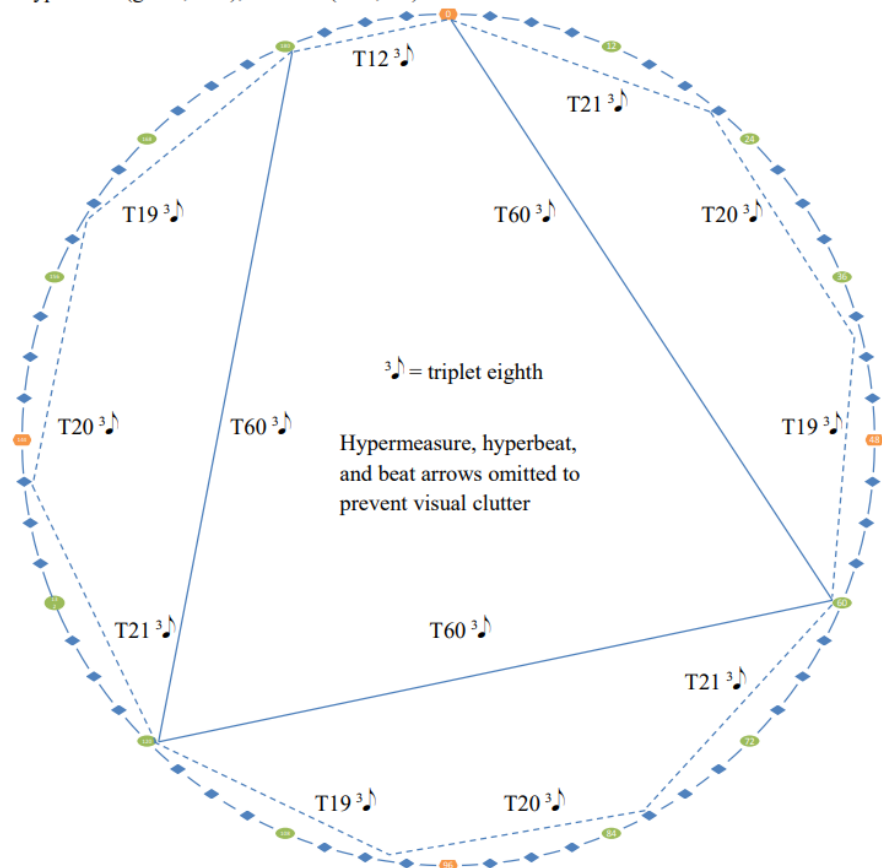


Figure 1: Cyclical representation of beats, hyperbeats, and hypermeasures

In Capuzzo’s diagram, a rhythmic structure can be observed; a high-level cycle can be broken down into four equal hypermeasures (groups of four bars), each hypermeasure containing four equal hyperbeats (groups of four beats). Concepts of hyperbeat and hypermeasure are featured prominently in my own rhythmic organisation, most notably displayed in *Translate* and *[in]dependence*.

In his work, Burke compares Meshuggah’s aesthetic and compositional style to that of Stravinsky’s *The Rite of Spring* (1913), drawing rhythmic parallels between the main motif of the song *Bleed* (2008) and that of *Augurs of Spring* (Burke, 2018, p. 55). Although several musical comparisons are drawn between Meshuggah and Stravinsky, Burke highlights the fact that Meshuggah favour a more measured and less ‘chaotic’ approach in the live setting, opting to use click tracks to execute songs with complete metric accuracy (Burke, 2018, p. 57) – this practicality forms a core technique within my own work.

Throughout the portfolio, harmonic content is handled by varying means, as discussed below:

- Developing initially rhythmic concepts to include increased pitch material, as demonstrated in *5:4 Guitar*
- Improvisation on broader harmonic progressions, as demonstrated in *LABO*
- Using polytemporality and cell-based rhythmic cycles as a catalyst for provoking subjective harmony, as demonstrated in *Fractal*
- Utilising technology and automation to generate and enhance harmonic content, as demonstrated in *Translate*
- Traditionally intuitive approaches to harmonic composition, as demonstrated in *Cycles*, *Disconnect*, and *[in]dependence*.

In a broad sense, these compositions present a dialectic of familiar harmony against unfamiliar temporal elements. As a result of this, compositional approaches require reflection on stylistic conventions. Sheppard notes,

...most music is not imitative or representational, but convention plays an important part in music. To take only a few examples, there are conventions about the instruments used, about types of scale, and about the succession of quick and slow movements. Conventions may pervade a whole artistic tradition', also noting 'The truth is that understanding a work of representational art involves both a recognition of resemblance and an appreciation of convention. (Sheppard, 1987, pp. 11-12)

When considering live performances of polytemporal works, this leads to dialectical discussion on the nature of ensemble itself; the following discussions explore and detail a variety of approaches to ensemble, leadership, and networks. Several of these approaches and ideas are referenced when considering the ensemble works in this portfolio, and while not every theory is expanded on practically I think it important to investigate these and surface the broad issues and implications of these.

1.3) Alternative Concepts of Ensemble

Ramona M. Wis discusses ‘servant leadership’, a concept coined by Robert K. Greenleaf which proposes leadership not from ‘managers’ but from ‘servants’. This yields an arguably more satisfying, individualised but cumulative and collaborative leadership style by the latter; the servant leader is driven first by the desire to serve, before leading (Wis, 2014, pp. 229-230). Specifically, Wis discusses the role of ensemble leader as servant leader, noting that this breeds more trust in musicians, owing to the fact they are viewed on the same social level as the performers being conducted (Wis, 2014, p. 231). While in the case of my work the laptop functions as ensemble leader, it lacks any other human qualities – this yields both benefits and implications, further discussed in section 1.4, p. 40.

My ensemble compositions can be considered through a social network perspective. This concept, as considered by Katz et al., describes an organisational system where nodes are connected by ties. Nodes (or ‘actors’) can refer to participants or groups, with ties providing multiple levels of relationship and therefore analysis. The authors write, ‘The defining feature of the network perspective is the conceptual building block of the tie – of individuals to individuals, groups to groups, or individuals to groups’ (Katz, N., et al., 2005, pp. 278-279)’. Katz et al. continue to elaborate on different forms of tie, as well as the strength, direction and content of these. This can then be visualised as a sociogram, shown in Figure 2 (Miller, 2017).

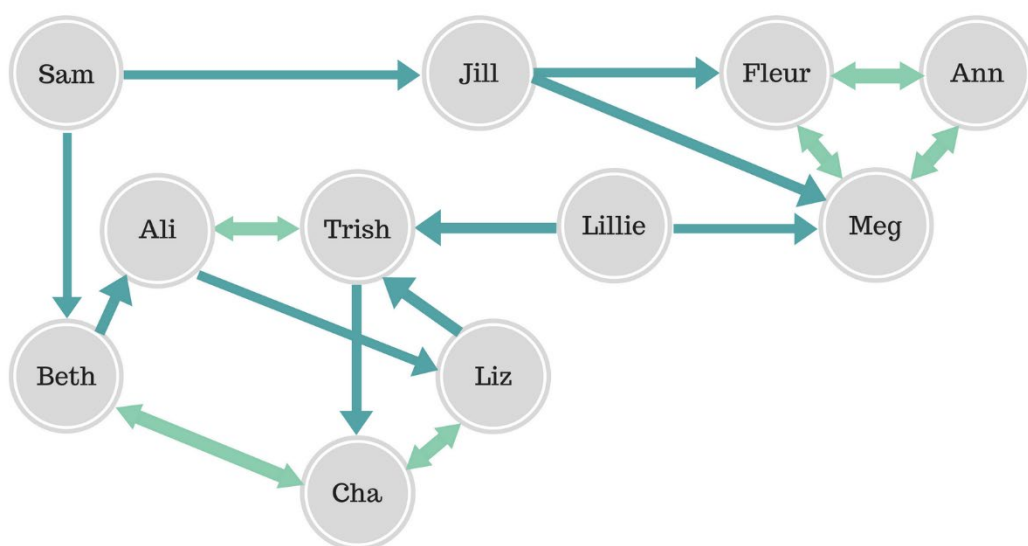


Figure 2: Example of a sociogram

In this example, an omnidirectionally communicative network can be observed. This visualisation can be used when approaching discussions of ensemble, particularly to establish the channels of communication available to a group and the implications of these; particularly in the case of my work this involves non-verbal communication, discussed in relation to *Maggini*.

To further elaborate on this, Wellman proposed 5 fundamental principles to this approach (Wellman, 1988):

1. Relationships within the network are what helps predict behaviour
2. Relationships should be the focus of analysis, not nodes
3. Do not assume independence; look at nodes relationally, assume interdependence
4. Look beyond simple dyadic relationships; look through the lens of the network as a whole, or clusters within it
5. Remember that boundaries are not hard, but fuzzy; nodes may cross these

These principles provide insight into the nature of ensemble in a polytemporal setting, and particularly conflicts which can arise where performers are communicatively restricted by way of headphones (further discussed in section 1.4, p. 40). For example, points 1 and 5 are affected in a network where nodes' communication are restricted, however points 2 and 3 could be applied when considering the execution of a work as a whole; if a compositional performance is manifested by the actions of a network, relationships and interdependence (although not necessarily consciously considered by performers as nodes) are of paramount importance in the accurate representation of the piece itself.

A further theory considered by Marwell and Oliver is 'mutual interest and collective action'; the authors state, 'mutual interests and the possibility of benefits from coordinated action', can outweigh individual self-interest (Marwell, G. & Oliver, P., 1993, p. 2). This concept is referenced in relation to the performance of *Maggini*, as well as in the context of human/laptop interaction in *Translate*. This (while drawing parallels to the above writings discussing Wellman's principles) is linked to public goods theory and can potentially be applied to my compositions. A network of musicians may 'communicate' by way of performance with the laptop to produce the music for the audience – or, to create and

maintain the public goods. This communication manifests in different forms however; the laptop is able to send signals to the performer but not receive these (as a non-human performer this would be considered non-analogic codification, discussed later on p. 25 – an exception to this statement is the receipt of audio stimulus from the live performer in *Translate*), and the performers are able to receive information and act based on this. It is of mutual interest to the musicians in the network and maximises self-importance. Katz et al. note, ‘the motivation to forge ties and form a group is to maximize their collective ability to leverage resources and mobilize for collective action in their environment’ (Katz, N., et al., 2005, p. 285).

In their text ‘Traces, Trajectories, and Timings’, Arrow et al. discuss various group models. The ‘Repeating Cycle Model’ discuss the formation of groups where the activities are temporally shorter than the life cycle of the group. The authors consider the different stages of these (Arrow, et al., 2005, pp. 328-329):

- Discontent – ‘the group is not a significant part of members’ identities. Members feel alienated and participation is low. To move past this stage, the group needs a ‘precipitating event’ that sparks renewed member interaction’ (Arrow, et al., 2005, p. 329)
- Precipitating event – something that renews interaction and enables the rediscovery of commonalities, developing hope the group can change
- Group identification – Strong boundaries are developed between the group and outsiders - identity is established
- Group productivity – collective work focused on reaching group goals
- Individuation – members’ focus shifts to themselves, there emerges inter-group competition as members seek recognition
- Decay – individuation can lead to group breakdown
- Returns to discontent

It could be considered that the initial stage of discontent is representative of the disparate tempi as a concept, dividing the group, as they are unable to engage with each other because of these. The precipitating event then can be considered the introduction of the technologies and methods required to enable interaction, revealing the commonalities of the musical material through performance. With this, the group assumes its identification and can be

productive from within the ‘strong boundary’ that contains them, as members enter the ‘individuation’ stage of performing, however in the context of a musical work, the inter-group competition and decay would not apply. This model also suggests dialectic, where the group identification and execution of the task forms a synthesis to the discontent and precipitating event. Comparisons to this model are drawn in *Maggini*.

Within group productivity and individuation links can also be drawn to teleology, particularly Arrow et al.’s consideration of ‘Adaptive Response Models’, which discusses the teleological motivation of multiple goals being pursued. The authors consider this as ‘equifinity’ – the concept that many paths can lead to the same destination (Arrow, et al., 2005, p. 330). With reference to McGrath’s writings on TIP (time, interaction, performance) theory, Arrow et al. propose that ‘groups typically pursue multiple concurrent projects’ (Arrow, et al., 2005, p. 330); this mirrors closely Fink’s concept of recombinant teleology (Fink, 2005), further discussed and exemplified in *Maggini*. ‘Structuration Theory’ looks at the distinction between ‘*system*, the observable pattern on relations in a group, and *structure*’ (Arrow, et al., 2005, p. 347); the rules and resources members use to generate and sustain the group system – this draws strong parallels to the musical ensemble; within a group structure, there must exist a system of rules and resources available to performers. In the case of my works, the forms of notation involved (traditional printed score, and audio score) function simultaneously as the rules (the click track) and resources (notated instrumental parts) to enable performance of the work.

The nature of ensemble can be considered at a variety of levels, presenting discourse on hierarchy within social, physical, and psychological frames, and parallels can be drawn to hierarchy in rhythm. Analysing this at lower levels, research into gesture and non-verbal communication, how this affects behaviour, and movements at the most micro-level can also be considered – these issues are discussed in relation to *Maggini*, *Disconnect*, and *Cowbells* respectively.

As headphone usage is a core aspect of the practical execution of my work, research into the impact of restricted listening and communication can also be employed. In a study by Novembre, a pianist performed the right-hand part of six Bach chorales (*Herr, ich habe mißgehandelt, Meines Lebens letzte Zeit, ‘So gibst Du nun, mein Jesu, gute Nacht, ‘Christus, der ist mein Leben, Die Nacht ist kommen, and Gottes Sohn ist kommen*) while the left-hand

part was not performed. In one performance the pianist played the single part, while in a second performance the pianist was led to believe the left-hand part was being played by a second performer from behind a screen, however this was not the case (it was instead pre-recorded). In the instance the pianist thought they were being physically accompanied, their physical nerves and mental responses were measurably heightened (Novembre, 2012, p. 2898). A further variation on this can be observed in a video clip of bassist Victor Wooten (Sabbagh, 2013), in which a student performs noticeably differently ‘unaccompanied’ to when Wooten instructs him to play while imagining a performer is playing the drum kit behind him – Wooten’s goal being to display the impact of groove as a concept on performance (groove is later discussed in relation to *Cowbells*, section 2.3, p. 68), and by association also highlighting aspects of rhythmic entrainment (further discussed in relation to *Drum Kit*). These observations can provide further insight and speculation into my own compositions where executed in situations restricting communication and listening.

Schechner and Mintz consider ‘analogic codification’ to be communication that is not digital; as such, all human musical communication throughout the portfolio can be considered analogic (Schechner, R. & Mintz, C., 1973, p. 102). Continuing, kinesics (gesture as non-verbal communication) is discussed within the context of performance:

Psychoanalysis is profoundly discursive and individualist. Kinesics is analogic and collective-as such it has more of a bearing on performance which traditionally communicates through images, actions, and gestures; even, as in opera, using words-as-sounds rather than discursively. (This operatic use of words is a recurring characteristic of modern experimental performance.) Performance is a collective activity both from the performers' and the spectators' points of view. (Schechner, R. & Mintz, C., 1973, p. 104)

It is therefore important to keep in mind that the reception of communication, particularly via gesture, is variable from subject to subject – aligned to this, the inclusion of the laptop as non-human ensemble member (most notably demonstrated and discussed in *Translate*) also highlights elements of non-analogic codification. However, Schechner and Mintz note that performance as a concept derives not just from performers themselves, but also the audience. This is reinforced by Bell:

While some singers find earpieces very useful, the audience may be intrigued or even disturbed by their presence. The listener will often be seduced by the immersive feeling of performance happening all around him, but at the same time he might be disappointed or intrigued if the performer is merely reproducing what is heard through his ear, as he might perceive it as a threat to the genuine engagement of the performer on stage (or in situ). (Bell, 2016, p. 168)

This suggests a dialectic where facilitative technology is utilised; while this can be used to enhance the accessibility of a performance by way of audio scores (discussed in the following section), it can impact on audience reception where this may conflict with conventional expectations or authenticity – though I recognise such potential implications, this portfolio does not seek to discuss these, instead primarily concerned with compositional and practical processes.

Schechner and Mintz continue to outline terminology defining communicative movements, this is useful when analysing works however also draws parallels to other research including that of specifically musical performance:

The kine is the smallest kinesic unit-the smallest particle of visually perceptible motion (for example, the eyelid closure in a wink). The kinemorph is a set of kines that compose the particular motion isolated for study (for example, the wink itself). Allo kines are variations of kines that do not change the meaning of the kine within the pattern of a particular kinemorph (for example, closure of the right or left eyelid in a wink-"rightness" and "leftness" are allokinic, one can be substituted for the other). A kinemorphic construction is a combination of kinemorphs (for example, a wink plus a head nod). (Schechner, R. & Mintz, C., 1973, p. 106)

A single kine can be likened to micro-timings present in musical performance, further discussed in relation to *Cowbells*, (section 2.3, p. 68), with a kinemorph suggesting a full musical motion; a bowing on a violin, for example. Combining musical motions into a performance therefore produces a continuous and complex kinemorphic construction per player.

Schechner and Mintz interestingly also refer to ensemble performance as a manifestation of ‘harmony’ – a term with obvious musical connotations comprising concepts of consonance and dissonance. The authors note that harmony stems from ‘intra-group reciprocation of movement’ (Schechner, R. & Mintz, C., 1973, p. 107). On this basis, successful (perhaps considered *consonant*) harmonic interaction (irrespective of whether this is musical or not) is impacted by the reciprocation of movement and gesture, and therefore will potentially be negatively affected (perhaps considered *dissonant*) should interaction be prevented. This draws parallels to musical performance where modes of communication are mitigated, also discussed and demonstrated as part of *Maggini*.

Katz et al. also consider the theory of ‘social exchange and dependency’ (pioneered by Homans in his work ‘The Human Group’ (Homans, 1950)), particularly the concept that ties can be established where ‘valued resources’ can be exchanged, determining whether a relationship can be sustained over time (Katz, N., et al., 2005, p. 284). This could be likened to Stupacher’s research on rhythmic perception and social affiliation (discussed in relation to *LabO*, section 3.2, p. 92), if rhythm is considered as a ‘valued resource’ within a musical situation (similar to concepts of group mutual interest, previously discussed on p. 22). As discussed below, the authors propose several findings of Network Perspective Research. These points suggest correlation within my own work, as outlined below (Katz, N., et al., 2005, pp. 288-289):

Group composition

- ‘The greater the diversity of the group, the lower the interaction level’ – this does not explicitly define ‘diversity’ but could be applied to the diversity/complexity (and number) of subjects in a group and the effect on their relationship; for example, if applied to groups of tempi, those with complex relationships feature less direct correlation than simpler polyrhythms – this can be likened to temporal consonance and dissonance particularly when considering Nancarrow’s definitions. Within this, complexity and diversity can reflect concepts of rhythmic hierarchy, specifically with regard to rhythmic density (further discussed in relation to *Cowbells*, section 2.3, p. 68), which can in turn affect the accessibility of the instrumental part for performers. Allied to this, performance accessibility on a technical level is linked to performer proficiency; it is on this basis that to enable maximum accessibility works are built on layered simplicity as much as possible.

Group projects

- ‘The greater the complexity of the task, the more likely a decentralized communication pattern will emerge within the group’ – similarly, this is exemplified by the fact that as more complex rhythmic components are added to a piece, the less a group are able to process these in synchrony; this necessitates a more singular mode of communicating rhythmic ideas, most notably the audio score. It could also be considered that this notion is affected where non-human group members are present, and as such can maintain a high degree of centralised complexity; this is particularly demonstrated in the execution of *Translate*.

Group structure

- ‘Technologies and resources may be conceived as nodes in the network’ – as referenced above, this can directly reflect the use of technology as a means of communication to facilitate performance. Considering this as a node (perhaps on a sociogram), a non-human actors functions as a centralised node facilitating group performance – this then mirrors the ‘wheel’ structure, as discussed below).
- ‘Groups with centralized networks are more likely to produce a leader; the individual in the most central position is likely to emerge as the leader’ – while in terms of ‘group projects’, decentralised communication can be likened to the act of ensemble members focusing on their own individualised communication (i.e. for their respective tempo), this can be considered low-level within a larger hierarchy; in this instance, a laptop can be considered the central leader, which distributes the independent communications to the individuals of the ensemble. Notation can also support this model, however in my own work, *Maggini* displays a decentralised network which, at the instruction of the score, sees individuals assert themselves as leaders.

Katz et al. also consider the formation of groups, and how this affects relationships and efficiency. Referring to several MIT investigations conducted between 1950 and 1964, it can be concluded that of a series of different small group structures, a ‘wheel’ network was most effective (Katz, N., et al., 2005, pp. 289-290); this structure featured four outer nodes

(A, B, E, and D), with a central node (C). Within this structure, outer nodes could not communicate with each other but could communicate with the central node. References to this model are made throughout the portfolio, it closely representing my ensemble structures (particularly with the laptop functioning as central node, most notably demonstrated in ensemble works such as *Disconnect* and *[in]dependence*). The wheel model was similarly structured to the ‘all channel’ group, which differed in that all nodes were connected – this fact however meant the group did not organise itself as efficiently, and interestingly it is noted that where ‘sub-optimal’ communication patterns were available, groups actively chose these (Katz, N., et al., 2005, p. 291). Reflecting on this, the authors note, ‘in groups that were structured as a wheel, the communication pattern that quickly emerged was a two-level hierarchy, with all information going to and from the hub’ (Katz, N., et al., 2005, p. 291). This provides a direct comparison to ensembles where there is a central point; traditionally a conductor or, in the case of my compositions, a laptop. In the case of my work, the laptop serves as the central node which distributes all communications; the performers are able to engage with the laptop by way of receiving communications, but not being able to send any to it. The fact that the laptop cannot receive communications from performers may suggest further efficiency, however this is at the cost of flexibility being rendered impossible. This may affect the accessibility of performing in this way; to refer back to discussion on servant leadership, performers trust conductors who can be viewed on the same social level as themselves, and as such with this mode of leadership this is not possible.

It could be considered that the all-channel network is most representative of a collaborative ensemble such as a band which may meet and ‘jam’ – while it will reach its goal may not do so in the most efficient way, as all nodes can communicate with each other, therefore slowing the trajectory of the group towards its end goal. The concept of an improvising ensemble (for example, in conventional jazz structures) could however be considered to straddle these two groups; a single node may assume the role of ‘leader’ for a solo, with other participants communicating to support this, before the leadership position is passed to another member of the group. In the case of my compositions where improvisation is featured, the performers are at certain points able to be influenced by each other’s performance, but in the context of the central node – they have controlled freedom in the pre-defined structure, duration and direction. This approach is exemplified particularly throughout *LABO*, *Disconnect*’s drum solos, and *[in]dependence*.

1.4) Complexity, Accessibility, and Polytemporal Notation

My work utilises various forms of notation as discussed in these methodologies, however discussion is required surrounding how notation is presented in terms of media, and for what purpose – this then raises concerns around the representative nature of notation, particularly with reference to what the musical output is in its ‘pure form’.

In their work, Miller et al. discuss the origins of written musical notation, with earliest examples of neumes (curved lines), developing into Common [Western] Music Notation or ‘CMN’. Miller et al. note the core function of CNM as ‘to assist musicians with the accurate communication, interpretation, and reproducibility of compositions. CMN enables the capturing of musical aspects for creators and composers likewise to conserve their ideas, unambiguously.’ (Miller, M., et al., 2018, p. 1). The authors consider the implications of designing new notational systems, proposing categories covering the broad function of the notation:

- Live performance
- Analysis
- Art
- Education
- Instrument support
- Composition
- Entertainment

Miller et al. note that although these are not exhaustive, each category’s notational output would yield different information, and as such it may be that multiple notational forms are required to fully convey the levels of depth of the work. This approach is described with reference to ‘Users’ and ‘Tasks’ – a performer would have a different set of needs to a conductor in terms of requirement to execute the work (Miller, M., et al., 2018, pp. 2-3); this provides a parallel with previous discussion on Structuration Thoery, which looks specifically at the resources required to sustain a group executing a task.

One of the goals of my compositions was to establish accessibility for performers; while at a high-level the work will be complex, in particular with regard to rhythm, low-level

(individual parts) are as simple as possible in order to achieve the desired musical outcome. Regarding complex output and the skill required for this, Graham considers:

To handle the huge forces of a symphony orchestra satisfactorily, as both composer and conductor, requires a very great mastery of musical materials. Yet from the point of view of pleasurable feeling, there does not seem any reason to prefer or commend this mastery. Complexity in a piece of music does not in and of itself lead to greater pleasure on the part of the listener. On the contrary, since a large-scale piece of music demands a great deal from us in the way of sustained and concentrated attention, simple harmonies with a catchy tune are usually much easier to enjoy. (Graham, 2005, p. 78)

In many instances within the portfolio instrumental parts are derived from cyclical rhythmic cells juxtaposed with temporal dissonance to provide a complex result, most notably demonstrated in *Cowbells*, *5:4 Guitar*, *Maggini*, *Fractal*, and *Cycles*. Where single cells are repeated without harmonic variation this does then present additional challenges to produce the ‘simple harmonies’ and ‘catchy tunes’ associated with Graham’s argument, however it does prompt further discussion into the type of listening required for this kind of music. He continues,

[a highly sophisticated piece of music] not only is worth listening to but requires listening to over and over again. This is not simply because we can enjoy it more than once, but because there is more and more to discover in it. It may also be performed again and again in markedly differing ways, because it allows considerable variety of interpretation (Graham, 2005, p. 78).

The complexity of the music, particularly the aspect of polytemporality, promotes this form of deeper, repeated listening. Individual components can be aurally isolated and interpreted in various ways; for example, spatially within the stereo field (most notably demonstrated within *Translate*’s stereo configuration), within live performance (as discussed in relation to the premiere of *[in]dependence* where performers were spaced throughout the room), or via multimedia presentation (first discussed in relation to *Drum Kit* and developed regarding *Translate*’s animated notation). Graham considers this necessity for repeated listening a form of ‘richness’ (Graham, 2005, p. 79).

Problems with western notation can arise due to various factors, specifically where the music in question does not adhere to a standard rhythmic structure across multiple instruments – this is a common issue when transcribing and analysing non-western music, an example being West African music. While my own compositions can be considered Western in many aspects (including the musical demographic of the performers participating), they encounter many of these same issues when approaching written notation.

In his work, Temperley discusses issues when applying Western metric theory to African rhythms. Specifically, he notes that ‘a metrical structure is best regarded as something in the mind of the listener, rather than being present in the music in any direct way’ (Temperley, 2000, p. 67) This notion of meter as an artificial, induced concept is also discussed in relation to *Cowbells* (section 2.3, p. 64), and also provides an example of the wider issue of attempting to apply Western concepts of meter to music which does not broadly abide by Western rhythmic or notational conventions. Applying this concept to the West African piece *Gi Dunu*, Agawu produces notation of two parallel parts with independent time signatures and barlines (to present a polyrhythmic notation), before critiquing this as being,

...not only an abstract and theoretical exercise, but it falsifies the inherent (and exciting) structural tension between foreground and background. This is, in fact, the problem with some of Brandel's transcriptions (1961), which completely obliterate such tension and replace it by an additive conception of meter, Stravinsky style. (Agawu, 1986, pp. 70-71)

While I agree that this could change the intuitive ‘feel’ (suggesting notions of groove, discussed in *Cowbells*) and possibly authenticity of the representation of the piece, such modifications for notation can provide additional accessibility and aid accurate performance by ‘Western traditional’, classically trained players. This type of notation is also presented as an analytical tool by Pieslak when analysing Meshuggah’s track *Rational Gaze*, displayed in 4/4 and 15/16 simultaneously (Pieslak, 2002, p. 221). This notational format of displaying independent barlines and meters is adopted for my own work, where full scores for ensemble pieces are provided (the first piece utilising this being *5:4 Guitar*).

Clayton considers the issues of applying meter to non-Western music, noting: ‘Central African polyrhythm on the other hand consists of a web of interlocking, periodic rhythmic patterns, organized around a single primary pulse level. Since there is only one pulse level, and no regular ‘accentual matrix’, this organization cannot (according to Arom, 1991) be described as a type of metre’ (Clayton, 2008, p. 31). It is interesting to note that although Clayton identifies a singular ‘pulse level’, due to the nature of the rhythms imposed upon this meter cannot easily be applied; this could be said to mirror my approach of having a single ‘base tempo’, upon which other tempi are derived (this methodology developed in the following section). Chernoff also notes in his analysis of African rhythm that complex polyrhythmic material (‘cross-rhythms’) are derived from simple patterns with uneven amounts of repeats (Chernoff, 1979, p. 45), drawing parallels to my own methods on complexity via layered simplicity. While meter by definition can be perceived by strong and weak beats over a pulse (later explored in relation to *Cowbells*), additional accents and performance instructions can be included to distract from a meter having a specific number of beats (as is exemplified in Meshuggah’s music where emphasis is placed on the juxtaposition of a 4/4 backbeat), resulting in Western notation being used only as a performance aid or analytical tool. As well as (perceived) metric changes over a single pulse, Agawu notes that temporal changes are also prevalent in West African music, using as an example *Nyekpadudo*, a vocal work conceived by the Malinke (Agawu, 1986, p. 74). In addition, changes in tempo, rhythmic divisions such as triplets, and interplay between free and strict rhythm, suggests dialectical thinking, as discussed by Ekwueme:

The existence of two parts implies the existence also, real or inherent, of yet a third part: the antecedent, the consequent part, and their combination. In every binary form, therefore, there is a third part. By the same token, every duple time also implies a third or triple time. It is rather like the Hegelian theory, which, with a Thesis and an Antithesis, yields a Synthesis. (Ekwueme, 1975, p. 30)

Freeman considers the notation of a work only as a representation of the performance itself, stating:

Notation makes human musicianship possible at the output stage of an interactive system: The system creates notation for musicians to perform rather than creating sound directly. The form of the notation, naturally, must evolve from the printed page: As a key component of an interactive system, it must become dynamic. (Freeman, 2011, p. 15)

This considers the facilitation of a performance a ‘system’ mirroring network perspectives, particularly parallels can be made to Structuration Theory and its notion of considering systems and resources available for the completion of a task. Freeman in this instance also views notation only as a means to enable performance, whereas my work views notation as an analytical tool where full scores are provided (as these cannot facilitate performance), and as a form of accessibility enhancement (displayed most notably by the visual presentations of *Fractal* and *Translate*). Freeman further elaborates on this, documenting the rise of complexity within printed notation, noting this can be considered a detriment to the live performance by reducing interpretation.

Bell also discusses the subjectivity of the written score when considering live performance:

The notation of time is at the core of the performer’s understanding of the score, and yet its representation is highly equivocal. To give a simple example, whilst a notated middle C will, in all but exceptional cases, be interpreted by composer, performer, and audience in roughly the same manner, a rhythmic figure of comparable simplicity may be notated in a virtually infinite number of ways, which are then themselves open to different varying interpretations by the performer and subsequently, the audience. (Bell, 2016, pp. 27-28)

This highlights the subjective, interpretive nature of notation, and in turn surfaces potential issues with the realisation of compositional ideas. It can be argued that the utilisation of click-tracks and audio scores serve to mitigate this subjectivity by providing aural stimuli to assist the performer in executing exact phrases. Even with this, however, musical training often results in rhythm displayed in Western notation to be perceived in specific ways (when considering notation as a form of written language), and as such an intended rhythm may be interpreted in performance differently simply based on its notation.

Considering this research, it can be argued that works can be experienced differently based on their form of presentation – the recorded output featured in the portfolio can be considered the *pure form*, with different forms of printed notation fulfilling specific functions; the full scores provided fill a more representative role, providing a framework for analysis yet impractical for performance. Repeat performances therefore require different forms of scores, specifically individual instrumental part scores and accompanying audio scores. Should the score and associated parts and instructions be used to re-execute the work, this then opens up discussion around whether the notation or new performance be reaffirmed as a new *pure form*, as previously suggested by Freeman. The underlying representation of notation can also be considered in a more philosophical way; Maestri offers an overview of notation with reference to the past, present, and future. A recording would represent a past form of a work, while a live performance represents the present, with future performances held within the instruction of the score (Maestri, 2016, pp. 1-3).

Incorporated within live performance and studio recording is practical consideration into how the compositions are executed; this issue of practicality draws my research into accessibility – this then prompts investigation into non-standard forms of representative notation to achieve different goals.

As discussed, while works require notation in order to be performed, there should also be notation produced to view the work in an analytical capacity; for this purpose, a full conventionally notated score will be most suitable. Although this is standard practice for western tonal music, polytemporal composition presents issues with this approach where decisions must be made in terms of representation – these include similar issues to those previously discussed in respect to the musical material being notated not adhering to western notational conventions, but also fundamental principles of the printed layout of notation. Due to the rhythmic correlations of polytemporality being the core focus of my compositions, all parts would need to not only be fully notated, but also rhythmically correlate accurately in order to provide a visual overview of the work. Gestalt Laws can be considered when adapting conventional music notation in this way; this is considered by Zentz with regard to conventional notation in music education, with the following principles of most relevance to my own work (Zentz, 1992, pp. 33-34):

- Law of Proximity – grouping components spatially, for example the beaming of notes so subdivisions of beats can be perceived: a benefit of composition in a polytemporal setting is that multiple simultaneous meters (and therefore beamings) can be present across the notation; this can be reflected in the score.
- Law of Common Direction – grouping components to clearly show progression, for example consistently grouping the same number of bars per page to aid clarity: while notation is read in a standard left-to-right process, creating notation that adheres to the Laws of Proximity and Simplicity in a polytemporal setting must result in different numbers of beats per page, or system. As reflected in my own scores, this results in system breaks in the middle of bars, which is unavoidable.
- Law of Simplicity – grouping components as regularly as possible, for example equidistant spacing, and vertical correlation: this represents the most fundamental principle in my production of notation; as discussed later in this section, verticality in a temporal sense is not valued in Western notation, and must therefore be manipulated to reflect this.

Many of the works in this portfolio are designed for performance, and as such the use of live musicians is an invaluable means of measuring the accessibility of these compositions in multiple capacities. Performers are required to execute their individual parts simultaneously with others in conflicting tempi, which raises practical issues of accessibility, taking into consideration the nature of ensemble and social interaction – the most obvious implication being how performers are expected to perceive their pulse in a setting where multiple pulses coexist (further discussion on pulse perception is later handled in relation to *Cowbells*). Due to the precision required in executing my work, traditional notation may require augmentation in order to realise this in a live setting. As such, my research investigates forms of notation beyond printed score to aid live performance.

In their writing, Stenberg and Cross comment on the act of sight-reading, noting ‘from its inception, Western music notation was not designed to be used for performance at first sight’ (Stenberg, A. & Cross, I., 2019, p. 1). Particularly due to its reliance on knowledge of material and context, the notation itself then only serves as a form of memory prompt, reinforcing Freeman’s views on p. 33. Due to the diversity of musical material, Stenberg

and Cross consider it to be impossible for musicians to sight-read conventional music notation with complete accuracy.

Bell argues that augmenting (or even replacing) the printed score with audio scores (forms of score delivered via headphones as a combination of click tracks and audio cues aural forms of notation) can aid accessibility, streamlining the learning and rehearsal process, also acknowledging (like Stenberg and Cross) that ‘Non-specialists often find contemporary repertoire very challenging’ (Bell, 2016, p. 167). Although Bell highlights the benefits of audio scores (and combining these with traditional printed notation) for less experienced musicians, his arguments in favour apply more to virtuosic performers; particularly he notes that,

...both media can explain each other; as a result, the information is considerably simplified. Performers never get lost, singers can adjust with little effort to intervals which would otherwise be very difficult to pitch (in the case of voices a cappella). Thus, they can focus entirely on their performance, more than on the technical realisation of the text. Finally the score becomes much easier to learn from memory, and watching the audience is made easier. (Bell, 2016, p. 167)

Audio scores form an integral part of realising my works in accessible ways; in the case of most works in this portfolio, performers are provided with both printed score comprising as minimal notation as possible (often omitting numbers of repeats, as this can be conveyed via spoken cues) as well as audio score. The audio scores combine 3 components; a click track, automated to follow the metric changes within the part score (high clicks accenting the first beat of each bar, as is convention in this format and considered effective with reference to rhythmic perception, as noted by Krumhansl; ‘a higher pitched sound tends to define the beginning of the group’ (Krumhansl, 2000, p. 161)), spoken cues, and backing tracks allowing for performers to rehearse or use in a performance, also potentially reducing rehearsal time. Animated visual notation was also utilised in *LABO*, although this was found to be less effective than using audio scores exclusively. Video presentation is utilised to enhance the accessibility of the listening experience for multiple pieces, initially demonstrated and discussed in *Drum Kit*. This can be considered to be a form of notation for the audience, while *Translate* incorporates varying forms of animated notation alongside

video of performance to aid accessibility of the complex work (in contrast to *LabO* however, *Translate*'s animated notation does not facilitate performance).

Accessibility therefore functions as a core concern across all works both in terms of accessibility for performers to execute the work and how listeners perceive it, and as such research should be undertaken to gain a fuller understanding of this.

Eisentraut proposes three levels of musical accessibility, broadly categorised (Eisentraut, 2013, p. 29):

- Level I – physical access (the physical act of locating and hearing the music)
- Level II – personal reception (the internal response one gains from the music)
- Level III – participation (being able to interact with or have a use for the music)

Level I is a broad-level accessibility, though the terminology of 'locating' the music can be additionally likened to the psychoacoustic property of presenting music as video, or utilising spatialisation elements such as instrumental placement or the stereo field. Level II refers to subjective response by the listener – in the case of my work this would be how the listener experiences the music and perceives its polytemporality. This can range from listening to a recording or live performance, but also augmented by doing so with the accompanying video, or scores (particularly with the notion that scores are developed as analytical tools). Level III in the context of my work will be concerned with performers, and how they engage with the process of executing the pieces; this is done by way of printed notation, audio scores, and click tracks. Eisentraut also acknowledges that these three levels are linked; he considers, 'in order to be able to enjoy music (Level II) we have to first hear it (Level I). In order to voluntarily participate in music (Level III), we would need to be able to at least tolerate it (Level II).' (Eisentraut, 2013, p. 29)

Eisentraut discusses that accessibility of particular musical elements could be said to be hard-wired into cultures; this may mean that from the outset certain musical approaches may by default be less accessible than others. Eisentraut continues to comment on short-term memory and the ability to process and internalise certain musical information, stating 'Melodies or beats that do not lend themselves to being grouped into 'gestalt' or

conceptualised into a composite form will also represent a barrier to comprehension' (Eisentraut, 2013, p. 278); this notion can link to concepts of rhythm and pulse perceptions. Eisentraut's case studies conclude that, 'economy of musical material, discernible structures, and repetition' are common elements in popular music across cultures (citing punk rock, English folk and Brazilian genres), considered to be 'perceptually accessible' (Eisentraut, 2013, p. 281). Although the cited examples of 'popular music' present a somewhat subjective argument, concepts of economy of musical material and repetition do mirror my own approaches in creating instrumental parts that are accessible to performers; as previously discussed, a core concept of this portfolio is to create complex music via layered simplicity, and as such performers should be given as little musical material and printed notation as possible.

An integral component of my work is the use of click tracks to enable synchrony with a central temporal structure when performing and recording pieces. The laptop, as central node and group leader (to consider the structure as a wheel network) is able to govern the temporality of the works via DAW. By issuing click tracks to performers, this serves to enhance performance accessibility by way of giving participants not only a temporal reference point but can be augmented (for example, automated to follow metric changes within parts) as part of the audio score.

Vickery considers the development of musical notation away from western notation with reference to the 1950s onwards, noting a 'concerted effort was made in some quarters to liberate the music score from the manacles of left-right/up-down orientation' (Vickery, 2010, p. 63), working towards the concept of score 'mobility'. Vickery mentions the development of polytemporal music first citing Henry Cowell's work in the 1930s, noting also that Charles Ives and Iannis Xenakis would employ multiple conductors and metronomes to realise the work, in much the same way as the more modern use of click tracks. Vickery references the work undertaken by Emmanuel Ghent, who in 1967 utilised tape to achieve temporal synchrony across performers (or to synchronise tape works to musicians), developing transmission via small headphones (Vickery, 2010, p. 64). This is a key practical device used in my works, as click tracks are used to accessibly enable musicians to execute this material accurately (though the use of headphones can provide its own issues, discussed later in this section) as well as provide cues as audio score, while being hidden from the audience.

Bell discusses the concept and usage of audio scores noting, ‘This intricate mirror-like identity between score and audio-scores makes possible a fruitful dialogue between the two media’ (Bell, 2016, p. 22), commenting on the complexities of precise rhythmic execution; ‘The metric structure of a piece conveys the performer a sense of architecture or coherence whilst it often remains potentially enigmatic for the audience (when there is no conductor)’ (Bell, 2016, p. 28). This also draws comparisons with the ambiguities of executing notated rhythms, as well as broader concepts perception of rhythmic structure. The importance of a click track within an audio score provides this ‘architecture’ to the performer in order to correctly execute written rhythms, without this colouring the experience of the audience. Audio scores, particularly involving click tracks, are seen as a reliable way of achieving temporal synchrony – examples of this include Stockhausen’s *Helikopter-Streichquartett*, as well as Meshuggah’s live shows completely reliant on click tracks (Lentz, 2012).

Replacing a conductor or other musicians with audio scores opens up issues surrounding reduction of human expressivity (and therefore non-verbal communication, discussed further in *Maggini*), as well as the added implications of headphones – the musicians’ communication is then restricted, providing obstruction from specific communicative stimuli. This raises issues surrounding how musical performance in an ensemble setting where communication is reduced affects player performance on an individual level (Bell highlights issues surrounding this below), as well as in terms of intra-group communication. Concerns are also raised surrounding audience reaction to this (as previously discussed in section 1.3, p. 26 Bell notes this can distract from the performance), as well as the more philosophical notion of the term ‘ensemble’ in circumstances where individuals are not able to easily communicate with each other.

Bell quotes an interview with Austrian composer Pia Palme: ‘I use audio scores mostly because of the performative aspect rather than the compositional aspect. I use them because they bring in another completely different way of immersing the performers into a score/music.’ (Bell, 2016, p. 163). Bell also references Palme’s 2012 work *Cantu Foliato* in which singers respond to auditory stimuli via headphones. While Palme praises the use of audio scores, Bell also highlights the risk of isolation performers face by using headphones, jeopardising listening. He notes that ‘With earpieces, singers (or instrumentalists) sometimes experience difficulty in adjusting their dynamics, which suggests that their

abilities to listen to each other may be hindered.’ (Bell, 2016, p. 166), also commenting that audio scores (or the physical act of wearing headphones/earphones) can prevent performers hearing themselves.

McNutt considers the restrictive nature of the ‘fixed accompanist’ in a more negative light, noting:

For the player, performing with fixed accompaniment is like working with the worst human accompanist imaginable: inconsiderate, inflexible, unresponsive and utterly deaf. While the performer commands the audience’s attention, she is in an ironically submissive relationship to her chamber music partner, focusing most of her attention on coordinating with her accompanist. (McNutt, 2004, p. 299)

These concerns are echoed by Vickery who notes this can ‘generate problems for the live performer because of the friction between the intangibility of the pre-recorded sound and the fixity of the notated score’ (Vickery, 2010, p. 65). This may also provide links to the trust built between performers and human ensemble leaders discussed with reference to servant leadership, and how this cannot be present with non-human performers. While McNutt’s quote reflects more on pieces for audible accompaniment (such as tape), it can be considered when applied to an inaudible click track to which a performer plays. She highlights an approach where the fixed mechanical component can provide a frame within which human performers have opportunities to deviate from this, considering ‘the player can maintain an illusion of interaction and temporal ‘give and take’ with the electronic sounds’ (McNutt, 2004, p. 299). A parallel can be drawn from this to my work – considering again the fact that the ‘fixed accompaniment’ (the laptop, as ensemble leader) is inaudible (an exception could be *Translate*, in which the mechanical components directly and audibly manipulate the incoming human stimulus), a main goal of the work is to present to the listener the illusion of inhuman rhythmic precision. The click track, in this instance, serves only as the rhythmic and structural framework (as central node, to reference the wheel model) to facilitate human musicality. McNutt does consider the musical risks associated with the use of click tracks, highlighting that the use of these ‘emphasises the reactive, rather than interactive, situation of the piece. Focused on accurately following the click, the performer is less able to inflect her timbres to suit the accompaniment, or to keep up the illusion of interactivity in other ways’ (McNutt, 2004, p. 300).

These very valid concerns do need consideration when executing ensemble music to click, however do provoke some dialectical discussion when benefits are considered. Vickery highlights these, considering that ‘In some cases, the implementation of these works in a computer-based hypertextual medium may provide a more “natural” vehicle for their performance’ (Vickery, 2010, p. 65), a key example being ‘creating a more practical, pragmatic medium for presenting information to the performer’. Bell also echoes the sentiments of ‘disconnectedness’ when audio scores are used, however resolves this by suggesting ‘In spite of these states of isolation which I will come back to in the general conclusion, I believe it is part of the actor's skills to make the audience forget about these technicalities’ (Bell, 2016, p. 168). In this way, Bell suggests that it is in fact part of the performers’ theatricality to transcend these restrictions for the audience (therefore leaving only practical technicalities such as headphones an arguable issue), and it could be inferred from this, that this transcendence can apply to intra-group communication. This is well demonstrated in Motl’s live performances (further discussed in section 2.1, p. 56), where performers have blinking metronomes alongside scores, as well as optional ‘haptic pulse devices’ to deliver vibration on downbeats (Motl, 2018).

From this research and demonstrated within the portfolio, the use of audio scores can provide an effective means of notation for performance. However, as previously discussed with reference to Gestalt laws, producing printed notation representing a polytemporal work comes with complexities in terms of temporal accuracy within its layout due to western notational conventions. With reference to the three Gestalt laws, while generally adhered to in conventional notation, require additional consideration when dealing with multiple tempi (to echo problems encountered with Western notation). This is particularly relevant when considering the Law of Simplicity; conventional music notation is not designed to horizontally maintain rhythmic accuracy as a temporal grid system; bar widths are scaled to fit not only the printed page but also their musical content (conflicting with the Gestalt laws in respect to spatial accuracy and verticality) – in Figure 3, all three bars of music are the same temporal duration.



Figure 3: Temporal inaccuracies in western notation

This results in a notation which can only be considered rhythmically accurate for each bar independently, due to this distortion. This is not considered an issue for full scores in general, however polytemporal music by its nature results in barlines rarely lining up exactly and as such a full notation requires accurate verticality to reflect the sounding result. Notation therefore must be aligned to a strict temporal grid in the first instance to ensure event onsets (this rhythmic terminology discussed in relation to *LABO*, section 3.2, p. 91) are always vertically accurate across the score. This is first demonstrated in section 2.1, p. 58 as a handwritten approach when initially developing methodologies but was a highly manual process and included many possibilities for error, and as such required technological refinement. In order to achieve this, I have developed a system whereby notation can be created in the usual way using software, however this is then exported as a vector graphic so as to allow its individual lines and symbols to be manipulated. This can then be imported into design software and manually aligned to a grid (this mirroring the act of audio quantisation) in order to achieve a notation that both adheres to conventions, but is also temporally accurate. The example in Figure 3, following this process, then appears as in Figure 4.



Figure 4: Using grids to create temporally accurate notation

The grid can then be removed, and the notation can then be formatted to the page for printing. As can be seen in scores where this form of notation is provided (*5:4 Guitar*, *Fractal*, *Cycles*, *Disconnect*, and *[in]dependence*), this does result in systems cutting directly through bars – due to polytemporality resulting in barlines rarely meeting exactly, there is no way around this. On this basis, caveats must be acknowledged regarding the function of the score when representing music of this type – these are included in program notes. Coloured notation is also integrated into this to further enhance accessibility, utilised in scores for *5:4 Guitar* and *Fractal*.

Linked to the concept of verticality in western notation, the focus on ‘white space’ or ‘gaps’ is discussed by Stenberg and Cross who investigate the effects of spacing within the printed score (Stenberg, A. & Cross, I., 2019, p. 1). This is conducted by comparing the cognition of a piece of notation with varying amounts of ‘white space’, including a comparison between conventionally spaced (i.e. rhythmically inaccurate) and a modified version with rhythmically proportionate spacing (Stenberg, A. & Cross, I., 2019, p. 6). Spacing between musical phrases yielded greater cognition from performers, and although having this spacing be rhythmically accurate did not enhance the performance of the work, it could be argued that it may aid understanding when viewing instrumental parts in the context of others in a polytemporal setting. On this basis, my concern for accurate vertical spacing is not applied to individual part scores provided to performers, but is applied to the construction of full scores when used as a representation to aid understanding or facilitate analysis.

Further issues arise due to additional conventional music notation symbols; as well as verticality expanding or contracting depending on the number of notes and duration of these within a bar, contents and width will also scale to fit other symbols such as clefs, time signatures, and accidentals. There would be two options to accommodate this; either the temporal grids can be expanded to accommodate the possibility of additional symbols (demonstrated in my initial handwritten notation), resulting in a far greater paper demand due to this extra provisional empty space, or the score can be scaled as these symbols are inserted, as with standard notation, which is demonstrated in the completed scores for *Cycles*, *Disconnect*, and *[in]dependence* specifically (as more complex pieces). This saves paper but distorts the horizontal aspect of the grid slightly with each instance, although I considered this method to be far more effective visually as well as being economically refined with regard to space. While this does not provide a truly accurate verticality with regard to Gestalt laws, as the score is aligned to strict temporal grids in the first instance only the minimum expansion necessary is applied to ensure additional symbols can be accommodated. To exemplify this, an extract of the *[in]dependence* score is featured in Figure 5, with grids (one per tempo) displayed.



Figure 5: Example of polytemporal notation

As can be observed, components such as time signatures require additional space on a score – as such, the grids, with music and symbols, must be distorted accordingly to allow for these meters to fit while maintaining temporal accuracy across the parts.

The result of this is a rhythmically accurate full score in conventional music notation format which can be used to view polytemporal music as a whole and see its various correlations. Although the grid is distorted where required so as to fit all symbols and components, it maintains its accurate verticality; the function of this is to broadly visualise the temporal difference between each instrument while providing exact accuracy in terms of event onset. As discussed, this form of notation facilitates analysis, but is not functional in a performance situation due to the unavoidable system breaks occurring within a bar and as such cannot be physically conducted by a human performer. It can be noted also that this approach could be

reverse-engineered as a compositional tool if the temporal grid is used to produce bespoke manuscript paper, similar to its original handwritten incarnation.

Beyond the augmentation of traditional western notation, video is used within the portfolio to enhance accessibility and navigation through the pieces; animated notation is also utilised specifically in *LABO* and *Translate*. Definitions for this kind of notation include:

- ‘any notational approach that is represented in real time as a necessarily dynamic set of notational symbols that rely on the functional relationships between these symbols to prescribe musical actions’ (Smith, 2016, p. xiii)
- ‘abstract graphics (avoiding images, symbols or pictograms with an inherent meaning) are put into motion for music notational purposes and manifest as fixed media’ (Fischer, 2015)
- ‘any notation, either traditional or graphic, which is created or transformed during an actual musical performance’ (Clay, A. & Freeman, J., 2010, p. 1)

Pryer defines graphic notation as a system where ‘visual shapes or patterns are used instead of, or together with, conventional musical notations,’ separating this into two categories: those that ‘attempt to communicate particular compositional intentions’ and those in which ‘visual, often aesthetically pleasing, symbols are presented so as to inspire the free play of the performer’s imagination in unstipulated ways’ (Pryer, 2011). This further raises discussion around representation where visual elements are included, expanding this to consider whether visual components can be categorised as representative (as demonstrated in the video presentation of *Translate*), interpretive, prescriptive (the animated notation present in *LABO* could be considered both interpretive and prescriptive), or aesthetic. This therefore presents a rationale for notation not being strictly representational, as well as potentially reconciling issues surrounding problems with notation by way of additional visual material.

Hope does however object to the practice of displaying notation alongside a sonic work:

Showing the score as a piece of music unfolds in performance detracts from the privileging of sound that a performance of music requires, dividing the audience’s attention between the performance and the accompanying visuals, giving away the

wonderfully abstract nature of music and its mysterious passage through time. I have no pride invested in the way notation looks. Notation serves a purpose, yet it has to be neat to be clear. I stand by my claim that the scores I make are created primarily and fundamentally to transmit information to performers. (Hope, 2017, p. 24)

This opinion does appear only to reflect on works where the score exists solely to facilitate performance (as suggested by Freeman on p. 33); to compare this with Pryer's above writing, it can be argued that visualisation may not always detract from the sonic result – depending on the form of the notation displayed (as Pryer notes), this could provide additional aesthetic material, and even aid the accessibility of the work's reception.

Below are the forms of notation present throughout the portfolio:

- Composite printed Western notation for full ensemble scores designed as a printed representation to facilitate analysis; *5:4 Guitar, Fractal, Disconnect, Cycles, [in]dependence*
- Western notation as scrolling video score to be projected live for performers to follow; *LABO*
- Audio Scores in the form of automated click tracks containing cues to enable live performance, to be experienced by performers via headphones; *Drum Kit, Cowbells, Maggini, LABO, 5:4 Guitar, Fractal, Translate, Cycles, Disconnect, [in]dependence*
- Video presentations of pieces displaying physical performance of players, which serves as a form of notation for an audience viewing digitally; this yields psychoacoustic effects, specifically pulse perception via entrainment (also discussed in relation to *Drum Kit*, section 2.2, p. 60); *Drum Kit, Cowbells, Maggini, LABO, 5:4 Guitar, Fractal, Translate, Cycles, Disconnect, [in]dependence*
- Video presentation to be featured alongside live performance, both to serve the same psychoacoustic purpose as the above point and also to present animated pictorial notation to further enhance this; *Translate*

2) Experiments and Methods Overview

My initial practice-based work rigorously examines a variety of rhythmic concepts, developing the foundational principles and processes later used to compose the complete pieces in section 4. This research culminates in the following works:

- Practical polytemporal studies
- *Drum Kit*
- *Cowbells*

As well as practical research, these works examine fundamental concepts of meter, pulse, and polyrhythm, as well as provoking discussion around rhythmic perception, the concept of groove, and entrainment.

These works prove invaluable in forming foundations for later pieces; my initial research into rhythm and pulse prompting practice-based investigations into the use of electronic delay to create rhythm. Using various techniques this resulted in a rigorous case study into pulse-based delay rhythm, which in turn led to the development of polytemporal composition techniques (specifically calculation-based methodologies) which were then used and refined as a basis for other works.

2.1) Using Delay to Investigate Expanded Rhythmic Cognition

Delay (an electronically generated echo using analogue or digital equipment) was the initial catalyst for the polytemporal ideas developed across this portfolio. Delay is broadly defined by Geoff Smith as ‘one of the basic building blocks for many other effects, including reverb, chorus and flanging’ (Smith, 2012). In his article Smith discusses the differences between delay and reverb; delay can be interchangeable with reverb by subtly adding space and distance to the audio, however its rhythmic quality yields many other artistic applications when used as a foreground element – delay is later utilised as a rhythmic effect in *Disconnect* and *Translate*. All delay parameters can also be automated using software, this process explored specifically within *Translate*. As a rhythmic device, delay has been used by a wide range of artists and composers; notable examples of this include Musique Concrète pioneer

Pierre Schaeffer, who processed such audio manipulations as ‘variation of playback speed, backward playing, cutting, looping [essentially delay with much longer delay times] of a single groove, etc.’ (Palombini, 1993, p. 15). Composer Terry Riley comments on the psychoacoustic effect of tape looping;

the fact that you could make a sound that was fairly stationary [also referred to later as ‘static’ or ‘vertical’], and yet it would progress slowly just because every time the tape goes round it seems to change, or at least the relationship of your consciousness of the tape would change, so that you start hearing maybe deeper into the sound. (Castlelizard, 2013)

This comment particularly draws comparisons with repeated listening, discussed previously in section 1.4, p. 31 by Graham as yielding ‘richness’. Riley’s statement also indicates the nature of recombinant teleology, discussed further in *Maggini*, as he makes reference to musical stasis as a core function of a work. This approach was developed in 1972 by Brian Eno and King Crimson guitarist Robert Fripp into *Frippertronics* (Connor, 2010), the first album utilising this being *No Pussyfooting* (Fripp & Eno, B., 1973). The album’s compositions are based on a static harmonic base (sometimes ambient, at other times with more focused rhythmic content), with (mostly) a lead guitar providing a melodic foreground.

Initially interested in investigating the rhythmic potential of delay, I first considered the development of a tool that could be used for calculating delay times in milliseconds (ms). Several of these exist online (a common format can be found at Fugit’s website (Fugit, 2006)), but are heavily biased for use with delay effects units, resulting in relatively simple parameters for use only with most common notational values (crotchet, quaver, dotted, triplet). Using a calculation-based approach I created a table where a chosen tempo (in crotchet bpm) could be entered into a specific cell and the table would populate with delay settings in ms, which would correspond to musical rhythmic values (similar Fugit’s application albeit featuring more advanced musical rhythmic options). The initial concept was to use delay to enable metric modulation, however following some initial experimentation I instead converted the ms values into bpm which could then open up a compositional process making connections between musical time and clock time. This later became the foundation of my polytemporal compositional process. This is shown in Figure 6; a ‘base tempo’ could be entered into cell B1, which would then generate a table of

‘mutually compatible tempi’; in the below example, a base tempo of ♩ = 120 would be equal to ♪ when played at ♩ = 90 and so on. By combining musical time and clock time I began experimenting with triggering delay on a sound in one tempo which would rhythmically occur in a different, related tempo.

	A	B	C	D	E	F	G
1	♩ =	120.000					
2	Duration	Full	.	..	[3]	[5]	[7]
3	:O	960.000	1440.000	1680.000	640.000	768.000	548.571
4	○	480.000	720.000	840.000	320.000	384.000	274.286
5	♪	240.000	360.000	420.000	160.000	192.000	137.143
6	♩	120.000	180.000	210.000	80.000	96.000	68.571
7	♪	60.000	90.000	105.000	40.000	48.000	34.286
8	♪	30.000	45.000	52.500	20.000	24.000	17.143
9	♪	15.000	22.500	26.250	10.000	12.000	8.571

Figure 6: Calculation-based method for identifying tempi with mutual compatibilities

I was particularly interested in the theoretical applications of this technique; using this approach a piece could be constructed involving multiple simultaneous tempi, where due to the polytemporality triggered by the delay the sounding output is far more complex than the individual parts (this highlighting my aim of complexity via layered simplicity) yet have underlying temporal connections.

To begin, a Cmaj7#11 chord was broken into chord tones and sequenced as per Figure 7, with delay assigned to each note to produce delays corresponding to ♩ = 120, ♩ = 150, ♩ = 187.5, and ♩ = 234.375.

The result of this can be heard in Audio/Visual Example 1.



Figure 7: Initial polytemporal delay study

This yielded an interesting sonic result, with delays creating pulses asserting the individual, conflicting tempi. The lack of pulse-based material also generated increased rhythmic interplay, both in individual tempi and as a composite, and although I was interested in the resulting texture I was aware of the compositional limitations delay may have on creating dynamic lines.

Following some initial experiments, I began to move away from the use of delay into analysing polytemporality specifically, with a view to composing in multiple tempi. Using this calculation-based method, the resulting tempi could be used as a foundation for composition based in musical time, yet spread across simultaneous conflicting tempi.

I then converted the part previously utilised in Figure 7 to individual notes, assigning each one its own tempo (the tempi used matching the implied delay tempi; ♩ = 120, ♩ = 150, ♩ = 187.5, and ♩ = 234.375).

The result of which can be heard in Example 2

While an interesting rhythmic effect, it is not possible to discern the individual tempi – as discussed further on writings on concepts of rhythm and pulse in *Cowbells*, this is largely (though not exclusively – pitch content will also contribute to this) due to the individual parts having no pulse-based content. This temporal dissonance is then amplified by the fact that the rhythmic pattern being used, although very simple in isolation, is then distributed

across four temporal layers (demonstrating complexity via layered simplicity). Although the sounding result is rhythmically dissonant, the temporal relationships across the layers (due to the tempi being mutually compatible) result in instances of rhythmic unison, presenting the possibility of balancing temporal consonance and dissonance. If used as a compositional device, decisions would need to be made regarding whether it is an intention for the individual pulses to be discernible by the listener or not, this thinking explored throughout the portfolio.

Following this, I wanted to explore possibilities of refining differentiation and creating 'depth' within this technique, seeking to have the disparate rhythms exist together as a cohesive audio composite. To do this, I first sequenced a descending diatonic line using the same rhythm and tempi used in Examples 1 and 2. Pitches for each tempo were then grouped into specific octaves, and within these pitch ranges the dynamics (using MIDI velocities) adjusted. This was generated utilising the following rules:

- The first note of every seven is played at the highest volume and octave (taking on a somewhat isorhythmic, cyclical nature – this concept later explored in *5:4 Guitar*)
- The chord tones of C major (C, E, G) are played at a medium volume in a lower octave, to establish the tonality
- The remaining notes are played at the lowest volume and octave, to add underlying texture and ambience

This then creates a texture where all tempi overlap in terms of pitch, creating a composite with three distinct aspects.

This can be heard in Example 3

The sonic result of this did fulfil the expectations of this investigation – the variation in octave and dynamic did produce very clear differentiation across the polytemporal composite. This also produced the somewhat unexpected result of manifesting subjective melody and harmony, which later formed the basis of *Fractal*. As with the previous experiment the individual tempi are not discernible, however an argument can again be made

that the desired output is not the metronomic temporality, but instead the composite of this technique.

Following this, I began trialling these concepts with live musicians; the first instance of this being with the Splinter Cell ensemble, comprised of piano, violin, and ‘cello. Utilising click tracks delivered via headphones (the first instance of an audio score), a variation on the previous audio example was workshopped as a live piece, as can be heard in the MIDI demo (Example 3). Variations in instrumental technique (legato, staccato, and a combination of both) and harmonic changes were present, however these governed by clock time as opposed to musical time as my compositional technique was not yet refined to do this. Issues also arose around the use of click tracks – specifically, what the best use of timbre was for the click itself, as well as the effect of accenting beat one of each bar has on the performance (this specific issue also discussed in relation to *Cowbells*, section 2.3, p. 66, with reference to the impact of a higher pitched pulse in relation to a group those with lower pitches). The musicians themselves, being from a classical background, were also less familiar with working with this technology, and as a result this provides a further question on whether musical demographic may need consideration when executing works in this way, linking to considerations of accessibility. Further to this, performers were not able to hear each other due to the use of headphones, and although this did not hinder individual performance the disorienting nature of this was commented upon, as well as asking what the piece ‘sounded like’ – this provoked further research into the social effects of ensemble. This workshop also marked the first instance of a wheel model being used in a practical setting, as previously discussed in relation to network structures in section 1.3, p. 28.

Similar issues were discussed by Stockhausen regarding his 1995 work *Helikopter-Streichquartet* also featuring audio score delivered via headphones; Stockhausen noted,

The players originally asked to hear the counting voice of the click-track tape in one ear and the impulses in the other ear, and their instrument and voice in both ears... Voice and impulses were recorded separately on the two channels, so that the balance between them could be individually regulated. Originally, we had made a mono mix of both signals, but the players could not hear the voice loud enough when the impulses were sufficiently loud...Each player had a different mix of the microphones

and click-track which could be altered during the rehearsals. (Stockhausen, 2009, p. 5)

This highlights considerations that need to be made regarding audio scores and monitoring levels so as to maximise performance accessibility.

Following the experimental pieces outlined during this section, which I found to lack focus in terms of pulse clarity and clear harmonic movement, I worked on varying this to apply further harmonic and timbral changes though the structure of the whole piece and the changes within still governed by clock time. While composing, I found the main difficulty to be the lack of a refined workflow in terms of being able to compose polytemporally for all instruments simultaneously, as in a traditional score-based setting; using notation software does not facilitate this mode of composition. Using DAW software can be assistive due to its quantisation, yet I had not developed my approaches beyond simple technique, rendering more sophisticated rhythmic concepts difficult to realise. As such, I had been working on parts individually and therefore not able to reference or audition these in the context of others – by contrast, an example of Nancarrow's piano rolls (Figure 8) demonstrate the high-level clarity gained by being able to visualise material. While this can be resolved when composing within a DAW, it does render composing via score software impractical.

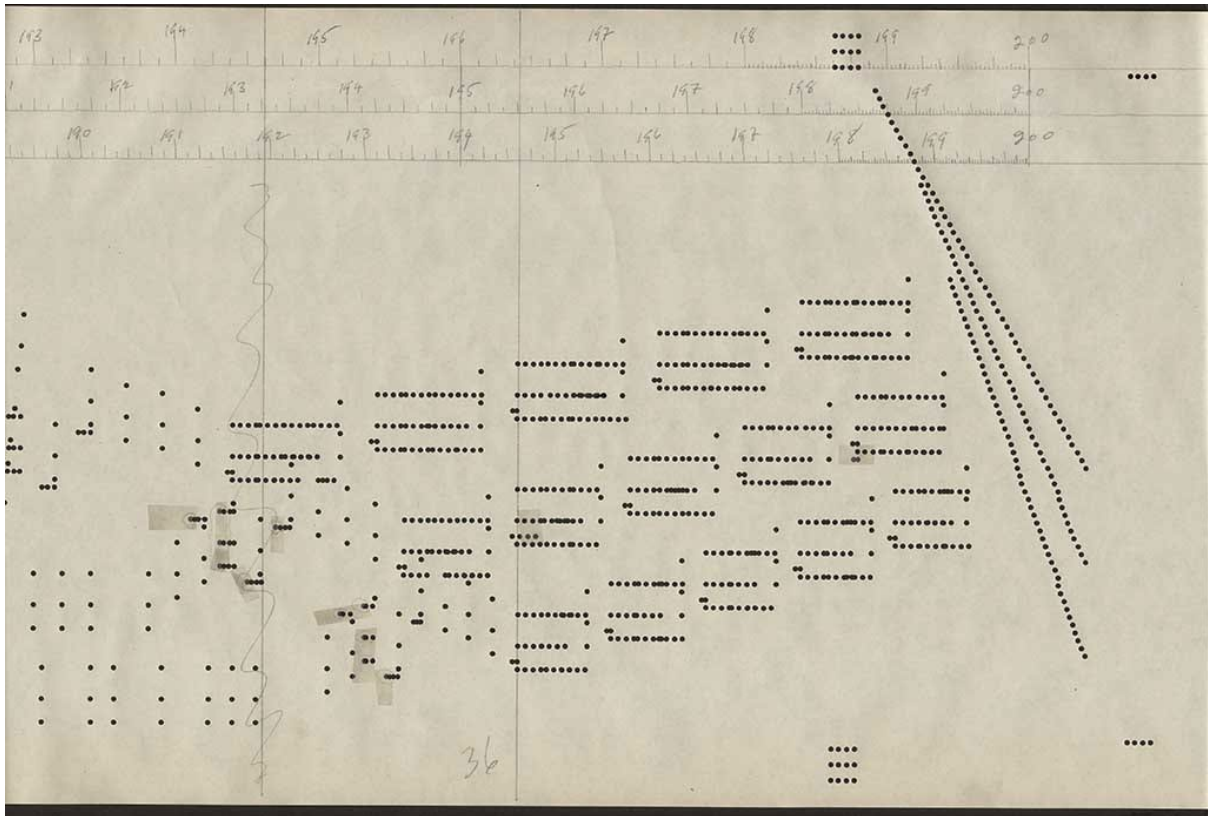


Figure 8: A photo of Nancarrow's piece Study No. 49c (Hocker, n.d.)

In order to seek new approaches in composing polytemporally, I looked into the work of composer Robert Motl, whose Octet perform polytemporal compositions where each performer is assigned their own unique tempo. As detailed on Motl's website, software was developed to map temporal grids for the chosen tempi, which could then be physically superimposed onto manuscript paper to enable composition (Motl, 2018), similar to how Nancarrow would manually measure rhythms on piano roll before composing and punching (Hocker, n.d.). Figure 9 shows an example of Motl's manuscripts, featuring the temporal grid glued to the top of the sheet.



Figure 9: A sample of Motl's work (Motl, 2018)

Motl's approach to handwriting score was also my initial approach to producing notation, as discussed below in reference to Figure 10. Motl has also utilised software to derive polytemporal notation, however multiple independent metric changes are not possible with this technique, resulting in large and potentially unwieldy time signatures (Motl, 2014).

It can be seen from Motl's score that the attached template (at the top of the image) can be utilised to plan barlines and identify rhythmic unison across the tempi, and meter can facilitate performers' opportunity to have simultaneous downbeats.

Following consideration of Motl's work (as well as Nancarrow having a similar approach), the next work utilising these generated tempi was composed entirely on paper (an extract shown in in Figure 10) – this was achieved by physically measuring the beats and notating by hand. This obviously presents risk due to having no access to playback, as well as the

physical act of measuring prior to notation, but can be checked by re-inputting the individual parts into notation software and combining within a DAW.



Figure 10: Handwritten Polytemporal Notation

This work can be heard in Example 4

This is broadly structured as per Figure 11 (time stamps reflecting the audio example) – this structure was derived both using clock time and approaches to tuplets in order to create rhythmic unison (shown in blue in Figure 11) as informed by the mutual compatibilities of the tempi.

	0:00	0:29	0:57	1:09	1:20	1:43
Piano	Pulse-based material (minims)			Melodic theme (rhythmic unison with violin)		Ostinato material (independent tempi)
Violin	Pizz.	Legato	Melodic theme			
'Cello	material	material	Pizz. material	Melodic theme (rhythmic unison with violin)		

Figure 11: Structure of second workshopped polytemporal composition

This aided in being able to track where parts should come together in unison, and otherwise be apart in their respective tempi. Although very manual, this method of composition was effective – an issue encountered however was the ‘cello tempo not being a whole number (the tempo chosen being $\downarrow = 93.333$ recurring). This resulted in the requirement of a subtle tempo manipulation for this particular track, in order to have the ‘cello rhythmically converge with the other tempi at each new minute of music (as would normally be the case when working in beats-per-minute). This piece was workshopped by Splinter Cell and found to be the most successful up to this point – although the same issues arose from previously regarding headphone isolation the group were able to discern the unity gained by the engineered temporal unity across their polytemporal parts, and as a result the piece had more of a focused structure and trajectory, suggesting elements of teleological development. Some other comments were noted; in order to produce rhythmic unity during the theme, the violin part featured quintuplet crotchets, which often featured ties – it was commented that this notation is somewhat difficult to read, and collectively the group remarked on potential other options for accenting the clicks during compound meters – due to the customisation available for automated click tracks, flexibility in terms of managing accessibility is afforded to make works as easy to play as possible. These practical opportunities and feedback proved invaluable when developing future works.

2.2) Drum Kit

From my initial experiments into polytemporality and in particular live workshops, I wanted to extend my research into the psychological and physical perception of rhythm (with reference to pulse perception, later discussed in relation to *Cowbells*) in order to better understand the implications of musical temporality.

Rhythmic entrainment must be considered as an integral factor of expanded rhythmic cognition; Trost et al. define this as ‘the process through which two physical or biological systems become synchronized by virtue of interacting with each other’ (Trost, W.J., et al., 2017, p. 96) – this draws direct parallels to Schechner and Mintz’s writings regarding group harmony via reciprocal communication in section 1.3, p. 27. With reference to Juslin et al. and Strack et al., Trost et al. assert the inherent impact of this; ‘the authors claim that “the powerful, external rhythm of the music interacts with an internal body rhythm of the listener such as heart rate, such that the latter rhythm adjusts towards and eventually ‘locks in’ to a common periodicity”’ (Trost, W.J., et al., 2017, p. 92) – this linking to discussions on perception of groove, further considered in relation to *Cowbells*. The term ‘periodicity’ is used to describe events occurring at regular intervals, such as pulse. The authors continue, ‘This adjusted rhythm is then proposed to trigger an emotional response much in the same way that smiling could trigger amusement via proprioceptive feedback mechanisms’ (Trost, W.J., et al., 2017, p. 92). This broadly uses the term ‘rhythm’ to describe the stimulus of rhythmic entrainment, but it can be assumed this would apply to a pulse. This then presents the question surrounding music with multiple simultaneous pulses, and whether the same emotional response can be provoked within a more complex texture comprising of greater rhythmic density.

Trost et al. (also referencing work with Vuilleumier) specify rhythmic entrainment behaviour on four distinct levels (Trost, W.J., et al., 2017, pp. 98-99):

- Perceptual (pulse perception)
- Autonomic Physiological (unconscious physical synchronisation with pulses)
- Motor (conscious physical synchronisation with pulses)
- Social (musically-driven synchronisation with others, a core theme of *Maggini*)

These elements (singularly or in combination) induce a sense of entrainment in two broad categories:

- Neural Entrainment (unconscious rhythmic perception unspecific to music)

- Perceptual Entrainment (the conscious process of perceiving pulse/musical periodicities)

As with previous writings on group theory and networks, not all of these forms of entrainment are influential within my own work, however I think it important to gain a full picture of these concepts in order to provide context on the broad subject of entrainment. Trost et al. consider, ‘For perceptual entrainment, a kind of temporal pattern recognition has to take place in order to extract the periodic information contained in the auditory signal, which can happen very fast, as soon as the first couple of beats of the music are heard’ (Trost, W.J., et al., 2017, p. 99). It is considered that ‘pulse clarity’ is also a considerable factor in perception (Trost, W.J., et al., 2017, p. 100) – this directly links to my work, in particular raising the question of how much pulse clarity can be said to exist in polytemporal music; at a high level it could be said that there is minimal clarity of pulse, however at lower level (within the parts themselves) this may be more readily apparent yet masked by the combined rhythmic density.

Considering this, *Drum Kit* was designed to observe the effect of free improvisation both within a strict rhythmic framework and in free time across four tempi. The work is a split-screen multitracked video piece recorded as single takes in isolation – the accompanying video was at this point an aesthetic decision for presentation, but this concept was later developed for all subsequent pieces due to its potential to enhance accessibility (discussed later in this section).

Please refer to the Drum Kit score and Audio/Visual Example 5

The work does not contain any predetermined musical parts and is instead derived from free improvisation, the rationale for this being that the performer is able to focus solely on the pulse where present (by way of a click-track in headphones). The use of a drum kit was chosen to remove the additional distraction of pitch material, allowing for a completely rhythmic study. Each part is assigned a single element of the kit (kick, snare, hi hat, and floor tom), the tempi and video layout shown in Figure 12.



Figure 12: Layout of Drum Kit, with tempi shown

The piece alternates between two distinct sections (A and B), each roughly two minutes in length; section A consisting of all parts improvising within their tempi freely. At section B the click-track (automated) exits save for one player which becomes the ‘leader’, at which point the other three parts would listen and enter into an improvisation (again linking to concepts of pulse-perception and groove) with this part before reverting back to their tempi when the click re-enters. This structure somewhat mirrors that of *Maggini*, also demonstrating similar approaches to recombinant teleology (as discussed in section 3.1, p. 77). As the piece was executed as a multitrack recording, the listening element is not possible as the layers are recorded individually; to alleviate this issue, as a temporary measure the clicks were automated to change tempi to that of the lead part where the piece transitions into section B. Although enabling the piece to be recorded single-handedly this approach can be said to be at the detriment of improvising by way of listening, though further discussion of this concept can be found in relation to *LABO*, and *Disconnect* which also features drum kit improvisation.

The instrumentation of the piece suggests certain musical conventions (likely a result of entrainment to my particular musical demographic, in this instance) which became evident in the sounding result of the improvisation, this was found to influence the performance of the piece particularly in the B sections; hi hats would mark a pulse, with kick and snare

falling on crotchet beats aligned with Moore's 'standard rock beat' pattern, which specifically places kicks on beats 1 and 3 and snares on 2 and 4 (Moore, 2001, p. 38). This resulted in the B sections somewhat resembling a unified groove, which often be played by a single performer before splitting back into its respective parts. With a limited timbral palette, the parts became varied by way of dynamic and repetition. With an inaudible click-track the individual tempi are not easily perceivable as the performed material lacks in pulse clarity; unlike subsequent works there is not a consistent element of pulse within the parts (for example, the repetition displayed in *Cowbells* or *Fractal*, resulting in a sense of groove (if measured in terms of subjective rhythmization (a term later discussed in *Cowbells*) being less successful; the parts themselves, lacking strict notation do not provide enough pulse-based repetition for a listener to organise these rhythms into its tempo.

Although not an intentional focus, the inclusion of video served to benefit pulse-perception via perceptual entrainment; as well as being a means of differentiating and anticipating the individual hits of the parts, the video makes available to the listener the movement of the performer's whole body. Though the click-tracks cannot be heard aurally, they can essentially be 'seen' as the performer physically moves in time with their pulse by way of nodding or swaying, not only exemplifying the physicality of groove but doing so also as non-verbal communication (a core component of *Maggini*). This opens up an area of rhythm which can be perceived only visually, incorporation of video adding both a new aesthetic and an additional means of expanded rhythmic cognition, enhancing the accessibility of the piece for an audience. Increasingly 'physical' instruments can therefore be very effective in providing the listener with this information, the drum kits of *Disconnect* and bow directions of *[in]dependence* are notable examples of this.

Temporal dissonance in this work is shown by the two extremes of polytemporal and monotemporal alternation; section A is the most dissonant section temporally; although it presents multiple simultaneous tempi featuring mutual compatibilities, the material is made dissonance by way of the improvisation not displaying pulse clarity. As previously discussed, without strict notation the parts are not easily arranged into tempi, and the result in this instance can be considered more akin to jazz drumming and improvisation. It could be argued then that polytemporality combined with improvisation produces a sounding result that, to listeners trying to discern it, is more temporally dissonant than work such as Nancarrow's due to its spontaneity. The B sections however provide a stark contrast to this,

converting the piece into monotemporality by way of convergence (this concept later becoming a core structural concept of *Maggini*), providing a rhythmically consonant sonic result.

In a broad sense this piece is more akin to a traditional teleology; the work as a whole builds in dynamic as it progresses, all parts steadily growing in volume in a unified teleological sense despite being comprised of polytemporality. Further to this, new sections are met by all performers simultaneously, due to the structure of the work based in clock time as opposed to musical time. Within the parts themselves an approach akin to recombinant teleology could be proposed however, as these individual parts move between distinct improvised and non-improvised thinking; while improvising, there exists a ‘stasis’ before a temporal convergence occurs, imposed upon the parts by the automated click track.

Building from this, *LabO* continues investigations on polytemporality with a focus on improvisation over a strict temporal grid, however involving increased harmonic and structural material. This initial investigation however assisted in the preparation for *Maggini* on a structural level, incorporating teleological movement between two modes of performance (free to structured improvisation). Although useful as a solo multitrack work, the piece could provide further insight into entrainment by being executed in the live setting, so as to allow performers to hear each other and allow observation into how performers of different musical demographics respond differently to this situation; *Disconnect* expands on this, featuring drum kit improvisation for two performers with a focus on non-verbal communication.

2.3) Cowbells

Following the improvised nature of *Drum Kit*, I wanted to develop my ideas and experimentation by utilising concepts of cell-based rhythmic cycles to analyse with rigour rhythmic interplay, as well as introduce some harmonic material. A key aspect of *Cowbells* is the inclusion of repeated polyrhythmic material as a base.

Within the broader foundations of musical temporality, concepts of meter and pulse require unpacking in order to be understood and used most effectively in compositions. Clayton defines these terms; ‘By pulse we mean a regular beat perceived by the listener to fall at

equal intervals of time—we can call these intervals 'categorically equivalent' since they need not be exactly equal in practice' (Clayton, 1996, p. 327) – for example in Japanese gagaku, where beats are observed to be 'elastic' within bars (Terauchi, 2011, p. 22). However rubato technique could be considered in a similar way, as noted by Parncutt; 'The widespread use of rubato (especially in Western classical music) indicates that a musical beat need not be exactly isochronous, or equally spaced in time, to be strongly felt' (Parncutt, 1994, p. 410). After considering the ambiguity of the term 'pulse' Clayton concludes, 'put simply and convincingly by Kolinski, metre is defined as 'organized pulsation functioning as a framework for rhythmic design'' (Clayton, 1996, p. 327). This framework was clearly exemplified in *Drum Kit*, which displayed improvisation both in rubato and within a pulse-based framework. A clear distinction can then be made between meter and pulse – meter providing a framework within a pulse. Clayton adds a second definition where meter is the 'measurement of the number of pulses between more or less regularly recurring accents' (Clayton, 1996, p. 327), where the pulses within a meter are considered 'beats', each with accented and unaccented qualities. Clayton considers these as 'distinct yet complementary'; however, my thoughts are that they essentially represent the same hierarchical structure albeit with different uses of terminology, although it could be argued that developments of this thinking can evolve to concepts of 'hyperbeat' and 'hypermeasure', as previously discussed by Pieslak in section 1.2, p. 18. Vuust and Witek add 'there are instances in which this sharp distinction between rhythm (perceived) and meter (induced) becomes blurred' (Vuust, P. & Witek, M.A.G., 2014, p. 2) this suggesting while a rhythm can be composed, it is also a natural perception (perhaps opinion) of a listener. This fits with the hierarchical concept of rhythmic structure – the meter of a passage can provide a frame in which lower level rhythms can reside, however the terms used are often less explicitly defined and so can contradict other sources, for example in the writing of Ullal-Gupta et al.: 'to synchronize movements to music, a listener must perceive its meter, which is subjectively experienced as an underlying pattern of strong and weak beats' (Ullal-Gupta, S., et al., 2014, p. 1). This is agreed with by Frigyesi who notes 'The perception of meter involves an awareness of the regular grouping of various metric accents, of the recurrences of relatively accented and unaccented beats' (Frigyesi, 1993, p. 63). This highlights the notion that all rhythmic levels are subjective and must be perceived by a listener (also considering pulse perception by way of entrainment), even if well-defined by a composer, therefore cannot be so easily separated as in Vuust and Witek's writing where rhythm is perceived, and meter induced. Frigyesi continues, adding 'In this sense, the meter is a continuous, underlying element of musical

temporality which may or may not clearly manifest itself on the surface in a given moment' (Frigyesi, 1993, p. 63). This can highlight discussion on accessibility, as pulse, rhythm, and meter, are elements that can in varying degrees be made accessible to a participant; to refer to Eisentraut's levels of accessibility (previously discussed in section 1.4, p. 38), these rhythmic concepts could be said to encompass in different forms all three levels, most notably however Levels II (personal reception) and Level III (participation) – issues such as pulse clarity will facilitate participants to engage with the rhythmic structure; for performers, this accessibility can be further enhanced by way of click tracks. It could also be argued that Level I (physical access) could be considered in terms of non-verbal communication – as discovered in *Drum Kit*, being able to physically see the performer can aid pulse perception.

With reference to investigations by Fraisse, Krumhansl notes that 'when listeners hear a sequence of identical sounds, they tend to group them by twos, fours, or less often by threes. Nothing objectively specifies the grouping, so it is called subjective rhythmization' (Krumhansl, 2000, p. 161). It is worth noting that the stimuli used for these experiments were not music, but 'taps, identical sounds, or at best, two types of sounds of different duration, intensity, or pitch.' (Fraisse, 1982, p. 170). This contrasts to objective rhythmization, which is considered to be a difference introduced to the given sequence of pulses. This difference (be it pitch, duration, volume etc.) inspires in the listener different perceptions; Krumhansl uses as an example 'listeners judge pauses to strongly mark group endings', an example being the end of sentences in speech (Krumhansl, 2000, p. 161). Continuing, Krumhansl notes that 'longer and more intense sounds are heard as accented, and these elements tend to define the beginning of subjective groups' – this could suggest the event onset of a note, this notion then drawing potential parallels to the very long, sustained material present in the slowest tempi of *Fractal* and their impact in punctuating large rhythmic cycles. Similarly, 'a higher pitched sound tends to define the beginning of the group' (Krumhansl, 2000, p. 161) – this immediately suggests a connection with the higher pitched click often used to accent the first beat of a bar in a click track (this specific issue being identified in early workshops), but can also signify notions of phrasing, hyperbeat, and hypermeasure. The inclusion of pitch content in this quote serves to blur the division between pitch and rhythm, provoking the discussion that they are two halves of a whole, with one having a significant effect on the other in terms of musical cognition – it could be argued that while *Cowbells* is representative of this, *5:4 Guitar* fully embodies this dialectic.

Krumhansl mentions the concept of 'metrical hierarchies', noting 'psychological tests support the claim that a hierarchy of stress, that is, a pattern of strong and weak beats, is perceived' (these psychological tests undertaken in 1987 by Palmer and Krumhansl), continuing with 'for example, in quadruple meter, the first beat has the highest stress, followed by the third beat, followed by the second and fourth beats, followed by the half-beats, and so on' (Krumhansl, 2000, p. 162). The latter part of this quote draws parallels with popular and commercial music, the emphasis on a strong first and third beat an integral part of Moore's 'standard rock beat' (Moore, 2001, p. 38) – this also being extended to a more macro-level when considering notions of hyperbeat and hypermeasure. Krumhansl notes that 'this description of metrical hierarchies does not extend to musical styles with polyrhythms or additive rhythms (groups of different numbers of pulses, e.g., 4 + 4 + 2 + 4)' (Krumhansl, 2000, p. 163). To be clear, such a term as metrical hierarchy can be categorised under the larger term of rhythmic hierarchy. Clayton questions and challenges the application of meter to non-Western music:

What concerns me more here is the acceptance by many ethnomusicologists that metre is indeed a simple concept which may be applied to a wide range of musics, which may as a consequence be notated with Western-style time signatures and bar-lines. Metre and its representation is in fact a complex area in Western music theory, so that to apply Western concepts and notational conventions in a simplistic way in ethnomusicological studies must be methodologically unsound ... How do we decide which time unit is to be taken as the 'beat', and how to notate it? How do we decide whether a grouping of 2, 3, or 4 beats is enough to specify a metre, or whether a higher-level grouping (of 6, 8, 12, or 16 perhaps) is also metrically significant? Where does the measure begin and end, and which pulse is a 'beat' and which an 'off-beat'? (Clayton, 2008, p. 29)

An example of East Indian music transcribed and analysed using Western metric concepts (many changing time signatures and note values) can be found by Sargeant and Lahiri; Clayton's argument can call into question the validity of this approach. Sargeant and Lahiri note that while similarities in form can be drawn to Western notation, beats are often extended and there are no implied dynamics (Sargeant, W. & Lahiri, S., 1931, p. 432) – it can be argued from this that the notation provided will give an inaccurate representation of

the piece, since for example Western notation implies dynamics in its beat groupings, beats and bars – particularly, this connects to discussions around ambiguity of Western notation (discussed in section 1.4, p. 34), which may be argued to provide an inauthentic performance of a work not designed for this form of notation (similar to discussion around notation serving only as representation, not the pure form of a work). Sargeant and Lahiri continue to draw comparison, stating that Western music has ‘based its time-structure upon the rapidly recurrent dynamic rhythms of the march and dance. Indian music is rather an outgrowth of vocal phrasing’, also presenting many theories applying Western metric changes to various parts of the piece (Sargeant, W. & Lahiri, S., 1931, pp. 433-434). This again could be a case for exemplifying flaws in presenting East Indian traditional music in Western notation. This practise is challenged by Zon, here quoting England: ‘No system of transcription, mechanical or otherwise, can preserve all of a musical example accurately and it is up to the transcriber to select or emphasize pertinent parts of the entire configuration. The standard western notation system tends to reinforce those aspects of the sound pattern which are compatible with our notation traditions and in varying degrees to distort or omit others’ (Zon, 2007, p. 251). This consideration of notational ‘distortion’ is also used when applied to producing scores for my own work, specifically applied to issues of expressing temporality in notation by way of accurate verticality.

Perception of rhythm and meter can lead into the somewhat subjective concept of ‘groove’, a term regularly understood by musicians but difficult to objectively define. Madison and Sioros note that ‘tempo is only weakly related to groove’ however, considering:

Physical correlates of the experience of groove might include (1) beat salience. i.e., the number and loudness of sounds that occur on the beat, (2) event density, i.e., the number and loudness of sound events per unit time, (3) fast metrical levels, i.e., the metrical subdivisions that sound events are articulated in, and (4) systematic micro-timing (MT), i.e., timing deviations from the metronomic positions of the metrical grid (Madison & Sioros, G., 2014, p. 1)

This again references a rhythmic hierarchy, presenting a set of variables that can be considered when defining groove. However, it could be argued inconsistent that beat salience is considered an important aspect of groove perception while tempo is not, despite beat salience requiring a definite tempo on which to exist. This can be challenged by

Zbikowski's comments; 'if recurrent musical events occur at too great a temporal interval (if the beat is too slow) the rhythmic frame diminishes in salience; if the temporal interval is too small (if the beat is too fast) we will typically find some other way of organizing the events in order to create a meaningful rhythmic frame' (Zbikowski, 2009, p. 279). In this way tempo must have a greater importance on groove, particularly since Zbikowski considers 85-100bpm as significant periodicities, (periodicity used to describe events occurring at regular intervals, such as pulse) noting 'whenever possible we prefer to locate the beat in this range', an issue encountered during the production of *Fractal* when handling very slow tempi. It could be argued that genre has affected Zbikowski's study, as only three examples for his model are used; Eric Clapton's *It All Depends* (♩ = 88, blues/rock, 1985), Miles Davis' *If I Were A Bell* (♩ = 96, jazz, 1956) and James Brown's *Doing it to Death/Gonna Have a Funky Good Time* (♩ = 114, funk, 1973) (Zbikowski, 2009, pp. 289-292). More granular analysis may need to take place into rhythmic organisation within these examples to fully investigate these works. This theory on preferred tempo can be challenged by Dahl et al., where authors point out that preferred tempo varies for each individual (including for the same individual over time) and therefore cannot necessarily be within a specific range (Dahl, S., et al., 2014, p. 222), providing a counter to Zbikowski. This does however note that studies by Fraisse considered significant periodicities to be between 100 – 133bpm, and that of Moelants concluding 115 – 127bpm (with a 'pronounced peak' at 125bpm) (Dahl, S., et al., 2014, p. 215). Dahl et al. focuses primarily on dance music, a genre which by definition is designed to physically stimulate the listener by way of social entrainment. It could be argued that dance then is one of the most important genres to consider when analysing groove, however was not included in Zbikowski's study (though funk is a closely related, earlier form of current electronic dance music). Beat salience then creates what could be considered meter in a traditional sense (i.e. a bar with a time signature), with event density and metrical levels (subdivisions) providing the rhythm (incorporating micro-timings to apply human qualities). Yeston considers the insertion of time signatures as 'nothing more than a graphic technology that helps to indicate which particular middle ground is meant [by the composer] to shape the foreground' (Yeston, 1976, p. 70). This considers time signature only to communicate manipulation of the strong and weak beats to performers, this can in turn enhance performance accessibility; Clayton notes that on this basis is utilises these symbols and rhythmic groupings 'to aid reading' (Clayton, 2008, p. 28).

A set of principles are presented by Zbikowski to describe musical rhythm (Zbikowski, 2009, p. 276)

P1 Rhythm concerns regularly occurring musical events

P2 There is differentiation between rhythmic events

P3 Rhythmic events are cyclic

P4 There is a strong sense of embodiment associated with musical rhythm

These principles to a large extent fit with concepts of meter and pulse; P1 can be said to define pulse, and P2 introduces concepts of metric organisation, specifically groupings and accenting. P3 and P4 however appear more subjective, and therefore difficult to quantify – it could be argued that this is less of a model for musical rhythm and more suitable as a model for groove. It should be noted that rhythm is often considered to be informed by pitch, Zbikowski notes this pertaining to groove, citing ‘Such [rhythmic] levels will be distinguished not solely by their place within a metric frame, but by association with distinctive timbres, registers, pitch collections, agogic accents or combinations of these things’ (Zbikowski, 2009, p. 286). This may explain why the examples given (and their specific genres) are considered in Zbikowski’s research beyond their strict metric structure.

Volpe et al. also reference groove when referring to the sociological aspects of the ensemble, noting ‘Interestingly, rhythmic complexity or music syncopation is an important structural factor in embodied and affective responses to musical groove, and, indeed, high-groove music increasingly engages the motor system in musicians’ (Volpe, G., et al., 2016, p. 2). In this statement the authors conclude that more rhythmically complex, syncopated music provokes a more intense response in the engaging musicians, however this raises the question of quantification – what the reference point is in terms of defining ‘rhythmic complexity’ or ‘syncopation’, and at what point rhythm and syncopation cease to be. Sioros et al. comments on the effect of syncopation, noting this ‘has been often associated with rhythmic tension and rhythm complexity...gradually increasing the syncopation also increases the desire to move, but only up to a certain point beyond which desire decreases’ (Sioros, G., et al., 2014, p. 2). Syncopation is however a contextual term, as a pulse is required for rhythm to be syncopated against; in the context of my work, the rhythmic interplay between instrumental parts may be received by a listener as syncopated, however

in compositional sense this is not the case unless inferred by a performer during an improvised passage – however, without the context of an underlying pulse, this may not be heard as syncopation (an issue observed in *Drum Kit*).

The definition of the term ‘polyrhythm’ can be construed ambiguously and is often interchanged with other terms when describing multiple simultaneous rhythms, particularly ‘polymeter’. Polyrythm, by definition, would denote multiple ‘rhythms’. Polyrythm therefore may be more clearly defined by Brown as ‘multiple, repeating rhythmic patterns overlaying one another to create complex but interconnected and interdependent rhythms, with no particular rhythm taking precedence over another and with each rhythm operating as a distinct sensory element’ (Brown, 2013, p. 270). Considering this terminology, I would offer the notion that these three terms (polyrhythm, polymeter, and polytempo), although not strictly interchangeable, can be related: polymeter suggests multiple meters simultaneously occurring, with polytempo reserved for multiple tempi simultaneously occurring. In this way a polytemporal work can also be polymetric (should it contain conflicting meters). The term ‘polyrhythm’ in this instance encompasses both polymeter and polytempo.

Considering rhythm in a raw form (perhaps as Clarke’s ‘duration between event onsets’, further discussed in relation to *LABO*, section 3.2, p. 91), Wilson comments ‘any movement persisted in, tends to become rhythmic, even if we deliberately try to keep it irregular. All regular or rhythmical movements tend to become automatic’ (Wilson, 1927, p. 3); this immediately draws parallels to conscious performative movements, for example the striking of a drum or bowing of a violin, however can also suggest subjective rhythmization and entrainment where subconscious. Commenting on irregular rhythms, Wilson writes:

While regular rhythms tend to be merely emotional, irregular rhythms have some extra meaning in their emotion by the very fact of being irregular, and when we measure the emotion of music by its quality, we necessarily imply meaning or intellect as the differentiating factor. We may say that the more irregular is the rhythm of music, the more intellectual it will be; or if this is too much, we can at least say that the more the emotion of music is of the sort that appeals to the understanding the more it tends to an irregularly accented rhythm. (Wilson, 1927, p. 5)

This considers *simpler* (implying regular periodicities or groupings) rhythms to contain more of a raw emotion, continuing to say that ‘undiluted emotion is always rhythmical’, Wilson comparing this to the dancing of children, or the patterns of repeated speech when adults are absorbed by emotion. This does not reference a specific study therefore is a very subjective statement, however can provide interesting discussion as a theory of rhythm on a micro-level (drawing parallels to micro-timings, previously discussed in relation to groove) Schellenberg et al. expand on this (with reference to Palmer and Krumhansl’s practical research) with a summary of studies into rhythm (separated from pitch) perceived as emotion:

[listeners] select descriptors such as "exciting" and "happy" for fast tempi, and "serene" and "dreamy" for the same pieces played at slower tempi’, also remarking that ‘whereas tempo was the best predictor of happiness, sadness, and tenderness, spectrum and articulation were the best predictors of angry and fearful ratings, respectively. (Schellenberg, E.G., et al., 2000, p. 156)

This particularly references studies by Hevner, in which classical music was used as stimuli; works including Debussy, Paganini, Wagner and Mendelssohn (Hevner, 1936, p. 250) – as with Zbikowski’s study, musical style and rhythmic organisation may affect findings; it could be considered that an underlying written tempo may not necessarily correlate with perceived tempo. For example, a ‘fast tempo’ may consist of few notes, and as such it may be that rhythmic density is a more reliable factor for measuring rhythmic reception. Closing their research Schellenberg et al. comment on pitch having a greater effect on perceived emotion than rhythm in a comparative sense, however noting that ‘the joint influence of pitch and rhythm on the perceived emotional content of melodies appears to vary across musical contexts’, yet also proposing that ‘the relative importance of pitch over rhythm could stem from listeners' exposure to Western music’, and that ‘listeners from other cultures (e.g., native African cultures), in which harmony is relatively less developed and rhythm more developed, may learn to attend more to the rhythmic rather than the pitch components of a melody’ (Schellenberg, E.G., et al., 2000, pp. 165-166). It is worth noting however that this claim could be considered a generalisation, as studies such as that of Kubik (1975) explore in greater details the complex harmonic elements of Traditional African music, referencing specific locations and tribes:

Harmonic sounds, arising from a plucked string have been recognized by members of the Khoisan race perhaps as early as this race existed. The playing of the mouth-bow gave rise to both tone systems and harmonic counterpoint. Some tone-systems of Bantu tribes in East and Central Africa with correspondent forms of harmonic part singing were also derived from the natural harmonic series. This is the case, for example, with the Wagogo in Central Tanzania, with the Bongili, Makua and Bakota in Congo-Brazza-ville and with the Fang' of Gabon in one particular type of music. (Kubik, 1975, p. 41)

From this example (as well as more mentioned by Kubik, notably the 'harmony map' of Africa developed by Jones and Kubik's extensive examples of polyphonic singing in various tribes and locations) it can be shown that traditional African styles in fact have a highly developed sense of harmony as well as rhythm, challenging the writings of Schellenberg et al. above. This can provoke further criticism on rhythmic analysis (Kubik's being largely pitch-based), demanding more focus be made on the specific tribes and locations when analysing 'African rhythm'; a point previously discussed section 1.1, p. 14.

Cowbells (later developed into *5:4 Guitar*) comprises of four simultaneous guitar parts multitracked at their individual tempi (derived using calculation-based methodologies), and is accompanied by a split-screen video (developing from the reflections made on the presentation of *Drum Kit*).

Please refer to the Cowbells score and Audio/Visual Example 6

A part score is provided for *Cowbells*, due to it functioning as a prototype for *5:4 Guitar*. The two works feature the same tempi, musical material, and structure, and as such the polytemporal notation for *5:4 Guitar* can also be used to analyse *Cowbells*, if desired.

The individual parts are based on an isorhythmic ostinato shown in Figure 13.

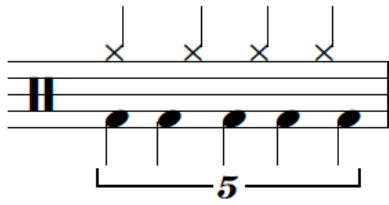


Figure 13: Cowbells sequence 1

To perform, the left hand played the hi-hat (groupings of 4), with the right hand playing the cowbells (groupings of 5). In this way, the left-hand acts as a metronome, asserting pulse, both hands together forming a cyclic polyrhythm.

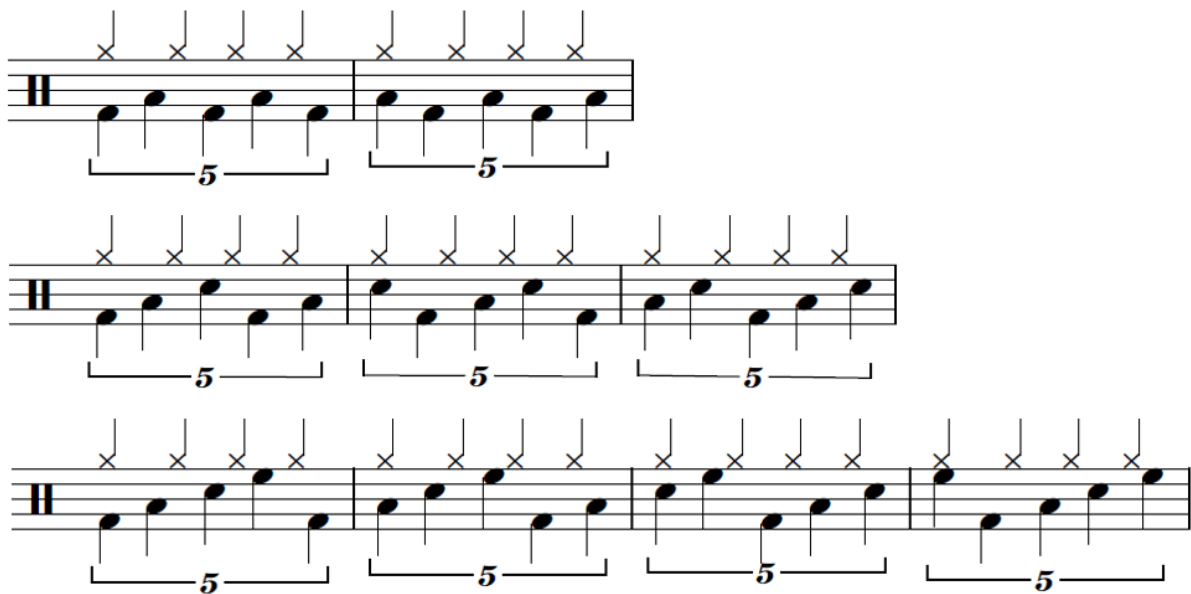


Figure 14: Cowbells sequence 2 - 4

As seen in Figure 14, each new sequence incorporates a new pitch to the right hand, creating an isorhythmic progression through the part. Sequence 1, 2 and 4 repeats for 16 bars until moving directly into the next pattern, sequence 3 repeats for 18 bars as it takes 3 repetitions to land on beat 1. Upon reaching the end of this larger cycle (which could be considered a hypermeasure) the part reverts to sequence 1. This sequence of repeated cycles progression forms the structure for each individual part, each of these being identical however moving through the sequences at different rates due to the differing tempi.

The tempi chosen were determined by my previously developed calculation-based methodologies with a broad range of tempi, shown in Figure 15

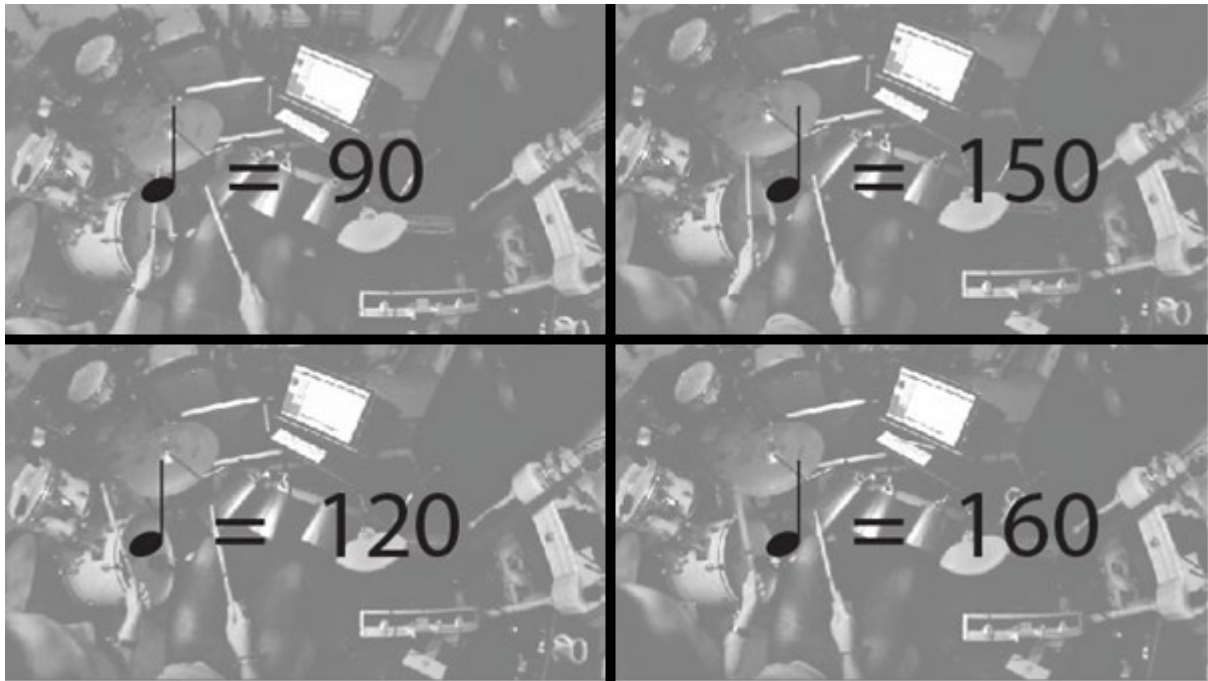


Figure 15: Screenshot of Cowbells displaying tempi

As previously discussed, one of the core aims of the work is to accessibly manifest sonic complexity from layered instrumental simplicity. Due to this, the individual parts themselves are not complex and as such do not necessarily require the use of formal notation, and in this instance were recorded sequence by sequence, utilising multitracking to edit these together. Performance difficulty did however vary across tempi, particularly the two higher tempi – during these takes the 5:4 rhythm began to psychoacoustically merge into a composite, as I experienced increasing difficulty with mentally differentiating the groupings of 4s and 5s. It could be argued that this is due to these falling outside of the ‘significant periodicities’ proposed by Zbikowski, Dahl and Fraise, and thus the event density of these causes the listener to reorganise these. While this psychoacoustic effect had a detrimental effect on the accessibility of performing the work, it does however draw a comparison to minimalist music in which this kind of reaction is often aesthetically sought-after (to refer to Riley’s comments in section 2.1, p. 50, as well as Graham’s comments on repetition breeding ‘richness’ in section 1.4, p. 31) from a strictly listening perspective. Given this, it could be considered that at low-level that the two slower tempi possess a greater sense of groove, and can therefore be ‘felt’ more readily by performers. Parts were recorded in isolation, so I did not experience distraction from hearing other tempi.

Fink's concept of recombinant teleology (later discussed in detail in relation to *Maggini*) can also be considered in this work; independent layers move through the cell-based structure, with multiple telos throughout as the group as a whole moves through the higher-level structure. This work could also be considered to resemble an Adaptive Response Model (discussed in section 1.3, p. 24), this also taking on a teleological approach as the individual parts move work towards individual goals within the larger structure.

The balance of temporal consonance and dissonance forms the basis of the work; when considering Nancarrow's definition, each individual part has a temporal dissonance of its own by the use of a 5:4 rhythmic ratio. Given their constant periodicity this in fact presents 8 individual pulses, resulting in a very high level of event density, further compounding the temporal dissonance present in the work. This dissonance however could be considered to be grounded to a certain extent by the fact the tempi have mutual compatibilities. Due to this, as with Nancarrow's music there are perceivable moments of rhythmic unison across the four seemingly disparate parts. With the four tempi moving simultaneously the listener is met with overwhelming event density and as such reception of this may be influenced by the underlying temporal consonance that links the conflicting tempi, creating a subjective listening experience. The inclusion of video presentation however, as with *Drum Kit* further enables accessibility, as being able to see the piece being performed aids the perception of the individual temporal layers by incorporating into the listening experience physical communicative stimuli.

In summary, these works provided invaluable insight into the issues involved in polytemporal composition. In unpacking notions of pulse and meter and by association how these are subjectively interpreted by listeners, my practice-based studies display the importance of balancing the dialectical components of pulse-based and atemporal material. Utilising calculation-based systems, polytemporal structures can be created which allow for flexible manipulation in order to enable synchronicity across conflicting pulses. When composing within this setting, approaches to beat density and pulse-based material can affect the discernibility of individual tempi; it therefore becomes a creative decision whether this quality is desired or not. As well as this, the audio/visual presentation of the works was unexpectedly demonstrated to enhance accessibility; the use of split-screen performance video enabling listeners to more easily discern individual parts.

3) Workshops

Following the development of foundational rhythmic techniques, the following workshopped compositions were composed to explore concepts of structure, live performance, and improvisation within the established polytemporal environment:

- *Maggini*
- *LABO*

These compositions expand concepts explored in the experimental pieces, workshops utilised to gain insight into the practicalities and impact of live ensemble performance in polytemporal settings. This work is informed by discussion on teleology, non-verbal communication and entrainment, leadership, improvisation, as well as further unpacking of rhythmic concepts and terminology.

3.1) *Maggini*

These workshopped pieces therefore were designed to look at form and structure, so as to explore how this can be handled and manipulated in a polytemporal setting, as well as the practical implications of this. *Maggini* (workshopped with the *Maggini* String Quartet) in particular is a work that specifically looks at structure in a multi-level, teleological sense, particularly with reference to Fink's discussions in his book *Repeating Ourselves* (Fink, 2005). Graham comments on the importance of expanding beyond simple structures;

[music] has a structure, which lends its interest and consequently value, and great music exploits structural possibilities to a degree that puts it far beyond the level of simple pleasant melodies. It does not merely have an effect on us, as the melody does, but provides us with material for our minds... To make structure the principle focus of critical attention is to leave out precisely what most people would suppose to be an essential element in music appreciation, namely, the ability to be moved by it. It seems possible that someone could analyse the form and structure of a piece of music and at the same time feel no sympathetic response to it. (Graham, 2005, p. 79)

Given this, compositional structure requires consideration; a piece as a whole may have a structure, however structure can also be applied to individual elements of the piece which,

in a polytemporal context, will move at different rates. This presents choices that may impact the accessibility of the pieces, from a listening perspective. Graham concludes with the argument, 'No purely formal property has value in music. In fact undue complexity of structure may undermine the very emotional experience aimed at' (Graham, 2005, p. 80).

Teleological discussion forms some central discussion surrounding the concept of my work, this is previously referenced when analysing *Drum Kit* and *Cowbells*. *Maggini's* primary focus was to represent recombinant teleology musically.

In his book, Fink considers two cultures surrounding teleology, the Culture of Eros and the Culture of Thanatos, and in particular their relationship to minimalist music. The former considers for music for pleasure, the latter considering the idea of music for discipline. In terms of repetition, Fink notes of the Culture of Eros 'repetition is a technique of desire creation, a more-or-less elaborately structured repetitive entrainment of human subjects towards culturally adaptive goals and behaviors', and of the Culture of Thanatos '...ambient repetition as a form of homeostatic mood regulation...The use of repetition to discipline and control attention'. (Fink, 2005, p. 8). Fink also mentions the potential presence of *jouissance* (intellectual pleasure) derived from music with an absence of teleology (Fink, 2005, p. 44), which could be discussed as an alternative to Eros in terms of compositional motivations. Fink explores the teleological differences between two musics based on repetition – minimalism and disco. He considers process music such as minimalism to present new forms of teleology; the musical 'stasis' of the style is in fact the *telos* itself:

Disco and minimalism appear as two linked instances of a new theoretical possibility in late-twentieth century Western music: not the absence of desire, but the recombination of new experiences of desire and new experiments in musical form across a bewildering spectrum of teleological mutation. Process music's recombinant teleology supports a revisionist (and perhaps transgressive) interpretive conclusion: its repetition is not the negation of desire, but a powerful and totalizing metastasis. Minimalism is no more celibate than disco; processed desire turns out to be the biggest thrill of all. (Fink, 2005, p. 9)

Fink's concept of recombinant teleology suggests a different take on teleology, based on evolving musical styles and compositional motivations; the music of minimalism or disco's

telos is not the end of the piece, but the repetition within the piece itself. Fink proposes, ‘...any music with a regular pulse, a clear tonal center, and some degree of process is more likely to be an example of recombinant teleology’ (Fink, 2005, p. 43) This also suggests parallels with an Adaptive Response Model (discussed in section 1.3, p. 24) wherein a group moves through multiple goals within the scope of a larger project.

Fink discusses the Culture of Thanatos in recent popular culture, considering the post-war concept of ‘repetitive listening’ – listening to recorded music, including multiple albums, as repetition. He continues, ‘...stack a half-dozen records, sit back, relax, and let the changer homogenize them for you into a home-made evening of musical flow’, considering this ‘repetitive musicking’ (Fink, 2005, p. 9). Although this may suggest parallels with Graham’s positive comments on repeated listening (section 1.4, p. 31), Fink considers this in an arguably more negative perspective, citing the homogeneity of musical repetition without focus. From this, it could be argued there may be different levels of the two cultures, in essence coexisting – at high-level, the overall effect of this listening experience is that of Thanatos, where the music chosen becomes as background music, regulating mood, the scale of the playlist diluting the individual tracks’ telos. However it could still be considered, perhaps based on the listener’s attention to the music, that the individual tracks may maintain their telos at a lower level, therefore providing a potentially hierarchical model of the playlist’s teleology. It could even be considered that a rhythmic hierarchy exists at a macro-level, in the rhythm of a full playlist, album, or individual work. Fink proposes, ‘...the absolute length of a work’s telos might remain within classical bounds while the quantum of teleological change is reduced, so the build-ups and breakdowns take place with an “inhuman” slowness and regularity’ (Fink, 2005, p. 44). In this way, teleology can be considered reducible, and therefore be considered on multiple levels, containing potentially multiple teleological elements, even crossing the two cultures.

Traditionally, teleology follows a linear form – a process would begin and reach its telos to end. This type of fixed form is rooted in human nature; however, Stockhausen argued that this should not always be the case. Fink quotes Paik from his *Essay*, 1961:

One evening in the summer of 1960 I visited Karlheinz Stockhausen with the intention of explaining to him that fixed form has to be maintained because it is based on the form of sex, one-direction-crescendo (can you imagine a many-direction-

crescendo? We have but one heart), climax, catharsis – human nature – Ying Yang – Nature of Nature – proton and electron...[Stockhausen] began to explain that we must get rid of fixed musical form because it is like sex. It has no freedom. It is as old as the theory of tragedy of Aristotle, of Faust, etc. Then Stockhausen explained the possibility of a free and calm love. (Fink, 2005, p. 31)

This thinking can apply directly to polytemporal music – instead of a single linear progression from start to end, polytemporal music contains multiple rhythmic bases, each with its own independence; this can specifically apply to works built on cell-based rhythmic structures, for example *Cowbells*, *Fractal*, or *Cycles*, but also apply to works containing both cyclical elements and larger hypermeasures such as *Translate*, *Disconnect* or *[in]dependence*. This may go some way to explaining why polytemporal music could be considered inaccessible to listeners – it does not necessarily follow a single direction towards a unified telos. In particular, the quote ‘can you imagine a many-direction-crescendo?’ is mentioned almost rhetorically, yet this can be an essential consideration in the composition of polytemporal music.

However, it can be argued that completely free-form music cannot follow Eros as it does not have teleology; it is therefore antiteleological. Meyer comments on John Cage’s chance music; ‘The music of the avant-garde directs us towards no points of culmination – establishes no goals toward which to move. It arouses no expectations, except presumably that it will stop. It is neither surprising, nor, once you get used to its sounds, is it particularly startling. It is simply there’ (Meyer, 1967, p. 72). Considering this, the composition of polytemporal music may need to integrate some level of fixed-form in order to maintain a level of traditional teleology and be received as such; it could be said that *Drum Kit’s* teleological discussion provides a response to this, as it is antiteleological when individual sections are considered unto themselves due to their free improvisation, but the work has an overarching structure within which the improvisation takes place. Fink continues however to reflect on the writings of Michael Nyman, who observed experimental musicians replacing the ‘time-object’ with the antiteleology of the ‘process’ (Nyman, 1999, p. 4). Fink remarks that Nyman’s thoughts reflect a similar sentiment from composer Philip Glass; ‘The music is placed outside the usual time-scale substituting a non-narrative and extended time-sense...[the listener] can perhaps discover another mode of listening – one in which neither

memory nor anticipation (the usual psychological devices of programmatic music whether Baroque, Classical, Romantic, or Modernistic) have a place' (Mertens, 1983, p. 79).

Iyer also comments on the listening experience being personal to the listener, arguing:

The claim that music perception and cognition are embodied activities also means that they are actively constructed by the listener, rather than passively transferred from performer to listener. This active nature of music perception highlights the role of culture and context. For example, the discernment of qualities such as pulse and meter from a piece of music is not perceptually inevitable; rather, it depends on the person's culturally contingent listening strategies. (Iyer, 2008, pp. 273-274)

This reflects on notions of pulse and meter potentially being subjective, which aligns to notions of meter being 'induced', as discussed in section 2.1, p. 65, which Iyer notes is dependent on the listener's musical demographic. He also comments on teleological approaches to structure, considering:

A teleological concept of form, in which the meaning of music is taken to be its larger-scale structure, may be replaced with an alternative, modular approach, in which the meaning of music is located in the free play of smaller constituent units. Such notions of musical structure appear in many African and African-American musics, from Ewe dance-drumming to Detroit techno. Instead of long-range hierarchical form, the focus is on fine-grained rhythmic detail, the dialogic interplay of various musical elements, and superpositional rhythmic hierarchy. Thus, large-scale musical form emerges from an improvisational treatment of these short-range musical ingredients – that is, from the in-time manipulation of simple, modular components (Iyer, 2008, p. 278).

Within this writing, Iyer mentions teleological connections with Ewe drumming, previously discussed within the context of hierarchical rhythmic structures in section 1.1, p. 14. His discussion suggests notions of recombinant teleology, by way of considering telos at lower-level, as well as considering this 'superpositional' – suggesting that within these smaller telos, musical matter may be more abstract, and based on fine detail.

I wanted to experiment with a less rigid structure while maintaining usage of click tracks as a rhythmic framework; the result of this is the structure of *Maggini* being dictated by the performers themselves via rhythmic synchrony, prompting me to extend my entrainment research further into social concerns.

Social entrainment as the act of people synchronising their movements with each other can be considered within a musical performance, as an extension of cognising meter and pulse. Where this underlying synchrony is desirable when working with a single tempo, it could be considered a risk in a polytemporal setting. Trost notes the ‘chameleon effect’ (a term coined by Chartrand and Bargh) to describe the positive feelings caused when multiple people mimic each other’s physical actions, often provoked by a combination of listening and moving, heightening the effect of motor entrainment (this form of entrainment considered as ‘conscious physical synchronisation with pulses’ (Trost, W.J., et al., 2017, p. 104). This is further reinforced by Trost’s reference to Bharucha et al., stating the act of physical synchrony in a group can be as powerful as the musical perception itself. This may also provide a connection to the psychoacoustic properties of works accompanied by performance video as the physicality of the performance suggests to the listener the underlying pulse, in turn heightening their aural sense of it.

Reflecting on this, it can be considered that music with high pulse clarity is most suited to social situations (dancing for example, also providing links to studies undertaken by Dahl et al., discussed in relation to *Cowbells*, section 2.3, p. 69), and also experienced at a deeper level by performing musicians communicating with one another due to this fundamental clarity of pulse. However this can also pose an antithesis argument, potentially explaining why polytemporal music is more difficult to physically execute in an ensemble setting unless performers are sufficiently isolated from each other; additional stimulus (click tracks for example) can be used to ‘distract’ the players from each other’s movements as well as musical output, but naturally there is still a risk where players can see and hear each other’s performance, initiating the ‘chameleon effect’. *Maggini* seeks to display both of these instances; the performers execute parts in their own tempo, however as the repetitions progress the group moves to actively mimic specific performers until rhythmic unison is achieved, representative (albeit by written instruction, and not intuition) of physical social entrainment, manifesting the work’s telos.

Intrinsically linked to social entrainment are concepts of non-verbal communication – in this work, movement through sections is governed by the performers by their shared physical communication.

Volpe et al. analyse communicative concepts in their publication *Measuring Social Interaction in Music Ensembles*. In particular, the authors propose that musical performers in an ensemble setting demonstrate the ability to communicate non-verbally while simultaneously receive and process this information from others in the group (this is similar to the all channel network where intra-group communication is unrestricted, discussed in section 1.3, p. 29). It is noted that ensemble instrumentalists in particular are ‘experts in a form of social interaction characterized by real-time non-verbal communication’ (Volpe, G., et al., 2016, p. 1), focusing on the communicative skills developed at the most micro-level; skills required to accurately encode and decode subtle sensorimotor non-verbal messages with the main purpose of establishing and maintaining a shared coordinative goal’. This description can be likened most notably to the micro-timing of physically performed rhythm as detailed by Madison and Sioros (previously discussed in *Cowbells*, section 2.3, p. 68). The proposal of a ‘shared coordinative goal’ immediately presents notions of teleology within the ensemble both mentally and physically, Volpe also mentions these goals being ‘technical, aesthetic and emotional’ (Volpe, G., et al., 2016, p. 1) – this concept is directly exemplified in *Maggini* as the performers collectively manifest the telos by coordinating their physical movement. Volpe et al. continue to analyse ensemble rhythmic perception, noting:

In group-level musical coordination, individuals might be conceptualized as processing units embedded within a complex system (i.e. the ensemble), engaged in a joint action, and sharing technical, aesthetic and emotional goals. Each participant may thus non-verbally transmit sensory information while, in parallel, decoding others’ behaviours. (Volpe, G., et al., 2016, p. 1).

This draws parallels to network structures, particularly notions of ‘mutual interest and collective action’, (discussed in section 1.3, p. 22); within *Maggini*, concepts of shared communication and joint action form a fundamental mode of structure, and as such research into non-verbal communication should be undertaken.

Volpe cites several forms of non-verbal communication, for example visual (body sway, or head motion, previously observed in *Drum Kit*, which also links to entrainment when subconscious, as in a biomusicological context), auditory (instrumental sounds) and somatosensory channels (floor vibrations), also proposing that musicians develop a ‘strong functional association’ with musical stimuli. Volpe even specifically references rhythm, noting that complexity and syncopation, particularly within the frame of groove, increases the engagement of musicians’ motor systems. The invaluable influence of non-verbal communication (particularly eye contact, facial and other physical gestures) has also been investigated by Yarbrough (1975), and Davidson & Good, J.M.M. (2002) discussed below. When considering my own work, it could be considered that this reception and engagement could be potentially jeopardised by the restriction of particular modes of communication, as highlighted practically in section 2.1, p. 54 when workshopping with Splinter Cell – while musicians perform in an ensemble situation, as well as aural stimuli being removed via the use of click tracks, the visual act of seeing other performers execute physically conflicting rhythms to their own (also prompting the chameleon effect). It could be considered therefore that this may be a form of dissonance on a perceptual level, wherein musical stimuli which can ordinarily be communicated between performers acts against the ‘refined skills’ cited by Volpe (this could be considered to conflict with underlying entrainment, resulting in cognitive difficulty experienced by the performers).

As a case study, Davidson and Good (2002) observe methods of communication within string quartets. Referencing investigations by Murningham and Conlon, the authors note that ‘action (music-making with the use of non-verbal gesture for indication) rather than talk would be used to work through a problem. Effective non-verbal communication between co-performers during the rehearsal period was thus found to be essential’ (Davidson & Good, J.M.M., 2002, p. 187). It must be noted that this is in effect ‘moment-by-moment’ while the ensemble rehearses and performs. This moment-by-moment analysis is termed by Shutz as a ‘mutual tuning-in relationship’ (Schütz, 1951, p. 79), highlighting the holistic reception, analysis and anticipation of ensemble performance – this ‘tuning-in’ can be demonstrated by the convergent telos in *Maggini*, but is also useful to note from a strictly rehearsal perspective; this could impact positively or negatively in a polytemporal setting where these works are less ‘organic’ (less based on practices of non-verbal communication, and concepts of groove, perhaps) than traditional ensemble pieces.

Davidson and Good also note that extramusical factors, particularly sociological and socio-emotional, for example performance anxiety (Davidson & Good, J.M.M., 2002, p. 189), can dramatically influence the function of an ensemble beyond the technical performance of the music. Considering how effective non-verbal communication is to the live ensemble, it reinforces the questions raised by my work in terms of the effect of removing some of these communicative stimuli (specifically the use of headphones). Interestingly, Volpe speculates that Davidson and Good's study indicates social dynamics are even more impactful to group cohesion and performance quality than the technical aspect of musical performance (Volpe, G., et al., 2016, p. 3) – this could draw parallels to writings on network perspectives, particularly with regard to trust of members in the context of servant leadership (discussed in section 1.3, p. 21) or productivity of team structures based on intra-group communication (discussed in section 1.3, p. 28)

As *Maggini's* duration and movement through the structure is dictated by the performers (unlike other works in the portfolio), this provokes discussion into leadership and influence within groups – this can also apply to other works where the group is led by a conductor, either in a traditional sense or via laptop.

Volpe notes the importance of a traditional conductor's role as:

not merely giving tempo to the players or the timing of attacks during public performances. In fact, the conductor is also selecting musicians, leading rehearsals, as well as deciding fine interpretation details of the pieces, based on personal taste and a philological erudition. At the highest levels, the conductor is the major driver in fine-tuning all aspects of the performance (Volpe, G., et al., 2016, p. 5).

Volpe et al., continue to reflect on a studies conducted by Wöllner (investigating the impact of viewing conditions), and Bigand (investigating conductor eye movements) to exemplify some of these claims, noting that a conductor's face provoked higher expressivity in performers than if only the arms were visible, however noting that the arms provided a greater amount of communicative information (Volpe, G., et al., 2016, p. 5). These studies and their results highlight the communicative complexities of the conductor and how the myriad of non-verbal information, potentially down to the smallest micro-timings is received and decoded by performers in real-time, influencing performance and shaping the

entire piece as a result. The conductor therefore can be considered the ensemble leader; Maxwell defines this role simply by stating, ‘leadership is influence – nothing more, nothing less’ (Maxwell, 1998, p. 17). These studies show the communicative power of the human conductor to the ensemble, and therefore raises issues of having a conduction role undertaken by a machine, and the effect of this on the ensemble – many of my works are handled this way, with audio scores delivered to performers via laptop.

Please refer to the Maggini score and Audio/Visual Example 7

Maggini centres on concepts of cell-based rhythmic cycles, punctuated by convergence points to create a work exemplifying recombinant teleology. The structure is similar to that of *Drum Kit*, whereby polytemporal and monotemporal sections alternate. Each performer is given a score containing a broad structure of three sections indicated by rehearsal marks, comprising multiple cells indicated by numerals. Each cell is looped as many times as desired until moving sequentially on to the next. Once a performer has reached the end of the cycle, they revert back to the first pattern and repeat. Similar to *Drum Kit*, the piece moves into a convergence point indicated on the score, where one lead player initiates via visual cue the new section. During this, the designated lead performer noted on the score loops one pattern, with remaining other players mimicking this, resulting in a unified rhythmic phrase. After a second cue from the lead player, the ensemble reverts to their polytemporal parts for the next set of rhythmic cells – this demonstrates previous discussion in this section on social entrainment, as well as mirroring the Repeating Cycle Model (discussed in section 1.3, p. 23); during the individual cycles, performers represent the state of ‘discontent’ by way of temporally dissonant cyclical material, with convergence points forming the ‘precipitating event’ leading to change. Within this convergency, ‘group productivity’ and ‘individuation’ are shown as one performer asserts their cell, before there is ‘decay’ for the ensemble to move to the next section of temporally dissonant cyclic material. The tempi used are as per Figure 16.

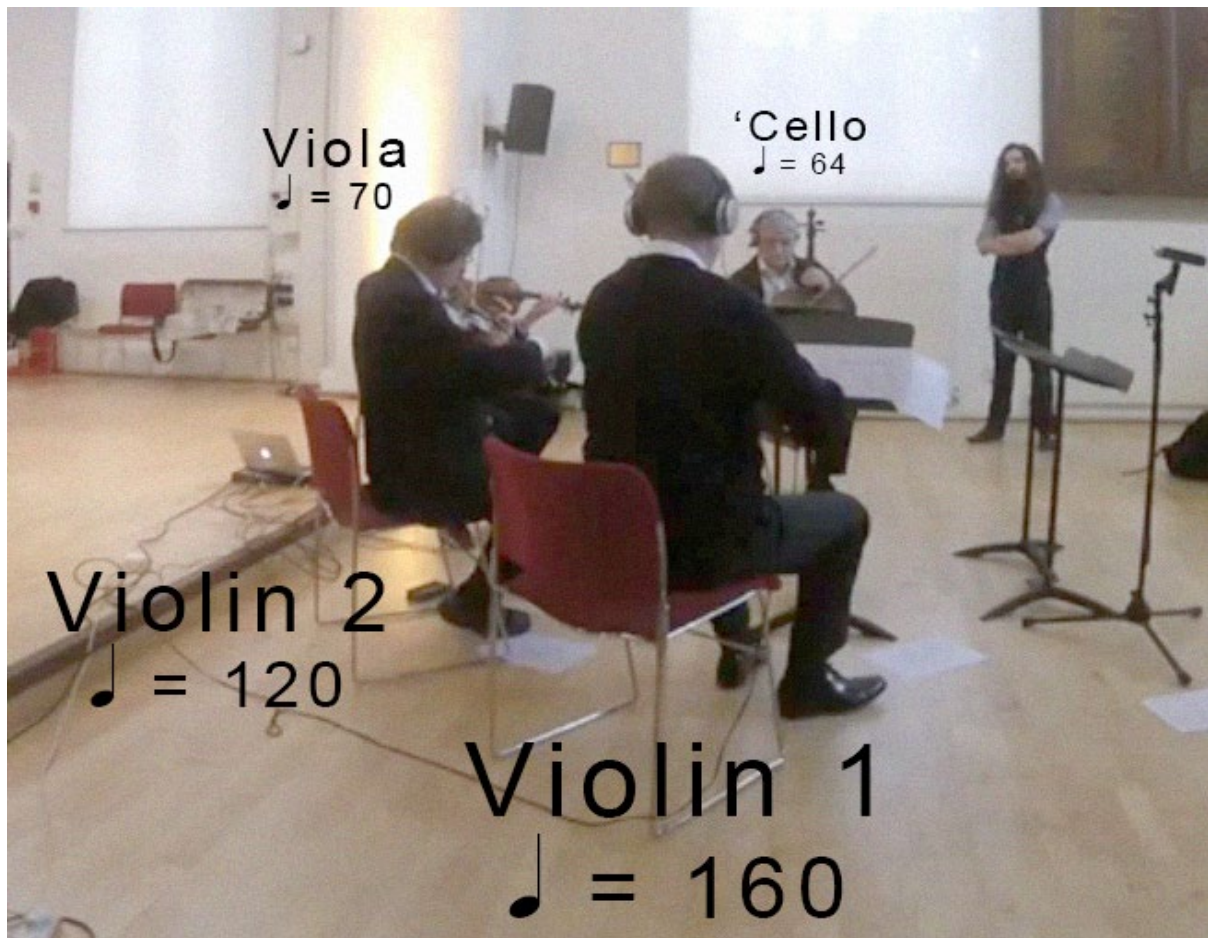


Figure 16: Maggini layout with tempi shown

Each cell comprises a single bar, containing minimal pitch content to, as with *Drum Kit*, focus the sonic result as much as possible on rhythmic interplay instead of becoming too distracted by harmonic material. As the piece progresses further pitches are gradually added to allow for variation. During the convergence points the performers' notes are not specified; in these sections they may choose their own pitches (akin to Frank Zappa's *Approximate* (The Dub Room Special, 1983)) with which to mimic the leading phrase. Dynamics and articulations were not included for this reason; however, these were incorporated with the Maggini Quartet during the workshop of the piece; section A (0:00) is executed in *pizz.*, B (1:25) *arco* and *molto espressivo*, and C (2:49) featuring a long diminuendo to finish. In order to execute the piece, as with other works click tracks were delivered to performers through headphones. The performers would use these as the pulse upon which to loop their patterns, however at the point of convergence would remove the headphones, placing them together as an ensemble to listen and imitate the lead player (suggesting a conscious chameleon effect). This was written into the program note to aid accessibility (as this

removes the click from the performers' ears, preventing conflicting entrainment), however when performed by the Maggini Quartet removing the headphones was found to be unnecessary, as they were comfortable adjusting their mode of listening to shift focus from the click-track to each other. The physical act of removing headphones does however provide moments of non-verbal communication to each other and the audience.

The defining character of the work is the collaborative interplay between the performers during the convergence points, developing my reflection particularly of the video aspect of *Drum Kit*, in which collaborative interplay was not possible due to the multitracked construction of the piece. The work is comprised of two opposing sections with distinct characteristics; the cyclical sections featuring all performers moving in simultaneous musical isolation with aural impairment by way of headphones, however when the ensemble moves into a convergence point the sound of the piece becomes radically different with sudden pulse clarity. All players move from an independent musicality to collaborative ensemble-playing, requiring this interaction to move into rhythmic unison. As can be demonstrated in the video, the non-verbal communication of performance proved paramount in the successful movement from section to section; gestures such as bow movement and eye contact used to initiate new material – these moments highlighted below:

- 1:02 (moving into convergence point A) – violin 1 moves upper body
- 1:25 (moving into section B) – violin makes exaggerated bow movement
- 2:15 (moving into convergence point B) – viola makes exaggerated bow movement
- 2:47 (moving into section C) – viola makes exaggerated bow movement
- 3:52 (moving into convergence point C) – ‘cello nods head

This draws together concepts of entrainment as at points of convergence performers display perceptual, motor, and social entrainment, as well as notions of kinesics and groove. Performers are able to revert back to an organic, traditional means of playing; they are able to manage their collective tempo, articulations and dynamics internally. This is most clearly demonstrated during the closing convergence point of the Maggini Quartet recording, which features a diminuendo (3:55-4:46). This then renders the piece suitable only for live performance, as this form of human interplay would not be possible from a multitrack recording, as structural aspects (unlike all other works in this portfolio) are governed by the

performers themselves. The entire work then can take on a more human quality, as there are no elements of clock-time enforcing the overarching structure.

Temporal consonance and dissonance is balanced similarly to *Drum Kit* in this piece; the cyclical sections comprise of four simultaneous tempi (therefore yielding a high degree of event density), however the repetitious nature of the cell-based rhythmic cycles reinforces a temporal dissonance closer to that specified by Nancarrow by way of metronomic musical material as opposed to improvisation. Although as with previous works the underlying pulse is inaudible due to the nature of headphone usage, the fact the unique cells are repeated enables greater accessibility for listeners to discern the pulses; the simple fragments contain enough repeated events that these can be organised to form pulses or, if an absolute pulse cannot be identified, the higher-level cell itself is a short enough duration to be able to be followed. The converged cells may be received in a similar way; these remove the aspect of temporal dissonance by reducing the ensemble to a single inaudible pulse allowing far greater pulse clarity, however perceptual allows for the cell as a whole to be perceived singularly.

As with *Drum Kit*, a simple dialectic can be established from the two overarching sections. It could be proposed however that the imitation of the lead player during convergence points forms a further dialectic; if the lead player is identified as *the* tempo during these moments, this then renders the rest of the ensemble the antithesis. The full ensemble at this point becomes a synthesis in rhythmic unison – the new thesis which collectively asserts itself for a time before collapsing (or ‘decaying’, to refer to the Repeating Cycle Model) back into its antithesis, polytemporality. In this way, the work as a whole demonstrates recombinant teleology when considered through Iyer’s lens; the cyclical, polytemporal material representing the homogenous ‘superpositional’ qualities Iyer refers to, contrasting to the pulse-clarity of its convergence points.

Though structurally akin to *Drum Kit*, this piece places more of an emphasis on recombinant teleology by its foundation of cell-based rhythmic cycles. In this way, multiple levels of recombinant teleology can be identified. At high-level the broad structure of the piece takes on a recombinant teleological approach, moving through the sections at an unfixed rate defined by the performers (each new section as a new telos), however this could extend down to low-level instrumental parts as each new cell could be identified as a new telos for

the player. With this, a teleological hierarchy could be established from the piece, with smaller, player-defined telos existing within the larger structure.

As a workshopped piece, this did demonstrate recombinant teleology as well as performers' abilities to govern structure and duration in a polytemporal setting. However, the format of the piece itself (cell-based rhythmic cycles and concepts of convergence via non-verbal communication and mimicry) could limit the variation and complexity possible due to this way of working – as the piece relies on non-verbal communication this results in delays in synchrony as performers need to process communicative gestures before using entrainment techniques to perceive and respond to the pulse, it may be that further modes of communication are required during moments of convergence to provide variation or increased complexity, such as additional notation, or improvisation (the concept of improvisation within a polytemporal setting being the basis for *LABO*). The nature of repeated cells also means definite harmony is also impossible to achieve, however this could be reworked to create more subjective harmony derived from repetition (this forming the basis for *Fractal*).

3.2) LABO

The next piece was workshopped by four performers at the LABO #5 event at deSingel in Antwerp, organised by ChampdAction. For this work, I wanted to bring together concepts of improvisation with new approaches to structure (as was identified as a point for development in *Maggini*). The piece forms a study into utilising scrolling multimedia notation as a structural foundation for a polytemporal work, existing simultaneously with a variety of click tracks which performers have in headphones.

This work primarily looks at improvisation within a polytemporal setting, as well as utilising visual score to facilitate structure. Individual pulses are not made audible to the audience, therefore a concept arising from this, given the piece's improvised nature, regards the definition of rhythm itself.

Egerton Lowe discusses the lack of clarity on the meaning of 'rhythm'; 'it would be a blessing if musicians could come to an agreement as to the true musical definition, or definitions, of this much-disputed term. There is, I think, no other term used in music over

which more ambiguity is shown' (Egerton Lowe, 1942, p. 202). What follows in the article is a series of definitions from a wide variety of sources from as far back as 1755, all with varying degrees of difference from each other. Most of Egerton Lowe's sources share a somewhat simplistic or ambiguous explanation, for example 'rhythm is the metre of music', 'rhythm is 'that property or quality by which the cadences of every kind of movement are regulated and determined'', 'a particular arrangement of the alternately strong and weak sounds of a musical progression', or 'in its fullest sense . . . it covers the ensemble of everything pertaining to what may be called the time side of music (as distinct from the pitch side)' (Egerton Lowe, 1942, p. 202). In more recent writing rhythm has been defined with far more clarity, both developing on and conflicting with the aforementioned quotes; a simple yet effective description is provided by Clarke, describing the term as 'the duration between event onsets' (Clark, 1987, p. 214). This forms parallels then with terms such as periodicity and beat salience; suggesting the term 'rhythm' can apply to any temporal event, not limited to music (as in Egerton Lowe's examples) or even sound, and can apply to broader concepts of hierarchical rhythmic structure as Clarke explains:

Since the primary rhythmic property is the duration between event onsets, the relative proportions of sound and silence within time-spans are not considered to affect rhythmic properties directly. However they may affect rhythmic properties indirectly by modifying the position or strength of group boundaries, or by modifying the pattern of directed motion within groups (Clark, 1987, p. 214)

The concept of rhythmic hierarchy and 'high' and 'low' level rhythmic structures is referenced by several other academics, many citing Yeston's work 'The Stratification of Musical Rhythm' which uses such terminology as 'rhythmic stratum' and 'level of motion' for these hierarchical levels (Yeston, 1976, p. 39). Though widely accepted as a valid means of analysing rhythm, the concept is criticised by Smith as 'treatment which, however, aggravates rather than eliminates the problems of that identification' (Smith, 1977, p. 149), however I find this a clear and focused way of deconstructing and analysing rhythm, as put by Yako; 'by adopting a hierarchical perspective, the position of a part within the whole becomes clear' (Yako, 1997, p. 47). The hierarchies are considered by Clarke as: 'the written symbols [notation] represent the lowest level of a hierarchical structure in which higher levels embody the relationships between lower level events. Higher levels are therefore more abstract, in the sense of having no immediate material reality' (Clark, 1987, p. 212). This

can consider lower levels to be more 'foreground', with higher levels 'background', and could be compared with the traditional explanations cited by Egerton Lowe, such as rhythmic 'grouping of notes into beats, grouping of beats into measures, grouping of measures into phrases, and so forth' (Egerton Lowe, 1942, pp. 202-203).

LabO explores the concept of improvisation in a polytemporal context by utilising click tracks delivered via headphones. This provokes further research into entrainment (building on writings in *Drum Kit* and *Maggini*) as well as investigating the effects of metronomes on performers.

In his 2017 study, Stupacher et al. investigate the impact of a metronome on social entrainment and cognition, considering 'movement synchronization and social bonding are tightly linked' (Stupacher, et al., 2017, p. 158). The authors notes the key differences between 'behavioral mimicry' and 'interactional synchrony'; the former is physical copying/mirroring of gestures etc. during social situations, the visual cognition and processing of this results in a 'time lag of a few seconds' (observed in *Maggini* when evaluating performers' convergence during the work). Interactional synchrony suggests deeper, more focused and predictive/anticipatory level, 'more aligned to a prolonged interaction, such as musical engagement' (Stupacher, et al., 2017, p. 159).

Stupacher et al. continue to note that, from a variety of sources, 'the interpersonal synchronization of movements, such as walking, pendulum-swinging, chair-rocking, body-swaying, or finger-tapping, promotes affiliation and pro-social orientation' (Stupacher, et al., 2017, p. 159). This suggests that humans are continually developing a natural affinity and potential bias towards social entrainment in a rhythmic context, also drawing parallels with non-verbal communication and perceptual entrainment. Hove and Risen, in their investigation involving participants matching physical movements with a visual metronome also comment that shared visual timekeeping has a positive impact on perceived social relationships (Hove & Risen, J.L., 2009, p. 957). This is applied to music when considering the physical aspect of music-listening; a study by Demos et al. involved partners rocking in a chair with partners, which concluded that rhythmic synchronisation and interpersonal feelings were positively connected (Demos, et al., 2012, p. 50), suggesting links to groove in a social context. This is further applied to social interaction by Hadley et al. investigating the effect of synchrony in dancers, noting that individuals' focus would tend more towards

dancers in rhythmic synchrony than those that were not (Hadley, L., et al., 2012, p. 386) . This research reinforces the impact of pulse clarity, as this is consciously and subconsciously perceived by way of entrainment and non-verbal communication as well as providing further links to kinesics and gesture.

Based on this research, Stupacher's experiment sought to test the social effects of synchronous tapping with music, and with a metronome, expecting synchronous tapping would lead to higher affiliation and pro-social orientation than asynchronous tapping, and that this difference would be bigger when tapping with music compared with a metronome (Stupacher, et al., 2017, p. 159). This experiment develops Janata et al.'s research, which looked at the psychological motor processing compelling young adults to, without conscious cognition, move to music (Janata, et al., 2012). The outcomes of this were that groove can be readily perceived in a variety of music, often eliciting spontaneous movement, and is affected by rhythmic complexity. Within *LABO*, performers are instructed to improvise in their own tempo and therefore will mentally perceive their own groove as subjective rhythmization.

Stupacher's results yield very interesting insight on the difference between rhythmic cognition of a metronome and of musical stimuli; tapping to a metronome saw subjects keep exact time, however tapping was slightly ahead of the beat with music. It is likely no coincidence that the stimulus chosen was 'groove' music; Stevie Wonder, The Meters, and Parliament. These styles of music often exhibit subtle yet perceivable behind-the-beat syncopation; this combined with the unavoidable human micro-timing elements (said to characterise groove) this could justify why a listener may tap slightly too early compared to 'locking in' with a metronome.

Further to these strictly rhythmic observations, Stupacher noted that their hypothesis was confirmed in that 'participants were more helpful toward a person who tapped synchronously compared with asynchronously – this further connects research concerning entrainment, non-verbal communication, and groove with social interaction (also integral to a functioning group or network), highlighting the impact of this. Interestingly, this was only true when participants tapped in time with music, but not with a metronome' (Stupacher, et al., 2017, p. 163). It could also be argued that this additional 'trust' manifests a form of accessibility, drawing potential parallels with the trust outlined between a conductor and

performers when considering servant leadership. The fact that social relationships were not affected when a metronome was used highlights some interesting issues; musical stimuli could be considered to have a more ‘human’ or ‘organic’ quality to it, prompting a similar social response in listeners, with its complex syncopation and micro-timings, whereas a metronome could be simply considered as a functional timekeeping tool, and nothing more – prompting no such reaction.

Stupacher considers however that musical training may have an effect on this; subjects with musical training may perceive more complex rhythms, such as polyrhythmic ratios (rhythms with more temporal dissonance, to use Nancarrow’s definition), within apparently ‘asynchronous’ tapping, and consider this ‘complex but stable’ (Stupacher, et al., 2017, p. 164). This highlights the subjectivity of asynchrony and raises questions of at what point a ‘complex but stable’ rhythm dissolves into asynchrony – as well as the impact of musical training on this. Although my compositions utilise mutually compatible tempi, these are of varying complexity, executed by trained musicians – metronomes are used in combination with live performance and listening (via audio scores) to create an environment straddling Stupacher’s methods. This can raise questions around how Stupacher’s study can be further developed to include multiple stimuli and degrees of musical training, as well as if these means of synchrony can be balanced in different ways; for example, would the same result be reached if all members of an ensemble used the same click track, as if only one member (such as a drummer) used a click and other performers listen to that performer? *Maggini* investigates this to some degree, as a central concept within it is the movement from independent performance to click to unison performance via rhythmic mimicry – this demonstrates perceptual entrainment two contexts; to strict pulses (utilising pulse clarity as a stimulus) and perception via social entrainment, initiated by non-verbal communication. The latter could be considered a more involved perceptive process, concerning groove, gesture and kinesics, the processing of non-verbal communication, and social entrainment. As noted while evaluating *Maggini*, this process can lead to a delay between hearing and replicating a pulse.

LabO’s improvisational focus draws parallels with *Drum Kit*, and in order to achieve a more sophisticated development of this research into the psychological nature of listening in an improvisational setting.

As previously discussed in *Maggini*, Davidson and Good consider key differences between this ‘mutual tuning-in’ in the context of improvised and non-improvised performance. In an improvised setting, Davidson and Good refer to Berliner’s term ‘striking the groove’ – this is defined as ‘the ability to find a collective energy for the music, but that this energy emerges out of general and shared socio-cultural knowledge, and social and musical skills in sign-reading which then enables shared moment-by-moment ideas to unfurl’ (Davidson & Good, J.M.M., 2002, p. 188). This again highlights the somewhat subjective and elusive defining of the term ‘groove’, and it can also be argued that the term ‘collective energy’ is also not clearly defined; this does however suggest links to social entrainment. Davidson and Good continue to note that the interplay found in improvised music is influenced by the musical knowledge at the disposal of the performers as well as the moment-by-moment communication at play. This differs from non-improvised music, where they note this knowledge is the ‘principle determinant of the musical outcome’ (Davidson & Good, J.M.M., 2002, p. 188), however stating the ‘tuning-in’ is still necessary to achieve a cohesive composite performance by the ensemble as a whole. Both of these musics however exhibit moment-by-moment interaction albeit in different contexts, and require this mutual tuning-in. This notion of ‘tuning-in’ could be quantified in a variety of ways; as a form of entrainment, connected to interpretation of non-verbal communication, perception of meter and pulse, or even more widely to enable productivity within a network.

Jane Ginsborg also highlights the importance of this moment-by-moment interaction, specifically considering the requirements of soloists and accompanists to ‘support and be supportive of each other’. She continues,

As they refine their initial responses to the music, it is important for them to articulate and communicate to each other their understanding of the compositional structure and the composer’s expressive intentions, filtered through their own individual interpretations; later in performance, they must communicate their shared interpretation to the audience. (Ginsborg, 2017, p. 170)

This further compounds the importance of social interaction within ensembles, also suggesting processes mirroring network approaches; specifically, this can be likened to theories of mutual interest and collective action, and further discussed in relation to *Disconnect* applying particularly to the aspects of improvisation.

Reflecting on Hostager et al., Davidson and Good work on the basis that music creation's fundamental is 'common ground' (Davidson & Good, J.M.M., 2002, p. 189), again suggesting parallels with theories of mutual interest and collective action. While their initial example is that of the written score, this notion could be applied to any common and fundamental element of a composition enabling its performance – this could be expanded to include components such as audio score or even the larger temporal framework; the mutual compatibility of chosen tempi. Following on from this, David and Good propose multiple dimensions of available communication (Davidson & Good, J.M.M., 2002, p. 189):

- Co-presence – whether two or more people share the same physical environment
- Visibility – whether the people are visible to each other
- Audibility – whether they can hear and be heard by one another
- Co-temporality – whether one receives at roughly the same time as the others produce
- Simultaneity – whether each can send and receive at once simultaneously

These dimensions form connections with writings on non-verbal communication affecting visibility, as well as issues such as headphone usage affecting audibility, within the larger scope of ensemble structures and networks.

Please refer to the LABO score and Audio/Visual Examples 8 and 9

To execute *LABO*, the video file is projected onto a screen which displays a scrolling visual notation as an extension to the audio score, designed to trial a visual enhancement to performance accessibility by way of animated notation. Performers would watch this and play from the projected score (choosing which notes and registers to perform), changing notes in accordance to the orange 'playback line', and sustaining in accordance to the coloured graphics (differing in layout from the score provided, as acknowledged in the program note). A sample of this is seen in Figure 17 – as can be seen, only noteheads are shown, without stems, meter, or barlines. This design was to transcend performers' individual tempi, functioning as an 'overlay' to their click tracks. Visual perceptions of

where notes should fall rhythmically will vary across performers (evident in the recording), due to there being no clear pulse to be perceived.

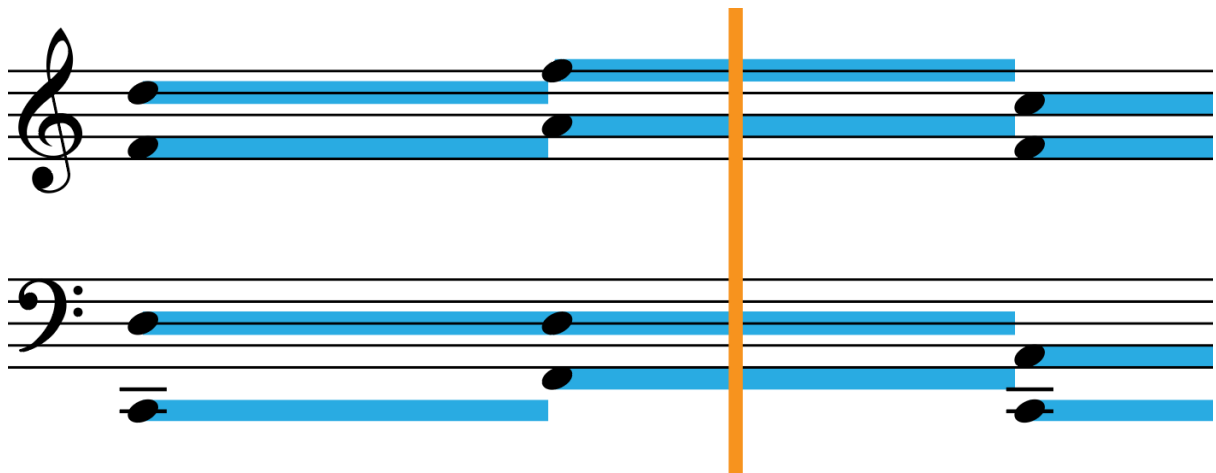


Figure 17: Sample of LAbO scrolling notation

While performing this, players also had independent click tracks in their headphones, as with other works these were derived via calculation-based methods (as the score is for open instrumentation, a range of tempi were brought). The piece therefore contained two simultaneous forms of timekeeping; visually, where performers play by eye from the projected score, and aurally, where playing in accordance to their respective click tracks. In the various sections of the piece, these two opposing forms of timekeeping alternate and coincide. This aspect of conflicting rhythmic stimuli is similar to *Maggini*, however headphones would not be removed by the performers during the piece – as discussed when reflecting on *Maggini*, this is not always necessary as performers are able to shift focus to different modes of rhythm. The piece was workshopped with four instruments (two guitars, clarinet, and harp), and follows the below structure (with reference to the rehearsal video and printed score)

Section A (0:04, score p. 2, system 1)

During the first section performers play exclusively from the visual score (although click tracks are present in headphones). This creates a melody executed in rhythmic, harmonic, and melodic unison, therefore presenting the most accessible and consonant material of the piece. The melody features largely sustained notes, implying simple, diatonic chords. While the click tracks are present in the performers' headphones, they are not utilised – this could be argued to increase the difficulty of the performance by creating a distracting 'pull' away

from the visual score, however as observed with the Maggini Quartet, this is not necessarily an issue.

Section B (0:55, score p. 3, system 1)

The second section integrates the click tracks. The notation scrolls through a series of chords (again triads), with chord names appearing above. Performers are invited to improvise rhythmically and harmonically (via arpeggios, for example) around these chords, following both the visual score (to identify harmonic movement) and their click track (as the pulse upon which to play, though without specified rhythms). This results in highly complex rhythmic content, however harmonic movements are made in unison. While in this section, performers will be using their respective pulses to inform decisions on rhythmic phrasing of their improvisation; this then means performers will be utilising subjective rhythmization to establish meter and groove against which to play.

Section C (1:50, score p.3, system 3)

This section develops the content of Section B by introducing further instructions on the score; as the improvisational section progresses players are asked to perform more pulse-based material and vary dynamic. This aims to assert rhythmic performers' independent tempi while maintaining the harmonic unison movement.

Section D (2:34, score p.4, system 1)

The final aspect of the improvised material sees the piece take on a more conventional jazz-type organisation, where players are invited to take turns to improvise melodically over the chords, while other players 'comp' beneath in their own tempi. Following this period of improvisation, the work revisits sections B (5:13, score p.7, system 1), C (5:40, score p.7, system 3), and A (6:20, score p.8, system 3).

Similarly to *Maggini*, this structure can be reminiscent of recombinant teleology, as each section undertakes a form of stasis or homogeneity in terms of improvised material (particularly section D), however the additional harmony induced in *LABO* could be said to add direction to these sections. As with *Maggini*, *LABO* could be considered to resemble characteristics of a Repeating Cycle Model, however focusing largely on stages of individuation without a strong sense of a precipitating event.

While the piece at the point of workshopping required refinement, particularly in terms of the scrolling video which did performers commented did not enable them to read ahead far enough, and did not scroll smoothly enough, the group found this an interesting concept and way of working. It should be noted that the visual element of the piece, particularly in section A, did not see players performing in exact rhythmic unison; this highlights a key difference in visual versus aural timekeeping. Performers when playing by eye alone exhibited far less accuracy to the score, due to the fact there was not an aural pulse present to enforce a fundamental rhythmic structure (highlighting the impact of aural pulse perception and groove). The resulting rhythmic inaccuracies could be attributed to discussions on social entrainment, specifically the ‘time lag’ that occurs when performers must interpret and respond to visual stimuli. Although the scrolling notation cannot be considered a form of analogic codification due to the digital nature of the stimulus (this concept discussed in section 1.3, p. 25), it could be said to provide non-verbal visual communication which performers must respond to, however without any of the expressive kinesic gesture required to be as effective as a human conductor. Without any pulse, performers must utilise their own subjective rhythmization in order to then perform from the score reactively. Without this aural pulse, or semblance of groove, rhythmic inaccuracies when performing to the score cannot be prevented; these inaccuracies could be considered to range from noticeably observable down to micro-timings of inaccuracy exaggerated by the requirement to cognise the visual score (the time lag).

It was commented on that the improvisational nature of the piece could result in a reduction of pulse clarity (an issue observed in *Drum Kit*), this revisiting questions posed throughout my works to this point of whether pulse clarity is a desired output of polytemporal music, or whether it should only function as the means to generate new musical material. As a result, a more successful rehearsal of the work was performed with performers playing lines that were more pulse-based to accentuate this, avoiding excess syncopated lines which could be said to ‘dilute’ the polytemporal nature of the work by maintaining beat salience – it is this rehearsal that features in the video. Although this recording does enable some pulse perception at low-level, this is not to a large extent, and other rhythmic events such as harmonic or section movement are not rhythmically discernible.

The use of multimedia score, although providing a structure to enable synchrony, did not prove to be the most accessible way to facilitate exact rhythmic accuracy – this is likely due

in part to the reactive nature of needing to watch the notation scroll without physical gesture, however I would suggest this is more likely linked to a lack of pulse beneath this (or a conflict with the pulses in performers' headphones). Given that the material in this work was very simple (long, sustained notes and triadic harmony), suggests that this form of notation and performance is impractical to create more complex notated material due to its reactive nature.

These workshops proved invaluable in realising works in a live ensemble setting, highlighting key practical issues, particularly of non-verbal communication and social entrainment. Both works explored concepts of teleological structure, giving additional structural control to performers; *Maggini* as a work where structure and duration is directly lead by the performers via non-verbal communication, and *LABO* featuring a stricter high-level structure but with more emphasis on improvisation. Although these works expanded ideas of flexibility and performer-control (also drawing comparisons to group models, specifically the Repeating Cycle Model), and it could be argued that this flexibility also restricts the potential complexity of the work in a dialectical sense; while *Maggini* displayed performer-led structure, this is at the cost of the cellular material needing to be simple and accessible in order to be mimicked. *LABO* similarly allows performers to improvise for the majority of the piece, however therefore requiring the underlying harmonic and melodic structure to be simple and accessible (compounded by the reactive nature of the scrolling notation). *LABO* particularly, due to its improvised nature, also suffered from an abundance of event density yet lack of pulse clarity. Both of these works therefore present difficulties based on perception and entrainment. *LABO* particularly was less successful due to the inclusion of visual notation; as discussed in the commentary, aural material serves to be more effective to achieve pulse-perception and establish groove, and as such where visual notation is provided this should be aligned to a click track or audio score. On this basis, the completed pieces in the following section return to a stricter and more traditional structural and notational approach, however integrating elements of improvisation.

4) Portfolio of Compositions

The final chapter of compositions displays a culmination of the techniques and practical research undertaken in previous works. Using this knowledge, the following completed pieces have been composed:

- *5:4 Guitar*
- *Fractal*
- *Translate*
- *Cycles*
- *Disconnect*
- *[in]dependence*

These works display the fully refined process of composition and (where applicable) live performance, presented as audio/visual experiences. Accompanying these are full scores demonstrating manipulated traditional notation to accurately display polytemporality (providing a core analytical tool), as well as materials required to reproduce the works (part scores and audio scores).

These works also expand on concepts of accessibility, ensemble and network theory, non-human performers, and approaches to pitch and structure.

4.1) 5:4 Guitar

This work builds on the fundamental form and concepts of *Cowbells*, however develops further compositional techniques by applying more of a focus on harmonic thinking. This then presents a clearer dialectic of pitch and rhythm, resulting in what could be considered a less rhythmically-biased whole. On this basis, previously discussed terms of consonance and dissonance should be applied to pitch discussion to develop this arc of composition.

The concepts of ‘rhythmic consonance’ and ‘dissonance’ show a borrowing from pitch terminology, thought by coined by Schillinger (Krebs, 1987, p. 99). Krebs links this to Yeston’s work; ‘Yeston considers collections of strata consonant when their rates of motion are multiples or factors of each other by an integer greater than one. When two or more strata are not related in such a simple manner, they are characterized as rhythmically dissonant’.

This definition is noticeably similar to Nancarrow's concept of temporal dissonance, initially quoted in section 1.1, p. 12. Yeston's definition can be likened to pitch content, as certain intervals, due to their frequency make-up, can be considered more consonant or dissonant than others. While I consider this to be suitable terminology, this writing does not explore pitch other than where it directly affects rhythm (such as in isorhythmic techniques or within works where pitch material is a specific focus).

One such example of pitch being utilised as rhythm stems from the work of Johannes Kepler in his book *Harmonices Mundi* (*'Harmony of the Worlds'*) which directly connected cosmic rhythm and tonal harmony. Kepler, observing the planetary movement of Saturn, Jupiter, Mars, Earth, Venus and Mercury, measured the perihelion (when the planet is nearest the sun) and aphelion (when the planet is furthest the sun), in reference to the speed of movement for each planet's orbit to determine rational relationships (Kepler, 1939, pp. 16-17) – these rational relationships can be said to draw parallels to my own methods, particularly concepts of mutually compatible tempi. These planetary ratios directly produced musical intervals. For each planet then, Kepler was able to produce a musical scale based on the elliptical nature of the orbits. Some planets (Mercury, for example) had very erratic orbits thus producing a large number of notes, while others (like Earth or Venus) did not, producing fewer notes. Kepler considered this the true 'harmony of the spheres', observing,

...you won't wonder any more that a very excellent order of sounds or pitches in a musical system or scale has been set up by men, since you see that they are doing nothing else in this business except to play the apes of God the Creator and to act out, as it were, a certain drama of the ordination of the celestial movements. (Kepler, 1939, p. 40)

Kepler's observations and concepts of planetary rhythm and harmony could draw parallels to polytemporal rhythm on a macro level, my work often dealing with cyclical rhythmic material. Within this, full cycles of this macro planetary rhythm can be likened to a large-scale hypermeasure, as well as recombinant teleology as planets possess their own cycles, with a larger movement towards convergence where the wider cycle (or hypermeasure) would restart. Of these larger telos, Kepler comments on the very long durations between the planets coinciding in perfect (or near-perfect) unison, noting the rarity of this, an example being the 800-year durations between Saturn's harmony with Jupiter. Again, this planetary

rhythm although on a macro scale does display practices handled in my own work, particularly the underlying compatibility of these large scale planetary ‘tempi’. Kepler continues to observe that, ‘Moreover, the other single pairs of planets have periods like that, although not so long. But meanwhile there occur also other consonances of two planets, between movements whereof not both are extremes but one or both are intermediate; and those consonances exist as it were in different tunings’ (Kepler, 1939, p. 44).

Kepler explores the other intervallic instances present in the two scales considered (major and minor). He notes that as further planets are added into consideration, although there would be an increasingly long period between absolute unison, it is important to consider other harmonies also present during their respective movements (Kepler, 1939, p. 48). This raises an interesting and important concern particularly to be considered when composing polytemporal music, namely managing the harmonies (be these rhythmic or harmonic) that may be present within a larger cycle – if one minute of the tempo (beats-per-minute) is considered a hypermeasure and therefore a high-level cycle, then these can be subdivided into lower level harmonies in the same way an octave is divided into our Western 12 equally tempered pitches. Similarly, once these divisions and combinations of compatibilities are established, one then has a greater understanding of how to manage harmony in a more sophisticated way within the larger hypermeasure – this is most notably discussed and demonstrated in *[in]dependence* where harmonic progressions can be observed, synchronised across tempi.

From this discussion, pitch can also be considered as a cyclical rhythmic device; a key example of this is the concept of isorhythm, a term coined by Friedrich Ludwig (Knighton, 1992, p. 393) where a series of pitches (color) are arranged over a repeated rhythmic pattern (talea) and overlap, generating new material (Bent, 1992, pp. 115-116). This type of rhythmic interplay was featured heavily in 14th Century Ars Nova motets, analysed in detail by in his writing *Isorhythmic Technique in the Early Motet* (Harbinson, 1966). Bent considers isorhythm a form of ‘restatement’, where melodic and rhythmic repetitions have ‘a proportional relationship or of a mensural re-reading’ (Bent, 1992, p. 116). Bent continues to note that ratios were often applied to isorhythmic composition to achieve proportional relationships. Further variation on the concept was practiced by ‘repeating the color with smaller note values in either free or strict diminution’, also experimenting with long colores, irregular ratios or regularly changing talea’ (Hoppin, 1978, pp. 365-366). As with previous

observations on Kepler's discussion, isorhythm itself could similarly be considered as a form of recombinant teleology due to its constant cyclical nature. Isorhythm then forms the fundamental concept behind the harmonic content both of *Cowbells* before being developed into *5:4 Guitar*.

Please refer to the 5:4 Guitar score and Audio/Visual Example 10

5:4 Guitar then builds on the fundamental structure of *Cowbells*, expanding this to include a greater range of pitch material. The same tempi are utilised, and the work is also identical in its isorhythmic approach and duration of repetitions. As with *Cowbells*, the work is accompanied by a split-screen video which further enhances accessibility. Figure 18 displays the layout of *5:4 Guitar's* video presentation, with tempi displayed.

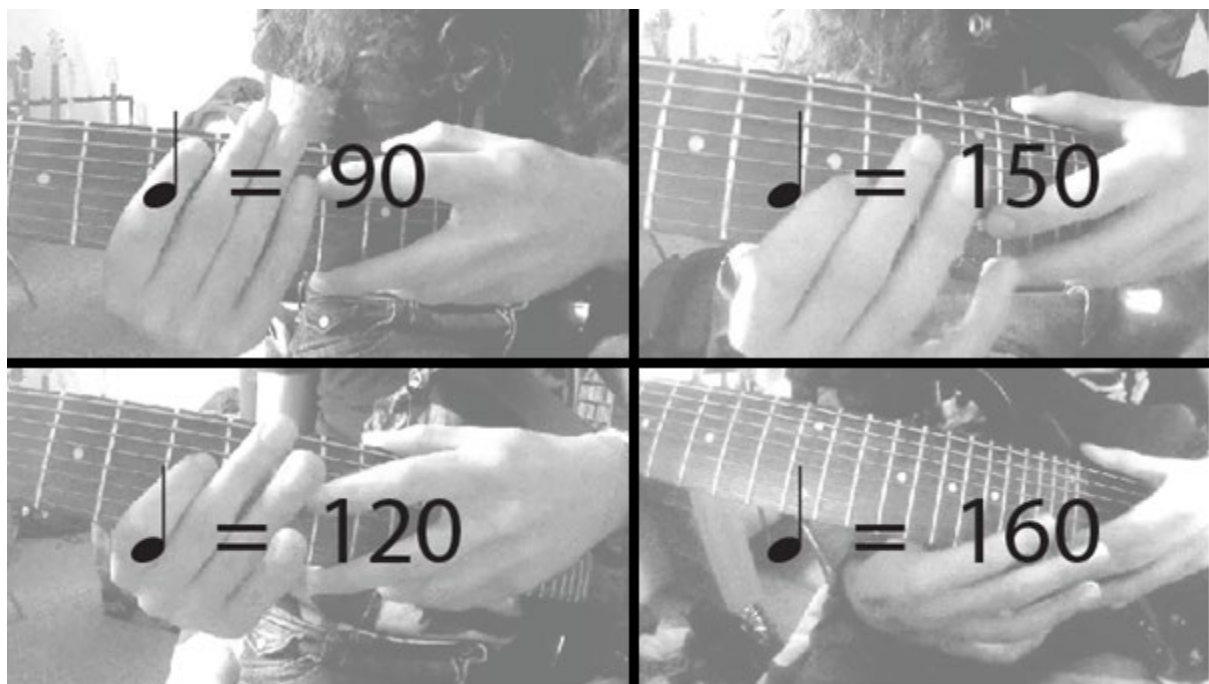


Figure 18: Image of 5:4 Guitar video displaying tempi

All notes are produced by tapping (a technique where the fingers percussively tap the desired frets to sound the notes), allowing one hand to tap four beats per bar and the other to tap five simultaneously. As discussed in *Cowbells*, the inclusion of constant quavers and quintuplets in essence doubles the temporal layers, providing a high degree of event density, however due to the wide pitch range of the guitar the tempo in this instance can be distributed across the instrument, allowing for greater pulse perception, both aurally and visually by way of

the video (discussed in greater depth later). The pitch interval in this case was chosen arbitrarily; a perfect 5th, chosen for its harmonic consonance (considering discussion around consonance and dissonance with respect to frequency in Kepler's work) which may allow the lines to be distinguished more easily; Figure 19 displays this range.



Figure 19: 5:4 Guitar pitch ranges

Due to this I performed the parts on an 8-string guitar, enabling the full pitch range to be executed on a single instrument. This allowed tonal consistency to be retained as a separate baritone or bass guitar would not be required.

This work demonstrates two previously undeveloped approaches to accessibility; on a practical level, concepts of audio score were developed to include both a click track and spoken instructions; whereas *Cowbells*, was recorded sequence by sequence, *5:4 Guitar* was recorded in full takes. As such, spoken cues were added to audio scores, providing me with verbal instructions on which sequence was about to occur and a one-bar count for these. To reference Eisentraut's levels of accessibility, this serves to enhance Level II (personal reception, as this stimuli provides a response directly to the performer) and III (participation, as this minimises risk of error by negating the necessity to count repetitions) accessibility. These messages provide a response from the performer similar to that of perceptual entrainment, reinforcing pulse perception and providing communicative stimuli which can be received and acted upon similarly to, although the antithesis of, non-verbal communication.

Additionally, *5:4 Guitar* features full score utilising methods discussed in section 1.4, p. 35; the notation displays the polytemporality of the work, allowing all four parts to be seen in a single score, with accurate vertical temporality. As discussed when developing this layout, this form of notation is designed for accessibility and analysis, and cannot be utilised for performance based on the displacement of barlines and system/page breaks. Due to this

function, *5:4 Guitar's* score utilises coloured notation to display each sequence, and can be viewed at high-level to heighten the accurate verticality of the notation (in adherence to Gestalt laws) to observe the 'cascading' nature of the polytemporal cycles – these methods are later utilised in the score and video for *Fractal*.

Similarly to *Cowbells*, the piece is designed primarily as a rhythmic study, and as such I chose to keep other elements as consistent and homogenous as possible; the same instrument was used for all parts along with the same tone, dynamics and equalisation settings. Although this theoretically would suggest all elements should be received by listeners equally, this was not found to be the case – the upper and lower extremities both in pitch and tempo appeared more readily perceptible than the inner layers; pitch content may justify this to a certain extent, potentially drawing parallels to Krumhansl's writing on the influence of higher/more intense pitch material in relation to *Cowbells* (section 2.3, p. 66). The inclusion of a video element alleviated this however, enabling listeners to visually isolate the layers to differentiate the pitch material, as previously observed in *Drum Kit*.

Further visual interest is derived from the use of unconventional fingering present in the instrumental parts; due to the limitations of using two hands on a single fretboard certain irregular position shifts are required to prevent hands crossing. This creates certain 'choreography' within the visual, the irregular positions creating larger intervallic jumps between frets, resulting in a further accessibility aid for perception of pitch material – a form of non-verbal communication generating entrainment responses. As well as this, the physicality of the fingers tapping the strings also heightens this perception, in a similar way to the striking of drums in *Drum Kit*, and later *Disconnect* which features both drum kits and guitar tapping.

While this work focuses on taking the rhythmic concepts of *Cowbells* and developing this harmonically, the result is isorhythmic harmony in a largely static form. A logical progression to this was therefore to develop compositional methods to manage pitch in a polytemporal setting, in order to further explore harmonic possibilities – this is a core function of *Fractal*.

4.2) Fractal

Please refer to the Fractal score and Audio/Visual Example 11

This work draws together cell-based cyclic rhythmic structures previously explored in *Cowbells* and by extension *5:4 Guitar*, seeking to produce a work that would place a greater emphasis on harmony. Visual concepts from these works are also employed based on the psychoacoustic properties of the accompanying video, developed to be more impactful in terms of providing both enhanced accessibility and a unique aesthetic. The work, built on cyclical diatonic cells, can also be viewed as an infinitely cycling ‘fractal’ concept, where the instrumentation and duration of the piece can be expanded endlessly – this therefore clearly establishes the work as a representation of recombinant teleology (previously discussed in *Maggini* (section 3.1, p. 81), as the function of the work is its cyclical nature and not a defined end point or climax. This work was premiered in an installation format at the Sidney Cooper Gallery as part of the BFE/RMA Research Students' Conference on 06/01/2017; in this performance the work featured four tempi, with one played live and the other three projected onto the walls of the gallery, spatial aspects of performance also referenced in relation to the premiere of *[in]dependence* and the spatial aspects of *Translate*.

As with other pieces, core tempi were derived using the calculation-based methodology, and four were chosen as a base for this; ♩ = 180, ♩ = 160, ♩ = 120, and ♩ = 105 (these tempi shown on the score). In constructing the recording, additional layers were created by extending the duration of the notes, effectively halving each tempo. The completed work then presents 16 individual layers, however these can be hierarchically grouped into 4 broad ‘strata’ (shown in each quarter of the video, in Figure 20) – there then exists a broad spectrum of temporal relationships across the layers.

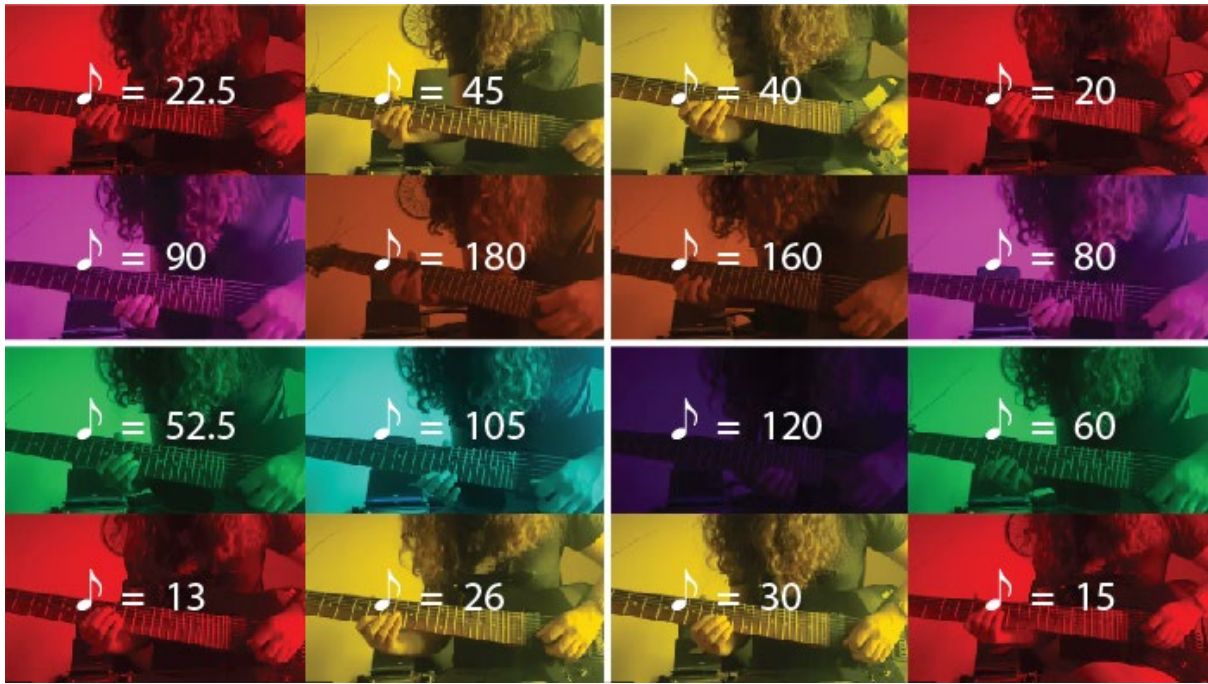


Figure 20: Video of *Fractal* demonstrating four 'strata' of tempi

As can be observed in the score and video, the work consists of up to 8 melodic phrases displayed in different coloured notation. This use of colour was a development of the score created for *5:4 Guitar*, designed for visual accessibility and analysis of notated material (individual part scores are notated in black and white as the colours do not benefit performance) – sequences and their associated colours can be seen in Figure 21. As with the audio score for *5:4 Guitar*, spoken cues can be utilised to enhance accessibility, as sequences can be repeated indefinitely by the performer until verbally told to move to the next sequence. While these were used during the premiere performance, this recording was constructed sequence-by-sequence as opposed to full takes (as with *Cowbells*) due to the high volume of layers involved.

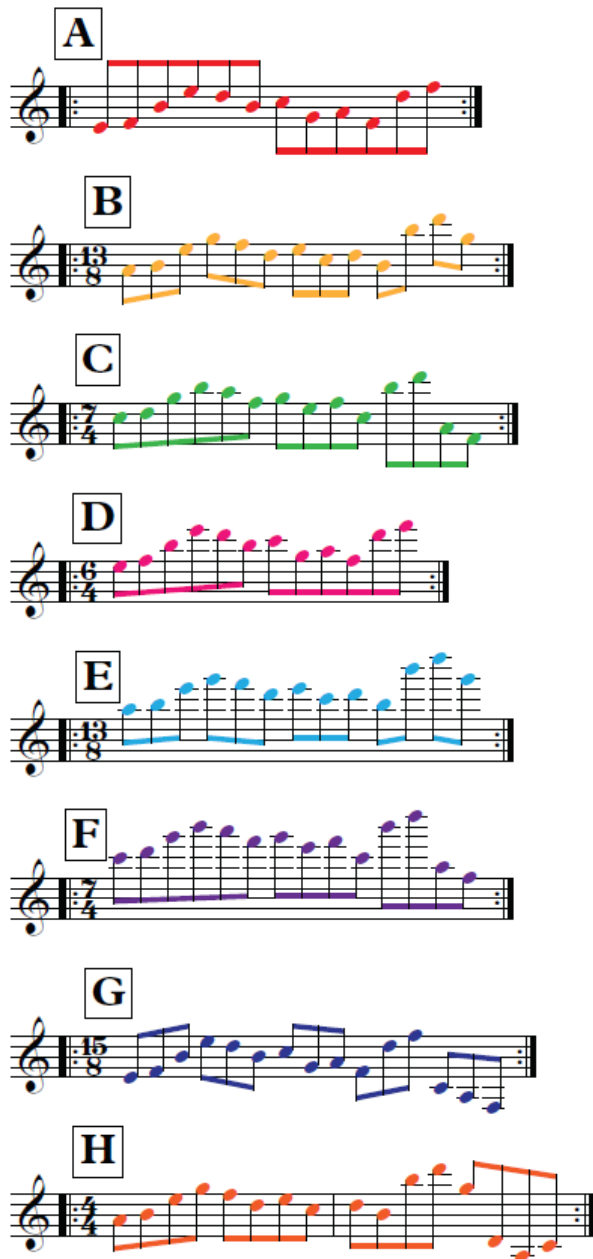


Figure 21: Fractal sequences, colours corresponding to video presentation and score

While *5:4 Guitar* utilised colour in score only to demonstrate the cascading effect of cell-based repetition in a polytemporal setting, *Fractal* extends this to video presentation, further allowing the listener to experience visually the mutual compatibility of the tempi – this can be seen at various moments as parts move to new sequences (with a change in colour) simultaneously, though due to the varying meter of the sequences this only occurs within individual strata, examples being 0:52 (upper left strata) or 2:14 (upper right strata).

The sequences are cycled in their respective tempo to click tracks, and rhythmically these are executed exclusively in quavers so as to maintain the maximum pulse clarity possible within a polytemporal structure. It can be seen in Figure 20 that the slowest tempo is 13bpm; in order to execute these very slow passages, click tracks of at least double this tempo must be used – this reflects previous discussion on meter, pulse, and groove, as Zbikowski comments; ‘if recurrent musical events occur at too great a temporal interval (if the beat is too slow) the rhythmic frame diminishes in salience’ (Zbikowski, 2009, p. 279). As such, pulse perception becomes much more difficult, requiring multipliers to be added to click tracks.

The approach of cell-based rhythmic cycles draws parallels with *Maggini* or *5:4 Guitar*, however displaying increased harmonic material. The inclusion of additional divisible tempi also greatly enhances the complexity of the work on a rhythmic level due to the increased rhythmic density, however does provide increased subjectivity; while the density of the 16 simultaneous layers significantly reduces rhythmic accessibility on an aural level, the inclusion of video can go some way to balancing this. Although a necessity in *5:4 Guitar*, guitar fingerings in *Fractal* were specifically designed to be unorthodox to provoke a further form of non-verbal communication to aid pulse perception, generating entrainment responses – particularly as pitch ascends with each new sequence, this can be visually identified by observing the hand moving further up the guitar neck. This therefore also provides some dialectical consideration, as while aurally the rhythmic and pitch content is difficult to discern on an individual level, visually accessibility is greatly increased both by having video accompaniment as well as colour-coding.

When viewed through a teleological lens, this work does draw parallels to *5:4 Guitar*; each individual layer contains its own linear recombinant teleological structure as it moves through the coloured phrases, however it could be argued that the high-level structure is less antiteleological than *5:4 Guitar* was observed to be; as phrases ascend in pitch, listeners may be able to discern new harmony from the constant texture, which could be considered ‘subjective harmonization’, to borrow Krumhansl’s term of subjective rhythmization. This may also be generated from the slowest material found in the work; as previously discussed in relation to *Cowbells*, Krumhansl notes that. ‘longer and more intense sounds are heard as accented, and these elements tend to define the beginning of subjective groups’ (Krumhansl, 2000, p. 161). On this basis, although the slowest tempo present in *Fractal*’s individual notes

may be sustained enough to contribute to subjective harmonic changes, irrespective of the fact it does not reach the second phrase across the entire 9-minute duration – this also exemplifying the fractal nature of the work. A broad view of the project in a DAW displays best the cycles, arranged in tempo order in Figure 22. When viewed in this way, rhythmic hierarchies can be considered; based on temporal organisation, it could be suggested that an overarching ‘hierarchy of periodicity’ is shown in Figure 22. However, this could be reorganised into hierarchies per strata; as these are built on multiples of two, this results in beats a larger rhythmic hierarchy where pulses within a strata occur in rhythmic unison – this would then be governed by the slowest tempo, with the next slowest tempo featuring two pulses in the space of one, the next tempo featuring four, etc. This could then outline a macro pulse, somewhat akin to Kepler’s writings, this larger cycle also being considered in terms of hyperbeat and hypermeasure.



Figure 22: *Fractal* 0:00 – 9:00 viewed in a DAW, arranged by tempo

This work is effective in generating subjective harmonic texture, however this is at the cost of pulse clarity; it does therefore lean in a broad sense closer to being an antiteleological piece (particularly with regard to Iyer’s comments discussed of ‘superpositional rhythmic hierarchy’ discussed in relation to *Maggini*, section 3.1, p. 81); while the work does in this instance have a finite duration, there is scope for it to repeat indefinitely with no single telos. The cyclic structure of this also renders it impossible to make simultaneous dramatic shifts

(rhythmically or harmonically); this would require deviation from the static, repeating form – while this may yield variation, it would arguably undermine the core function of the work.

4.3) Translate

While works in this portfolio largely focus on human musicianship within a facilitative digital framework (most notably the use of audio scores), I wanted to construct a piece where rhythmic material is derived via technology, augmenting a human performance. On this basis, *Translate* explores concepts both of inhuman levels of rhythmic precision as well as technology as a performer.

Although the concept of ensemble within the frame of network theory is discussed broadly previously, *Translate* exemplifies the proposition that non-human elements (such as laptops) can also be considered as actors within a network. This is considered by Prior while critiquing Bourdieu's broader sociological research, noting that all entities are influential in impact;

...actors like chemicals, airbags and door knobs impose their presence in all sorts of ways that make them partners in interaction. This means that action is no longer perceived as the sole realm of the human actor, but also the realm of the non-human actor, including the technological artefact. For their presence, the world is not exactly as it was before, a positivity has been made that changes the course of events. (Prior, 2008, p. 313)

Prior continues to comment, looking at Glitch music (elements of glitch featuring in *Translate's* aesthetic choices) through the lens of Actor Network Theory that these non-human actors as well as the actual medium impacts the definition and classification of the music on all levels:

After all, glitch is glitch (and not grunge, hip hop, trip hop or drum and bass) not just because of its field position as conventionally understood by Bourdieu; not just because of the habitus-derived uses its protagonists have made of hardware and software; but also because of these technologies themselves. That is to say, the

gathering of digital objects around glitch changes not only how the music is made, but also what the music 'is'. (Prior, 2008, p. 314)

This further considers that technological elements should not be exclusive to the function of a situation or music, as is the case for the majority of work in this portfolio. Technology in my work is utilised as a facilitative device, be this to execute calculations to derive tempi, provide a foundation for compositional process such as MIDI or multitracking, or to facilitate accessibility by way of audio score for live performance, polytemporal notation, or visual presentation – while in the context of performance technology may be considered ensemble leader, in all other circumstances it merely provides an interface to assist with the generation of resources. Prior's writing suggests that technology as actors are just as valuable as its human actors in defining and dynamically shaping what the goal is. Prior hastens to note that of course technology does not possess the same autonomous consciousness as a human actor – specifically, laptops have been argued to lack communication as effective as human non-verbal communication and gesture), yet to consider technology at the same level as other actors 'alerts us to how the technical and the social are inextricably linked, in turn sensitizing us to the fact that instruments and associated devices are not passive intermediaries but active mediators'. He concludes,

It is just not possible, during the process of what Small (1998) calls 'musicking', to distinguish between discrete logics belonging to the technical, the aesthetic and the sociological. And it is certainly not the case in music production that sociological questions are more relevant at the point at which the product finds its way through distribution processes, leaving the creative process itself to aesthetics or musicology (Prior, 2008, p. 315).

On this basis, with *Translate* technology is utilised as a performer, in addition to providing a fundamental framework; as discussed in the work's commentary, advantage is taken of the technology's strengths and possibilities beyond human performance, and as a result manifests a collaborative duo performance with the guitar. This is achieved largely through the use of automation of digital effects sent via DAW to manipulate live performance audio, and draws immediate digital parallels to writings on non-verbal communication in relation to *Maggini* as well as further discussion in relation to *Disconnect* which discuss the reception and decoding of information by participants in a group – in the same way, the laptop as a

performer receives and processes digital information in real time to achieve performance. The result of this collaboration can be viewed as dialectical, denoting the synthesis between human and mechanical performer. *Translate* can draw parallels to the network theory of mutual interest and collective action, however with the caveat that as a non-human element the laptop cannot have an 'interest' in an outcome, yet a mode of communication and collaboration is in effect to generate the 'coordinated action' which outweighs the individualism of the two parts. It could be said that two modes and directions of communication exist during this piece when considered from a network perspective. The laptop provides non-analogic communication to the performer by way of the audio score, which in turn is interpreted by the performer by way of pulse perception and entrainment, responding to the laptop with analogic non-verbal communication which the laptop decodes in order to process. After the piece is initiated first by the performer (running the file in the DAW), this communication between human and machine is simultaneous throughout the whole piece, this in itself drawing parallels to cyclical rhythm. The resulting synthesis of this work is audio output which cannot exist without this mutual communication and collaboration (or mutual interest and collective action).

Translate also explores concepts of space, in particular utilising digital automation of reverb to create spatial textures in the stereo field. Senior defines the use of reverb as 'about adding the characteristics of an acoustic environment' (Senior, 2008). Reverb can then function as a means of suggesting foreground to background depth (not dissimilar to my initial experiments utilising delay), as an increased amount of reverb would suggest in the physical world that a sound is further away, Aisher considering reverb as 'creating realism, depth and space' (Aisher, 2013). Senior provides an example later in his article, from a studio engineering standpoint:

For example, a bone-dry synthesizer track that belongs in the track's background might need lots of short reverb to push it away from the listener, whereas a lead vocal might only have just enough to make it sound as if it belongs in the mix — indeed, it might have none at all if you want to achieve the most upfront sound, albeit at the risk of it sounding disconnected from the record as a whole. Both of the tracks may need a bit of the longer reverb, though, if you're trying to make them sound natural together. (Senior, 2008)

Utilising reverb as a stylistic element and performative component in this context contrasts to Senior's notions of creating realism and space, instead adding to the inhuman, unnatural characteristics of the work (also utilising the stereo field) – this dialectic is representative of *Translate* in its synthesis of analogue guitar performance and complex digital textural output, but also of the nature of this portfolio's methods as a whole; most notably, technology has already been utilised to enable human performance with an inhuman level of temporal accuracy via click tracks.

Please refer to the Translate guitar score and Audio/Visual Example 12

Translate is therefore a duet for guitar and assistive technology, exploring the possibilities of stereo digital effect automation to achieve a polytemporal sounding result. In many cases the automation is duplicated for the left and right channel, however as the tempi are different this results in asynchronous automation cycles. As per previous works, the tempi are selected via calculation-based methods and share mutual compatibilities, but as demonstrated the rhythmic characteristics present are at times far more complex due to the laptop's inhuman precision – as with Nancarrow's application of the player piano. *Translate* is also accompanied by a video displaying all aspects of the piece, including the notation for all parts with a view of heightening the psychoacoustic phenomenon of using visual elements to enhance the perception of the different channels. The video presentation, as with other pieces, displays performative material however this is augmented to further enhance accessibility; the guitar part features some use of effects pedals, and as such the binary act of activating these is present on the video, further adding to the elements of non-verbal communication, an approach also later utilised in *Disconnect*. In addition, representative forms of animated notation are included both outlining the guitar parts (in standard notation) and providing representation of the digital manipulation taking place (in hybrid forms of notation) – this is discussed throughout the commentary. Figure 23 displays the video presentation of the work.

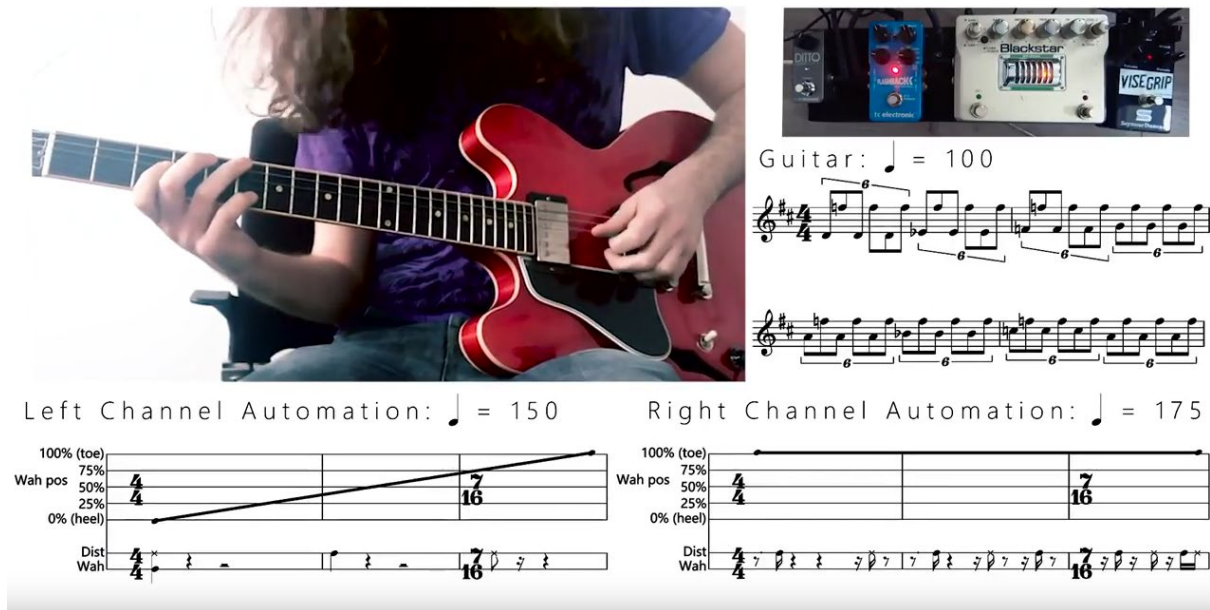


Figure 23: Translate video layout

Translate was premiered at Drone Cellar in Conquest House, Canterbury on 30/09/2017 and later performed (with video) at Wintersound in the Sidney Cooper Gallery on 13/01/2018. In order to perform the work, the signal chain in Figure 24 is required; this signal chain could also be considered a form of sociogram (this concept initially discussed in section 1.3, p. 21).

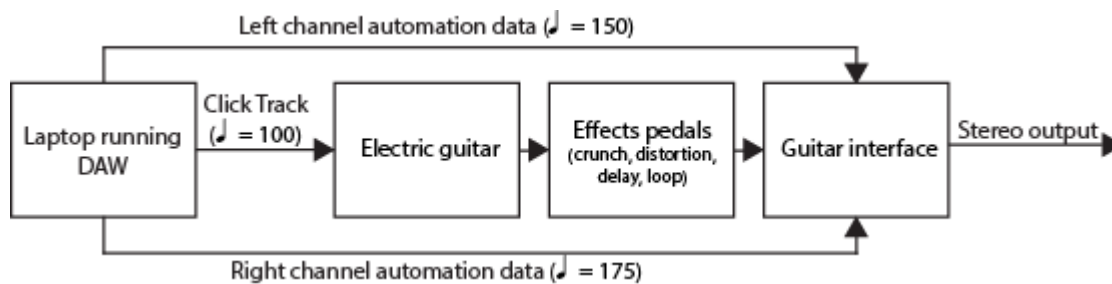


Figure 24: Translate signal chain

When the project in the DAW is run, MIDI information is sent from the laptop to the guitar interface. To compose this, blocks of MIDI (representative of beats in their respective tempo) were created in the DAW on separate channels routed to the interface, denoting pedal on/off controller and expression data. For many sections, these are organised into blank ‘block’ components on a separate channel, this would represent a form of hyperbeat which would identify and blanket cycles with most beat correlation across the tempi, allowing

automation rhythms to be constructed within. Figure 25 displays this; as with Pieslak’s discussion on hyperbeat and hypermeasure, individual sections of *Translate* can be grouped into equal hypermeasures, which in turn are grouped into equal hyperbeats (shown in blue), which then comprise a set of bars (often of varying meter) within which are beats of MIDI controller messages (shown in green where engaging an effect, and red where disengaging).

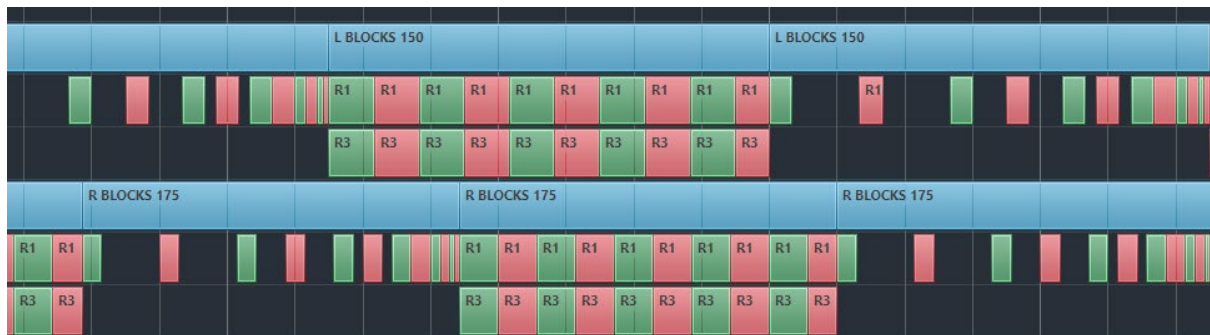


Figure 25: *Translate* MIDI automation data; blue blocks denoting hyperbeats

The work examines effects usage later found in *Disconnect*, specifically the interplay of guitar performed in one tempo, manipulated by effects occurring in other tempi. This has the potential to draw parallels with dissonances in perception, as the guitar tone is altered to a rhythm disassociated with the performative rhythm. As can be seen in the signal chain (Figure 24), the laptop functions as conductor, providing the human performer with the audio score to perform the piece, while simultaneously sending automation data to the guitar interface. As the guitar’s audio signal hits the interface, this is divided into separate left and right paths, simultaneously and independently processed by the automation data from the DAW, before being output to left and right speakers. As the piece progresses, patches on the interface are manipulated and changed to adopt different signal chains, as well as outputting different amounts of the unprocessed guitar to the stereo speakers for up to three points of rhythmic and textural interest – in this instance, rhythmic density is not a factor in *Translate* with regard to independent event onsets, however there is a density of rhythmic effects applied to the guitar stimulus (this may be considered ‘textural event density’)

In terms of accessibility of performance, *Translate* utilises practical techniques previously discussed in *5:4 Guitar*; specifically, the guitarist is provided with cell-based material which is cycled indefinitely until spoken cues instruct the performer to move to the next cycle, negating the requirement to count repetitions. As can be observed in the score, the work is

comprised of broad sections divided into ‘sub-rehearsal marks’; these denote cells which the performer cycles (this technique utilised for all ensemble works in the portfolio). In the Figure 26 example, the guitarist would cycle the four-bar phrase indefinitely to their click track, until a spoken cue is heard notifying the next section is about to start, followed by a count one bar before to lead out of the cycle.

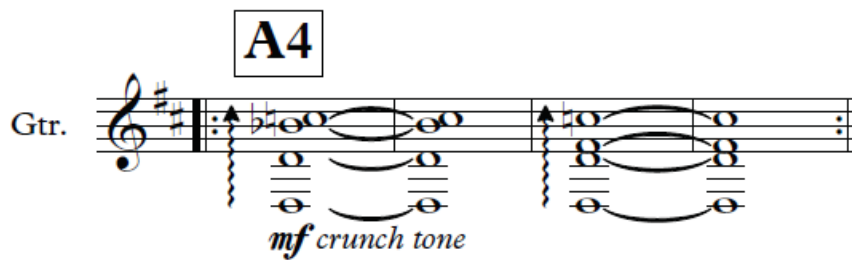


Figure 26: Example of sub-rehearsal marks to aid performance accessibility

Using this approach, I looked to create a piece with as much performance accessibility as possible, as the complexity is executed by the digital automation; the central guitar part is built on simple repeated phrases and with the integration of the automated click track and audio cues, the piece can be performed by way of memorising the sequences and listening for cues (as discussed in section 1.4, p. 36, sight-reading is not always found to be the most accessible means of notation).

In order to construct the piece, I looked at all available effects in the interface to establish the sort of rhythmic automation properties these possess; as discussed above, rhythmic complexity in *Translate* is designed to come from textural changes as opposed to conventionally performed rhythmic material or event density. Broadly speaking, these fit into one or both of the below categories:

- Effects that can be engaged and disengaged for a definite change in timbre; for example, engaging a highly saturated distortion to reduce the signal to noise, or a volume effect can be used to mute the signal
- Effects that possess more ‘sweepable’ characteristics; for example, a wah effect can sweep across frequencies (heel to toe), or reverb can be automated to increase in size or tail length to imply spatial depth. This can also apply to the stereo field by way of panning, similar to the distribution of performers in a physical space, as

demonstrated in the premiere of *[in]dependence*, or the spatial installation of *Fractal*.

With effects categorised in this way, the piece moves through a series of sections that explore the rhythmic possibilities of stereo polytemporal automation. These are detailed and time stamped below.

Section A (0:10)

The initial section features very sparse, improvised guitar harmonics being processed in the left and right channels by engaging and disengaging in alternation three effects for instant changes in tone. The effects utilised are a high-gain distortion (to reduce the signal to noise), a fast delay (50/64ms, to create a rhythmic ‘glitch’ effect, also utilised in *Disconnect*, and a slower delay (300/514ms, to elongate the tones), as shown in Figure 27. As can be observed, the notation utilised displays the MIDI automation data using a modified form of standard notation; standard noteheads are used to denote effects being engaged, cross noteheads used for disengagement. The automation rhythm displays high pulse clarity in the notation, however due to the fact that the automation itself is not producing sound, only manipulating incoming sound from a different temporal source, these pulses cannot be easily perceived on the guitar. At the outset of the piece the guitar rhythm is very sparse so as to achieve maximum pulse clarity and display as clearly as possible the processing taking place before the piece increases in textural event density. The automated parts are also structured as cell-based cycles as with the guitar; in this way, the work displays a recombinant teleological approach; the three components cycle in their respective tempi before moving to a new telos, the difference in this instance that these cycles, although independent, provide a single output as a composite, suggesting dialectic.

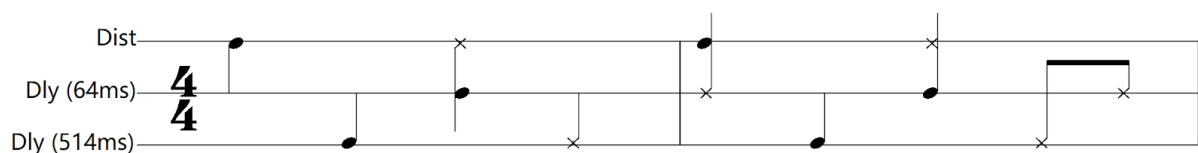


Figure 27: Translate section A automation

Rhythmic density increases on the guitar, serving to assert its tempo more clearly until reverb is utilised at 1:35, automated to move from fully dry to fully wet to transition the

piece to the next phrase. The guitar moves to chords and arpeggios following this, the arpeggios in particular increasing rhythmic density, which reduces the perceptibility of the automation rhythms; the guitar (possibly because this can be physically seen in the video, as with previous observations on video content and non-verbal communication, kinesics and gesture) may be more identified by human listeners. At the close of the section (2:55) reverb is again utilised as a transition tool, before the stereo channel volumes are rapidly automated to move to Section B. This displays the first instance in the piece of very high rhythmic complexity, as seen in Figure 28 – this kind of ‘sweepable’ effect is seen in *Disconnect*, however would not be possible to execute by physically using guitar expression pedals; this then exemplifies technology as a collaborative component within the work (previously discussed with reference to ‘mutual interest in collective gain’ theories), generating new rhythmic content by manipulating the guitar input. As can be observed in Figure 28, the notation applied to the automated parts is structured somewhat conventionally, incorporating metric changes, although these would not be required as human performance is not a factor in the work; this therefore assists the listener with pulse-perception, existing as representation of the abstract automated part. The rhythms can also be observed to be extremely fast, also highlighting the benefits of utilising technology to execute parts not usually possible for a human.

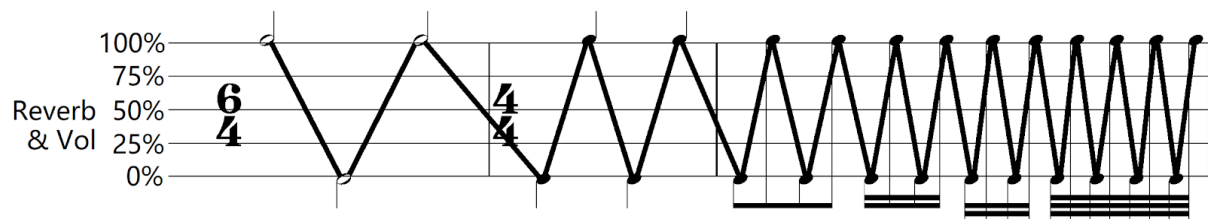


Figure 28: Rapid automation in *Translate*

Section B (3:05)

This section is characterised by simultaneous volume and reverb automation to a low-pitched, distorted and palm-muted power chord, emphasising the spatial nature of the piece. The use of static pitch content in the guitar, lack of sustain due to the palm-mute and high gain distortion results in the guitar taking on a rhythmic accenting role (in a similar way to how metal bands emphasise the rhythmic nature of cyclical riffs, Meshuggah noted as adopters of this approach). Non-verbal communication and entrainment are evident in the guitar performance of the video; particularly, the pulse can be readily perceived due to the

movement of the left leg. This movement demonstrates both Autonomic Physiological (subconscious movement to a pulse – the fact that the foot is tapping is not a conscious decision) and motor entrainment (the conscious perception of pulse, in this case the act of consciously synchronising guitar performance to the click track), these concepts are not dissimilar to the observations made in relation to *Drum Kit's* video. As discussed with reference to section A, these physical movements can suggest why the guitar pulse can be more readily perceived than those of the automated channels. The reverb and volume are automated to move from fully muted (including the input guitar part) to full volume and reverb before suddenly muting to repeat, the hard panning of these effects emphasising the unnatural and potentially unsettling nature of the reverb. The use of automated volume and no dry guitar output results in additional complexity when focusing on the guitar attack; due to the cyclical and overlapping left and right channel tempi, the guitar attacks are clipped or often lost entirely, again resulting in an effect that would not be achievable by a single performer without using technological augmentation, and potentially provoking further dissonance in perception due to the unnatural nature of the guitar affectation. As the section progresses, further metric changes are introduced to the automated rhythms, increasing asynchrony and intensity across the stereo field. The pitch content of the guitar remains static to allow this stereo effect to be the primary focus, until arpeggios are introduced at 3:50.

At 4:10 the central guitar is instructed to accel, however this is to be executed freely against the static 100bpm click track to generate tension as the piece moves towards a climax at 4:25, where all channels meet on a downbeat with maximum volume, reverb, and sustained chord. This is the only instance of this technique in the portfolio, used sparingly for tension – the notion of free rhythm and improvisation previously only explored in *Drum Kit*.

Section C (4:55)

The third section explores pitch material and features many permutations around a central harmonic/melodic theme, shown in Figure 29.

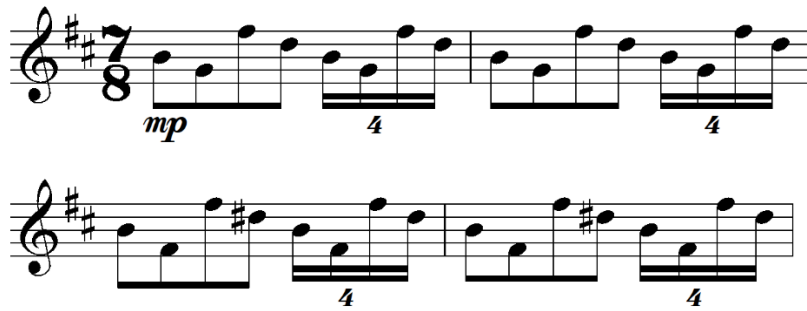


Figure 29: Translate section C melodic theme

This repeated phrase could be said to represent polytemporality within the rhythm itself; the second half of each bar (the quadruplet) replicates the first but at a higher implied tempo.

At 5:10 the central guitar moves to playing single notes in the above rhythm, and automation is utilised to construct harmony lines via pitch-shifting in their respective tempo; Figure 30 shows the notation for these in each channel. As can be observed, this demonstrates hybrid notation, designed to represent the interplay between the performed guitar, pitch-shift automation applied, and sounding result. In this instance, the upper notation displays the pitch manipulation applied to the live guitar within two octaves, with the lower line displaying in standard notation the sounding harmony in that respective tempo – this demonstrates a further instance of potential dissonance in perception, as there is a conflict of rhythmic event onsets as the guitar plays rhythms in its own tempo, with pitch manipulation occurring in crotchet values in the other tempi.

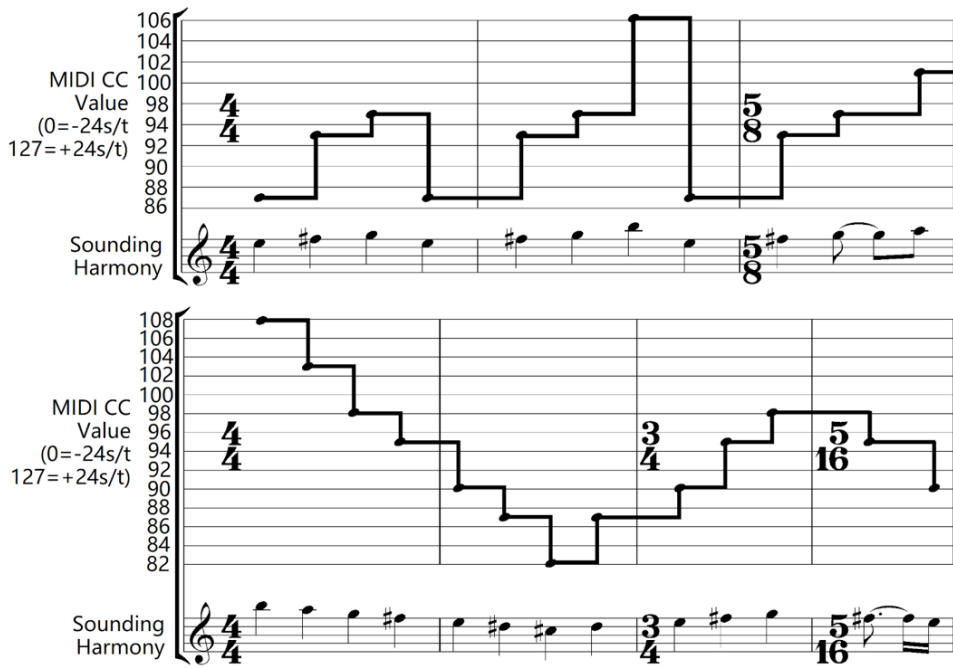


Figure 30: Translate section C pitch-shifting to create counter melodies

As previously discussed, the mutual compatibility of the tempi result in hyperbeats to be constructed across tempi illustrated in Figure 31; by using time signatures across the tempi, hyperbeats can be constructed which enable convergence across the tempi. Though this is utilised in other works, the non-human aspect of *Translate* enable this to be executed without the necessity for performance accessibility; in the example of Figure 31, a bar of 5/16 is present at a very high tempo – this would be extremely difficult to be played by a human performer, but this is not a concern when using technology.



Figure 31: An example of hyperbeat in *Translate*

The automated approach to pitch manipulation is varied at 5:35, where the central guitar line plays an ascending passage, with the left and right channels applying automation to create countermelodies that match the rhythm of the guitar; as can be seen in Figure 32, both stereo channels adjust incoming pitches to achieve a three-part harmony. As with the previous harmonic manipulation, the use of highly complex rhythmic automation results in countermelodies that would not normally be difficult to coordinate by human performers; in the below passages, the automated performer is able to execute in its own tempo pitch manipulation that matches the tempo and harmonic movement of the guitar's tempo.

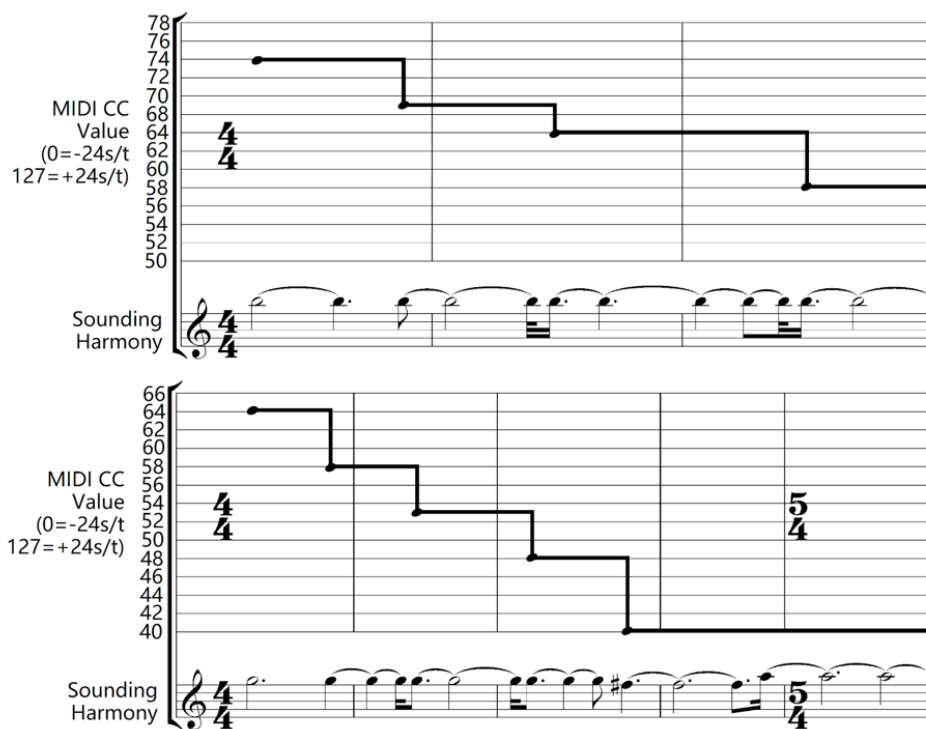


Figure 32: Highly complex rhythms matching performed guitar to produce harmony

These harmony lines are repeated over distorted guitar parts, where the separate tempi can be heard most readily during this section; at 6:25 the central guitar plays sparser, sustained octaves allowing the left and right channel tempi to move to the fore of the mix. This is presented with the same rationale of the opening of the work; minimal event density results in the separate tempi being easier discerned, augmenting listener accessibility.

Section D (7:35)

This section sees the central guitar move to looping arpeggios to create a more traditional, longer chord progression, with the automated channels integrating both on/off effects such

as fuzz, for a noise effect, as well as sweeping effects, in particular the use of wah to introduce additional pitch content (a technique also later utilised within *Disconnect*). The structure takes on a larger cyclical nature than previous sections, a hypermeasure derived from the central guitar part performing the arpeggios for 10 bars of 4/4 + 1 bar of 3/4, where the left channel cycles 2 bars of 4/4 + 1 bar of 7/16 for 6 repetitions and the right channel cycles the same pattern as the left channel, but for 7 repetitions. This demonstrates larger-scale hypermeasure and presents a clearer telos within the section. As mentioned throughout, the use of technology as a performer means executing compound time signatures at the tempi chosen (for example, 7/16 at 175bpm) is more practical than it would be for a human performer, negating any issues of accessibility – this can be linked to Zbikowski’s comments of rhythmic hierarchy; ‘if the temporal interval is too small (if the beat is too fast) we will typically find some other way of organizing the events in order to create a meaningful rhythmic frame’ (Zbikowski, 2009, p. 279). In this instance, individual bars of semiquavers at such high tempi would likely be too fast for a performer to on an individual basis. The inverse of this was highlighted in *Fractal*, where some of the tempi featured were too slow to be meaningfully perceived as pulse.

The ‘contracting’ binary nature of the rhythmic material featured in these hyperbeats (shown in Figure 33) could be said to demonstrate rhythmic hierarchy in a micro form; beginning at high level with the longest duration (bar 1 below), doubling until reaching maximum low-level complexity in the 7/16 bar, a sweep of dry to wet reverb is added to punctuate the end of a full hypermeasure. This does not feature pulse-based material, and as such pulse clarity is difficult to discern, however the accuracy of the contracting beats could be considered to mirror aspects of gagaku’s ‘categoric equivalence’.

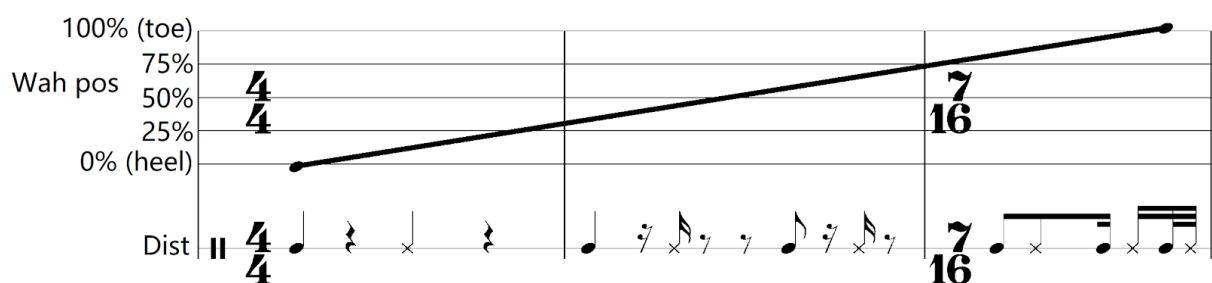


Figure 33: Contracting rhythmic material in a hyperbeat

Section E (9:30)

This section functions as a variation on the previous section, again utilising sweeping wah and binary distortion effects, however these are constructed to allow increased discernment of pulses, as can be seen in Figure 34 by way of pulse-based material. This serves to demonstrate more clearly the pulses of the left and right channel tempi by reducing event density in favour of regular rhythmic intervals. The binary regularity and percussive timbre of the distortion effect manifests alternating pulse clarity within the two channels of automation, however a dialectic still exists as the channels conflict within a hypermeasure. Three distinct textures are achieved via the distorted noise-like tone, sweeping pitch-like sounds of the wah, and clean central guitar tone, as well as variations of combinations of these across a large-scale hyperbeat.

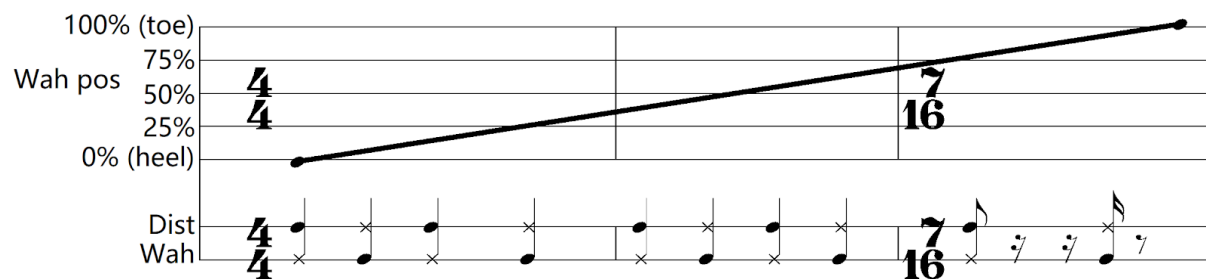


Figure 34: Pulse-based material in distortion effects

At 10:35 this builds to a climax, where the central guitar remains on a chord as the wah in each channel descends across their frequency ranges. At this point the central guitar part features its final point of free rhythm, with the instruction to *rall* against the click. This allows the guitar to move to the background by maintaining a single chord (further pitch content induced by the descending wah), as the pulse-based rhythmic material continues in the automated channels becoming the central focus. This allows the listener to clearly discern pulses due to the shift in event density away from the guitar, combined with pulse-based material executed within the automation.

Section A2 (11:10)

The piece then reverts to the chordal theme from Section A, albeit with very sparse pulse-based distortion in the automation channels retained from Section E. This provides a dialectical conclusion to the work; the initial material from Section A is re-presented, however utilising clear pulse-based material to generate a synthesis intended to provoke

resolution by way of pulse clarity. At 11:25, this moves to automated reverb and volume previously utilised in Section B, the duration of which expands to give the piece an implied feeling of *decelerando*. Although the tempi do not change, the reduction in rhythmic material can suggest in the listener a feeling the work is now displaying slower tempi, highlighting an instance of subjective rhythmization. As this happens, atonal tapped notes are added to the central guitar part before the loop pedal is engaged at 12:40 to create a small, ambient looping texture. Over this, binary distortion is added as the left and right channels are automated to fade – the guitar at this point no longer has any rhythmic material, resulting in this final section potentially displaying the most pulse-clarity of the piece with respect to the automated channels.

The inclusion of technological means as performer provided an interesting approach to compositional workflow, as performance accessibility was not required as a consideration; particularly in later sections, more complex rhythmic material could be composed and executed simply within the DAW. Similarly, the work could be constructed with sole attention being paid to rhythm, as the rhythmic elements exist within the context of live guitar to manipulate texture. As a result, creating resolved hyperbeats and wider hypermeasures became far more practical which opened up options to compose more extended cyclical structures demonstrating recombinant teleology, or structures composed of repeating hypermeters. While this did result in the piece often featuring indiscernible tempi owing to the ‘overwhelming’ textural event density, it can be argued that the accentuated levels of complexity present in the rhythmic aspects leading to reduced accessibility provide the work with its character, particularly in instances where ‘inhuman’ rhythmic complexities were featured. This provides potential links to groove perception within rhythmic hierarchies wherein Zbikowski comments on the impact of listeners experiencing rhythms that are beyond ‘significant periodicities’.

Allied to this, there became less of a focus on the performed guitar part, this instead forming a basis for rhythmic material (contrasting to most other works in the portfolio), and as a result the work has a highly accessible performance practicality. The accompanying audio score allowed (particularly the inclusion of spoken clues) for ease of performance, this work demonstrating the benefits of this means within a more complex and varied structure.

4.4) Cycles

Cycles builds on concepts of cell-based rhythmic cycles, however expands this to an ensemble work which undergoes rhythmic transformations across two distinct sections. This is the first instance in the portfolio that melodic concepts are also introduced in a completed work (though melodic material was handled in a more abstract form in *Translate*), as well as implied harmony via bass guitar. As such, repetition in the context of accessibility and structure is a core function of the work. As with other works, this piece is accompanied by performance video.

Eisentraut comments on the impact of repetition to impact (and arguably enforce) accessibility;

The frequently heard complaint that a disliked form ‘all sounds the same’ is because the stylistic commonalities are perceived more than the particularities of each piece. Repeated listening allows one to become habituated to the commonalities while more clearly differentiating the specifics. (Eisentraut, 2013, p. 279)

Eisentraut continues to explore this at a lower level; repetition within composition, for example, repeated phrases or ‘hooks’ in songs and improvisation facilitate accessibility without requiring repeated listening of the piece as a whole. To further develop this point, some ‘inaccessible’ elements are considered ‘desirable’, particularly after prolonged periods of this. Eisentraut illustrates this with the example, ‘To spend an evening at home on the sofa after an eventful day is bliss. To spend a month at home on the sofa under house arrest would be agony’ (Eisentraut, 2013, p. 280). In this way, attractiveness (and so accessibility to an audience) can be created by carefully balancing these opposing elements within the composition and over time, suggesting dialectic connotations. This could also be considered in terms of context; complex, constantly-changing rhythms could be made more readily accessible if offset by a strictly diatonic melodic line – this also highlights links to expectation and convention. Eisentraut concludes that ‘what is truly accessible, in the sense of being attractive and interesting, is a certain combination of easy and difficult, familiar and strange, safe and challenging – and these precise proportions required vary between individuals’ (Eisentraut, 2013, p. 280), displaying a clear dialectical form, and drawing parallels to forms of consonance and dissonance – my work specifically demonstrating

compositional methods to balance these elements, by way of temporal consonance and dissonance (for example, a core means of doing so being calculation-based methodologies), or familiar harmony and unfamiliar rhythmic material. This concept of balancing familiar and unfamiliar elements can be illustrated by the culture of remixing and rearrangement, an example being Jan Zehrfeld's rearrangement of Dave Brubeck's *Take Five* (Panzerballett, 2012); the original melodic content is entirely intact, however the band execute the piece in 5/4 and 4/4 simultaneously via continuous polyrhythms, giving the arrangement a very distinct, rhythmically (and at times harmonically) unsettling character as familiar and unfamiliar material is superimposed. Similar to issues discussed in *Cowbells* and by association *5:4 Guitar*, the consistency of the conflicting pulses allows the listener to shift focus to different pulses. In the case of *Take Five*, this is compounded by familiar harmonic material being distributed across this complex rhythmic strata.

Please refer to the Cycles score and Audio/Visual Example 13

Cycles features two broad sections, each with a different set of tempi. The work is, in both sections, concerned with instrumental arrangement as much as musical material; instruments enter gradually in separate pitch ranges, and cell-based rhythmic cycles are gradually displaced rhythmically via the removal of notes, to create space in the texture. This cyclical material however is not constructed to form hyperbeats or hypermeasures, resulting in two long, continuous sections. This work features a larger arrangement than previous works, with tempi outlined for section A in Figure 35:

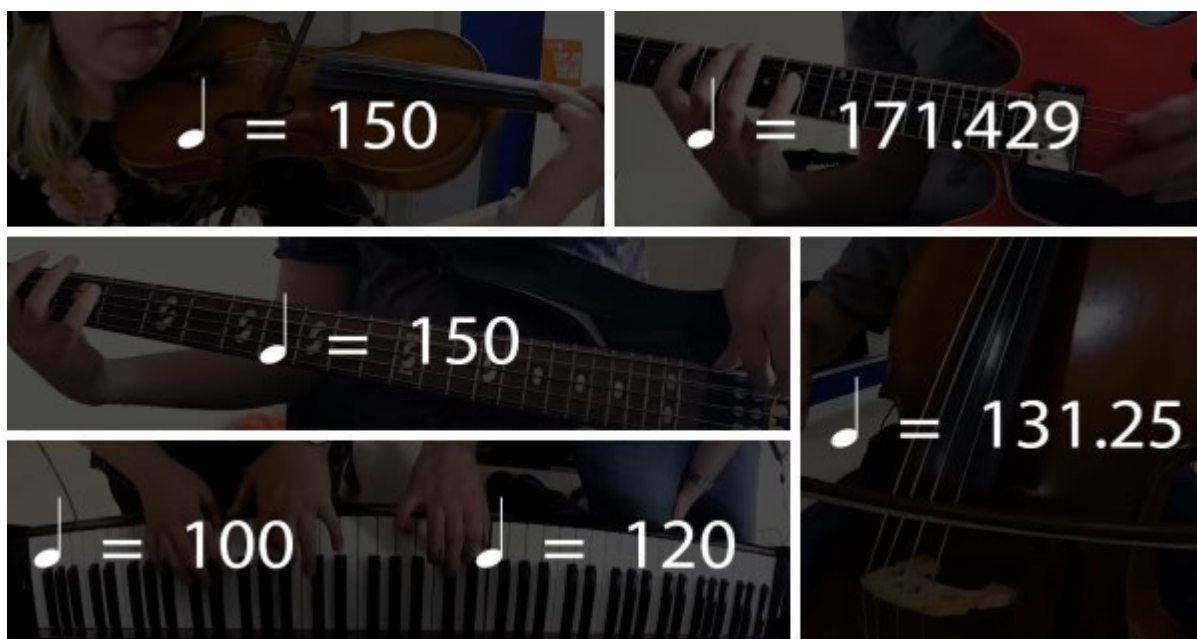


Figure 35: Cycles section A video layout and tempi

The piece features two distinct sections, designed to be contrasting; as such, different tempi are used for each. However, a case could be made whether this would affect the overall rhythmic ‘feel’ (this perhaps being synonymous with groove) as multiple tempi are being utilised. While this may depend on a variety of factors including the written rhythmic durations being performed and overall event density, it may provoke discussion into whether the ‘average tempo’ could be a factor in how a work is rhythmically perceived at a high-level. In the case of section A, the average pulse is $\text{♩} = 137$. This work has not been performed, and was conceived as a multitrack piece.

Section A (0:06, score p. 2, system 1)

The work opens with the guitar and ‘cello performing the core ostinato pattern in unison, this representing the fundamental rhythmic motif of the piece (constant straight quavers). Pianists then enter shortly after, providing the same material harmonised in thirds – these four parts therefore present rhythmic dissonance in their conflicting tempi, however this is balanced with a strongly established single tonal centre of Cm, giving the work an antiteleological approach to harmony. Unlike other works, it could be argued that the varied instrumentation and attention to pitch-range results in arrangement being a core component of pitch-discernibility; instruments generally have a distinct pitch-range and different

timbres aiding listener perception of the layers, as well as being handled spatially within the stereo field. As with other works, the accompanying video also enhances accessibility for the listener, and instrumental performance enhances accessibility of pulse perception via non-verbal communication and listener entrainment. Kinesics and performative gesture is very evident in the video presentation of this piece, specifically with bowing of the violin and ‘cello (later demonstrated as a core component of *[in]dependence*’s presentation), and to a less dramatic extent the hands and fingers executing notes on other instruments.

At 1:04 (score p. 4, system 1) a melody enters on the violin, this is then harmonised by piano 2’s right hand at 1:23 (score p. 5, system 1), seen below in Figure 36 – the rhythmic regularity of this exemplifying previous discussion on Eisentraut’s notions of repetition and accessibility. Due to their mutual compatibility, the piano and violin are able to play the melody in rhythmic unison despite their conflicting tempi; the 3:2 ratio between the tempi allowing for musically accessible rhythmic unison to be achieved by performers without difficulty. This highlights the considerations to be made when composing polytemporally; where specific rhythms must be used to engineer rhythmic unison, these must not be too temporally dissonant, or performance accessibility will diminish; this is contrasted when non-human performers are utilised, as demonstrated in *Translate*.



Figure 36: Mutually compatible tempi yielding rhythmic unison

Following this melodic material the ostinati move to 7/8 time with quaver rests interrupting the phrase (1:42, score p.6, system 1); this inclusion of silence serves to interrupt the flow of the pulses, disrupting beat salience with a subtractive quality and therefore creating tension by reducing pulse clarity.

Following this, the bass guitar enters (2:02, score p. 7, system 2), playing a conventional bassline which does not feature cyclical material. This could be said to imply new harmony (suggesting potential subjective harmonization, a component of *Fractal*); the part contains

additional accidentals implying mode mixture, however this does not affect the existing ostinati – this again draws parallels with discussions on repetition yielding accessibility, demonstrating the effectiveness of offsetting established material (in this case, the underlying tonal centre present in the cyclical figures) with the new material (the bassline, not adhering to specific modality). The straight nature of the bassline strongly asserts its tempo by way of pulse clarity, which is the same as that of the violin – this asserts 150bpm as *the* tempo within the listener, and it could be argued that this assertion is not dissonant due to the fact that the average pulse for the section is suggested to be 137bpm, fairly close to this. This pulse is further compounded by the re-entry of piano 2 (3:19, score p. 11, system 2), again utilising triplets to result in rhythmic unison with the bass and violin's pulse; at this point three performers are playing material in rhythmic unison, while three are playing rhythmically conflicting ostinato, which can serve as a dialectic imbalance. At 3:39 (score p.13, system 1), the ostinati move to 4/4 time, further increasing the amount of rests per bar, and thereby reducing accessibility of pulse perception before the section closes. Due to the lack of hyperbeat or hypermeasure in the work, there is not a clear rhythmic unison to the end of sections; tempi can be made to converge by way of meter and rhythmic material within bars due to the mutual compatibilities of the tempi, though this would disrupt the uniformity of the cycles so I chose to allow this. The scale of the ensemble can also be a factor in this issue, requiring careful selection of tempi to enable rhythmic unison accessibly.

Section B (4:04, score p.14, system 2)

Section B develops in a similar format to section A. This section features new tempi for all performers, shown in Figure 37.

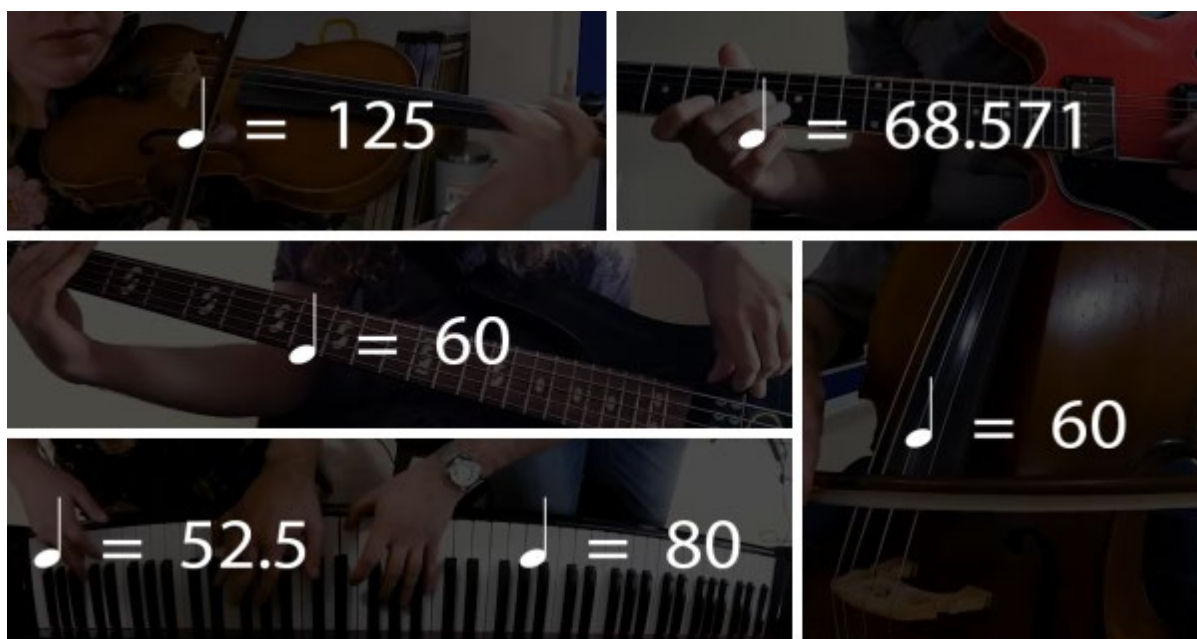


Figure 37: Cycles section B video layout and tempi

The intention for this section was to contrast to the previous; as such all tempi are reduced, the average pulse moving to $\text{♩} = 74$. All parts are centred around a straight $11/8$ rhythm, with static C harmonic minor tonality with increased dynamic material, as the parts build to a crescendo to finish. While the average tempo is around half that of section A, musical material within the parts is largely similar; tempi have in some instances been lowered drastically. As with the close of section A, rhythmic unison is not achieved due to lack of hyperbeat/hypermeasure organisation.

This work was designed to be as accessible as possible while maximising variation by way of harmonic change and arrangement, and these aspects I feel were successful; particularly, this displays (as with early experiments) the effectiveness of selecting tempi that have mutually compatible tempi, in order to produce rhythmic unison across arhythmic tempi – this concept is further developed in *[in]dependence*).

While the notation for individual parts was shown to be very accessible and effective due to the minimalistic nature of the repeating cells (also demonstrating recombinant teleology by way of their large-scale repetition and single tonal centre), consideration should be made for the performative aspect of extended repetition, particularly at high tempi – as previously acknowledged in *Cowbells*, and by association *5:4 Guitar*), sustaining this kind of constant

ostinati can prove difficult to perform in a single take despite the fact the material is relatively simple. As well as the physicality of this, I observed aspects of subjective rhymization when recording the guitar part in section A (quavers at $\downarrow = 171.429$, the fastest periodicity in the portfolio) – this draws parallels to writings on groove and its connection to significant periodicities, referencing Zbikowski's comments on reorganisation of rhythmic material at tempi beyond these significant periodicities.

4.5) Disconnect

This work sought to create a focused composition by way of using only two tempi and is for two pairs of performers; two electric guitars and two drum kits. *Disconnect* moves through various distinct high-level sections and seeks to create stylistic and timbral variation by way of technology and texture, particularly the use of guitar effects pedals, taking a similar approach to *Translate*, however without the use of non-human actors. As well as this, improvisation is present in the work, developing on earlier concepts explored in *Drum Kit* and *LABO*. This work was premiered on 10/05/2017 at St Gregory's Centre for Music in Canterbury.

Disconnect features an extended period of simultaneous improvisation for the two drum kits, during which emphasis is placed on performers to listen and respond to each other; this therefore requires increased non-verbal communication between drummers. As such, additional research should be considered into social entrainment and the interpretation of gesture.

Moore et al. discuss the distinction between non-verbal communication and non-verbal behaviour, noting that 'behaviours' are exclusive to living things (analogic codification). Inanimate objects however can (non-verbally) communicate, as humans are able to interpret this – this mode of communication is demonstrated in my work most notably via laptop by way of audio score. Similarly, humans are always behaving (as living entities) but may not necessarily be communicating; the authors explain, 'we use the word *communication* only when a receiver has *interpreted* a message as having some meaning. For communication to occur, a receiver must be present and must interpret (decode) the transmission of symbols (messages)' (Moore, et al., 2010, p. 7). This provides links to entrainment, particularly in

how rhythmic perception is. In this way, the act of instrumental performance in an ensemble can be considered a behaviour, however further focus may need to be given to the acts of communication occurring within this in my own live performances. The physical performance itself may inherently contain subconscious non-verbal communication, but this can essentially be offset by paying close attention to conscious physical communication. Moore et al. refer to this type of self-communication as ‘intrapersonal’ communication – internal decision-making (Moore, et al., 2010, p. 8). This term draws parallels to that of intra-group communication, potentially providing a lower-level equivalent within a network. This therefore suggests in a co-improvisational setting (such as the drum solo in this work), communication must be considered both in respect to the conscious sending of non-verbal messages as well as the interpreted receipt of these.

Please refer to the Disconnect score and Audio/Visual Example 14

Disconnect seeks to utilise only two tempi to cleanly explore rhythmic ideas (maximising the exploitation of mutually compatible tempi) and place further emphasis on harmonic and textural variation. The tempi selected can be seen in Figure 38, also displaying the layout of the video presentation. The use of drums highlights, as with *Drum Kit*, the impact of gesture on non-verbal communication; the performative aspect of drumming requires arguably the highest degree of dynamism by way of velocity of hits, allowing very obvious interpretation of kinesic gesture.

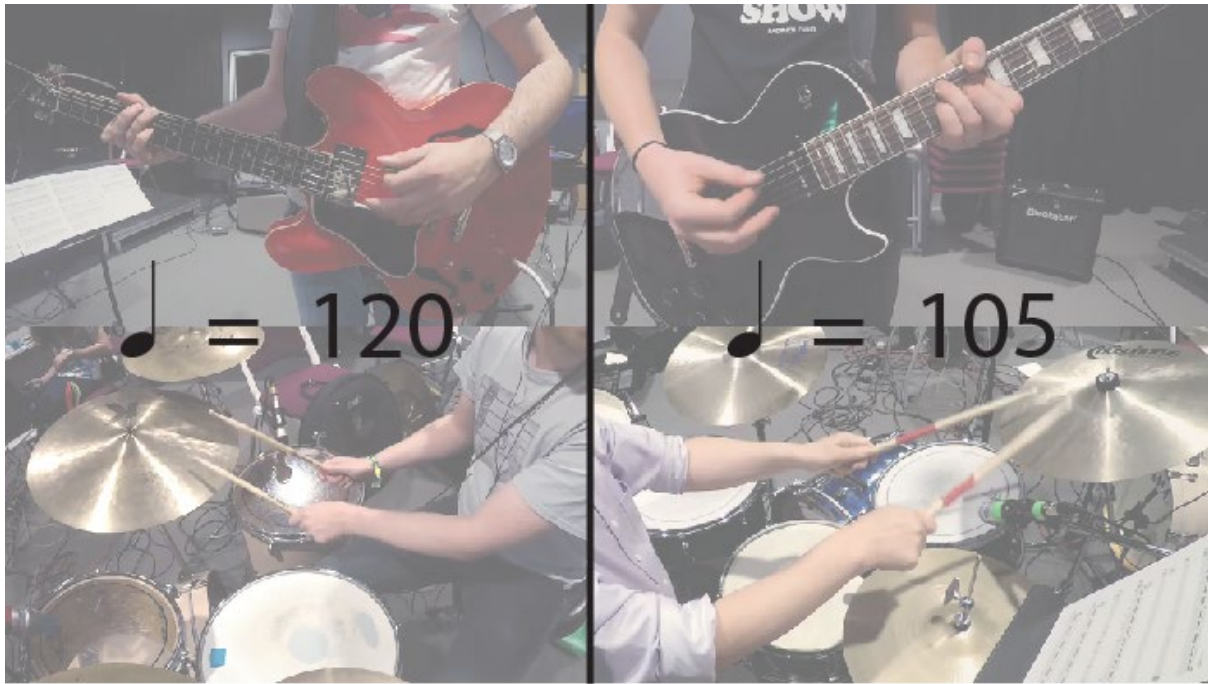


Figure 38: Video layout and tempi of *Disconnect*

The ensemble was chosen as a way of fully exploring, in as pure a way possible, rhythmic, harmonic, and textural content. A variety of musical material is explored throughout its sections. Performers utilise audio scores containing click track and cues via headphones from the DAW on the laptop, suggesting a wheel group model with the laptop as central node. As with other works, accessibility is enhanced by way of providing printed notation which does not require performers to count repetition, instead providing notation of individual phrases via rehearsal marked sub-sections, with audio cues to move to new phrases. The score for this work also includes detailed notation of guitar effects pedal ‘choreography’ by way of coloured notation (score p. 3), a concept previously developed in *5:4 Guitar* and *Fractal*; as can be observed throughout the score, noteheads are coloured in association with a guitar effect. This mode of notation adds a visual component, the cognition of which does not conflict with the traditional means of notation, in effect simplifying this; guitarists would not need an additional staff of notation denoting pedal rhythm, as these coincide with specific notes. A further idea utilised in this piece sees guitarists affecting each other’s tones by way of their physical positioning, as demonstrated in Figure 39.

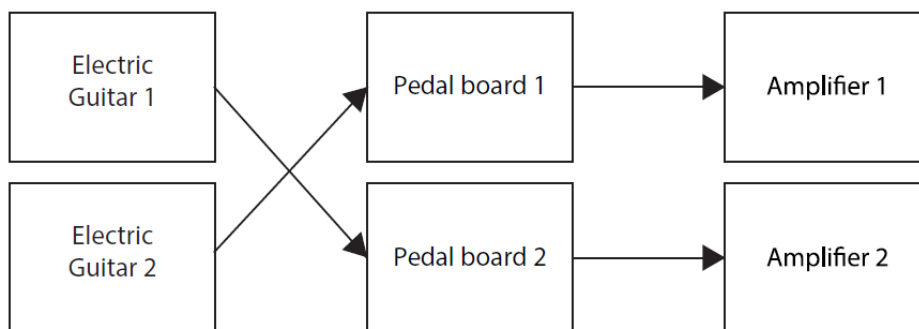


Figure 39: Signal chain of guitars in *Disconnect*

This created an additional layer of rhythmic complexity, introducing an ‘effects rhythm’ executed by guitarists’ feet. In this instance, textural changes in guitar tone would not always match the guitar parts themselves. This mirrors concepts undertaken within *Translate*, pedals also featured as a prominent part of the video presentation to highlight this. The inclusion of pedal usage in the video is designed to rationalise the potential dissonance in perception which may occur as guitar tones change arrhythmically to their performed material, however it could be argued that the fact this material is executed by two human performers may be a factor in why it could be considered more consonant a component, potentially linking to discussion around trust bred by human conductors as opposed to machines.

Section A (0:05, score p. 4, system 1)

The piece begins with drummers performing a crescendo and diminuendo (one bar each) on cymbals for one bar and cycling this in their respective tempi. This produces a wave-like texture in the drum kits’ asynchronous tempi, highlighting temporal dissonance by way of spatialisation – this technique later demonstrated in *[in]dependence*.

At 0:38 (score p. 5, system 1) the guitars enter, playing cyclical arpeggios; in order to achieve harmonic movement across polytemporal guitar lines, the left channel guitar strongly implies descending chords (Am7, Gsus4, D6), whereas the right channel guitar arpeggiates a higher pitch, ascending passage more centred around a Dsus4 voicing. Approaches to moving harmony in a polytemporal setting have been challenging throughout the portfolio; in this instance, the structure is most reminiscent to *Cycles*, wherein static tonality is established via ostinati (similar to guitar 2 here), while the bass implied additional harmonic movement (as guitar 1 does here). During this section, guitarists are using delay pedals with

a very fast delay time to emulate a ‘glitching’ sound, a technique also utilised in *Translate*. This essentially ‘blurs’ the distinction between the tempi as it is engaged and disengaged for the other performer often masking event onsets. Alongside this, the drum kit lines vary the wave pattern to include kick drum, tom and hi hat to punctuate the guitar line and provide pulse clarity, adopting drum patterns highlighting metric hierarchy within the part, as the kick is used to accent the first beat of each bar. At 1:58 (score p. 9, system 2) all performers move to punctuate a Bbmaj7#11 followed by Am7 chord, the piece utilising meter to engineer synchrony based on the tempi’s 8:7 relationship, creating a transition to move the work to Section B. This demonstrates the use of mutually compatible tempi to manipulate the metric structure of the work; the tempi converge on p. 9, system 1, yet additional bars can be added utilising the compatible nature of the tempi to create a second convergence a few seconds later to – this could be considered a small hypermeasure within the work.

Section B (2:06, score p. 10, system 2)

This section develops the concept of the crescendo and diminuendo wave motif, this now being executed by all performers. Guitarists utilise distortion and engage and disengage modulation effects to achieve textural variation (arrhythmically affecting tones), as well as cycling chords of D7sus4, Bb6, and Ebmaj9. Contrasting to the previous section and subsequent exploration into more traditional chord progressions refined in *[in]dependence*, this chord progression is notated identically across both guitar parts, the temporal dissonance resulting these chords cycling at different rates, creating harmonic dissonance as these chords are non-diatonic/modal. It could be suggested in this instance that there can be degrees of harmonic dissonance, informed by the temporal dissonance, as different chords coincide throughout the section. Although chords overlap due to their conflicting cycles, the crescendo/diminuendo in the guitar lines mitigate this harmonic dissonance as these dynamics suppress certain moments of ‘clash’, as well as providing spatial separation (reminiscent of the cymbal lines in section A). Due to this, although different chords occur at the same time this rarely occurs at the same dynamic, presenting a somewhat dialectical harmonic situation. This can be seen most notably in the score on p.10, system 1, where the Ebmaj9 reaches its loudest as the D7sus4 (a semitone away) is at its quietest - this technique could work well to enhance the spatial nature and harmonic accessibility of a work such as *Fractal*, or planned as a device within a large rhythmic cycle or hypermeasure (philosophically similar to Kepler’s writings on macro cycles).

Section C (3:20, score p. 15, system 1)

The third section features more dissonant and aggressive material, guitars switching to high gain tones and utilising fuzz (again affecting the other player) to augment this character. Improvised natural harmonics are executed, punctuated by corresponding drum patterns (now featuring the snare, moving the drum patterns closer to that of a conventional groove, particularly with reference to Moore's standard rock beat), followed by a crescendo on a palm-muted chord before cycling this motif. The drums in this instance, although notated with the same rhythmic material to match their respective guitar, perform the line on different parts of the kit (kit 1 focused on the crash and low tom, kit 2 on the hi-hat and high tom); this functions as an arranging decision designed both to enhance aural differentiation of the different kits, but also to challenge conventions and representation by essentially creating a single, composite drum kit sound from two kits. This therefore creates a disconnect between the 'idea' of a drum kit, and this work's representation of one, and discussion can be raised as to how this can be perceived from an entrainment perspective by a listener, should the video be removed; using the video, listeners are able to interpret the performative gestures displayed by the drummers by way of non-verbal communication and kinesic gesture. If listeners are unaware that two drum kits are being performed simultaneously, this could raise the question as to whether this provokes a dissonance in perception.

Harmonically, both guitarists cycle chords of F5, Ebmaj7, G, and Abadd9 asynchronously as with the previous section, however resulting in increased harmonic dissonance due both to the non-diatonic progression, and unmitigated by dynamic material featured in section B. Wah pedals are also utilised, marking the first use of a non-binary effect; this is first seen at 4:06 (score p. 17, system 2). This approach to wah was also utilised in *Translate*, the nature of the effect to increase the perceived harmonic dissonance of the piece by injecting additional modulating frequency content by way of its sweeping function. The left channel guitar engages and sweeps the wah pedal while playing an octave in straight semiquavers, however this is affecting the right channel guitar's tone who, due to being at a slower tempo, has not yet reached this material. At 5:33 (score p. 22, system 2) all musicians reach the same material, aligning the ensemble to the same musical material comprising of crescendo-diminuendo cymbal work and wah sweeping against semiquavers – this provides the most pulse clarity seen in the work, with both tempi performing consistent rhythms.

Section D (6:10, score p. 25, system 1)

The guitars then move to 5/8 semiquaver tapping; this contrasts to previous sections with a sudden move to very high periodicity and event density, presenting the listener with an overwhelming amount of staccato rhythmic information. This also provides additional kinesic information due to the increased physicality of the tapping technique (previously observed in the video presentation of *5:4 Guitar*). As with sections B and C, due to the guitar parts cycling at different rates with a tonality containing both D minor and D major, harmonic dissonance here occurs when guitars simultaneously execute F and F# notes. It could be considered however, that due to the speed of this cyclic progression and therefore its rate of repetition, this may become less dissonant due to its establishment by way of repetition (as previously discussed in relation to *Cycles*). Similarly with material in section A, and observed when the bass enters into *Cycles* and later discussed in *[in]dependence*, the chord movement executed in the lower register by guitar 2 becomes the overriding perception of harmonic rhythm.

Against this, drum kits emphasise the 5/8 pattern on cymbals, gradually introducing more complex and polyrhythmic. This is also punctuated by guitarists' engaging and disengaging of fuzz pedals, matching drum hits and introducing elements of pulse-based rhythmic noise to interrupt each other's parts.

Section E (7:30, score p. 29, system 2)

This material builds to a climax at 7:30, where guitars move to half-time cycling of this harmonic motif, while both drummers are given the opportunity to improvise simultaneous solos. This invites a different form of listening not explored in the portfolio to this point, as the drummers have the opportunity to freely play against each other with the click track. This section reflects on improvisational within a polytemporal setting, previously discussed in relation to *LABO*, as well as highlighting issues of non-verbal communication discussed and demonstrated in *Maggini*. These concerns are exemplified in the improvisation in the recording, as performers listen and respond to each other as a dialogue; notably, this can initially be seen at 7:37 where drummers execute a snare hit before moving to similar light cymbal work. At 7:54, a similar call and response can be observed with snare and tom material, and again at 8:01 where kit 1 (the left screen) performs a snare and crash phrase which is then reflected by kit 2. From 8:10, both drummers begin to increase their event density and dynamic, and from 8:37 begin to build dynamically to form a crescendo as the

solo reaches its conclusion. During this period of improvisation, the structure of the group changes when viewed through the lens of network theory this could be considered to divide into two, with the guitars and laptop forming one network (again this can be considered the wheel model). The drum kits then exist outside of the group, without click tracks, able to enter into a dialogue together; this draws comparisons to discussion on intra-group reciprocation of movement, as well as asserting individuation when considered as a state within the Repeating Cycles model. During this crescendo (from 8:30, score p. 33, system 1), the guitarists are instructed to physically switch places, essentially amending their signal flow (thereby altering the state of the network) as seen in Figure 40.

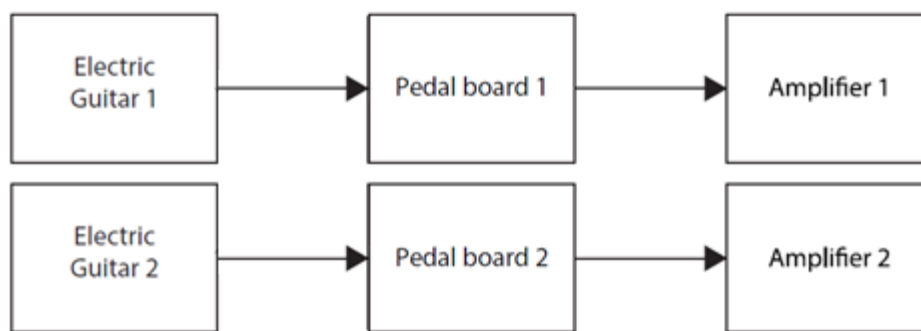


Figure 40: Restored guitar signal chain in *Disconnect*

This therefore restores rhythmic consonance to the ‘effects rhythm’ of the guitarists, as they are now affecting their own tones when using pedals – this serves to alleviate dissonance in perception, as textural changes are now synchronised with guitarists’ musical material.

Section F (8:50, score p. 34, system 2)

The piece returns to Section B, however with guitarists now switched places the textural changes generated by the effects pedals now correspond to each guitarist’s tempo, before the work then moves through a variation of section A to close.

This work is successful in achieving a more complex, varied structure in an ensemble situation, as well as maximising textural variation previously explored by *Translate* in a completely human ensemble. Approaches to harmony were further explored, including the implications and dialectical issues of simultaneously moving harmonic progressions and methods of mitigating harmonic dissonance, though this is further developed in *[in]dependence*. Additionally, the work also integrates improvisation within a broadly

composed structure, developing ideas previously explored in *LabO*. Notation was also developed building on colour-based techniques found in *5:4 Guitar* and *Fractal*, which further enhanced performance accessibility. In addition, *Disconnect* displays the compositional potentials of manipulation of the network; while the work (as with others in the portfolio) adopts a wheel model demonstrating performers as outer nodes with the laptop as ensemble leader, this work features instances where the make-up of the network is altered, displayed when the drum kits are removed from the network in order to improvise, and when the guitars switch positions in order to essentially re-route their signal chains.

4.6 [in]dependence

This final work expands the live performance composition techniques employed across the portfolio, presenting a 14-minute piece for string quartet and electric guitar. Each performer has an independent tempo, and the piece explores a variety of musical elements through several sections and methods. This work further develops concepts of harmony and arrangement particularly in the context of hypermeasures, as well as incorporating improvisation. As with other pieces *[in]dependence* has accompanying video to aid accessibility and promote expanded rhythmic cognition.

Please refer to the [in]dependence score and Audio/Visual Example 15

This work was premiered at Free Range in Garage Coffee on 07/12/18, and during this performance players were positioned at different parts of the venue which served to expand listeners' perception of multiple tempi by way of spatialisation. The tempi utilised are displayed in Figure 41.

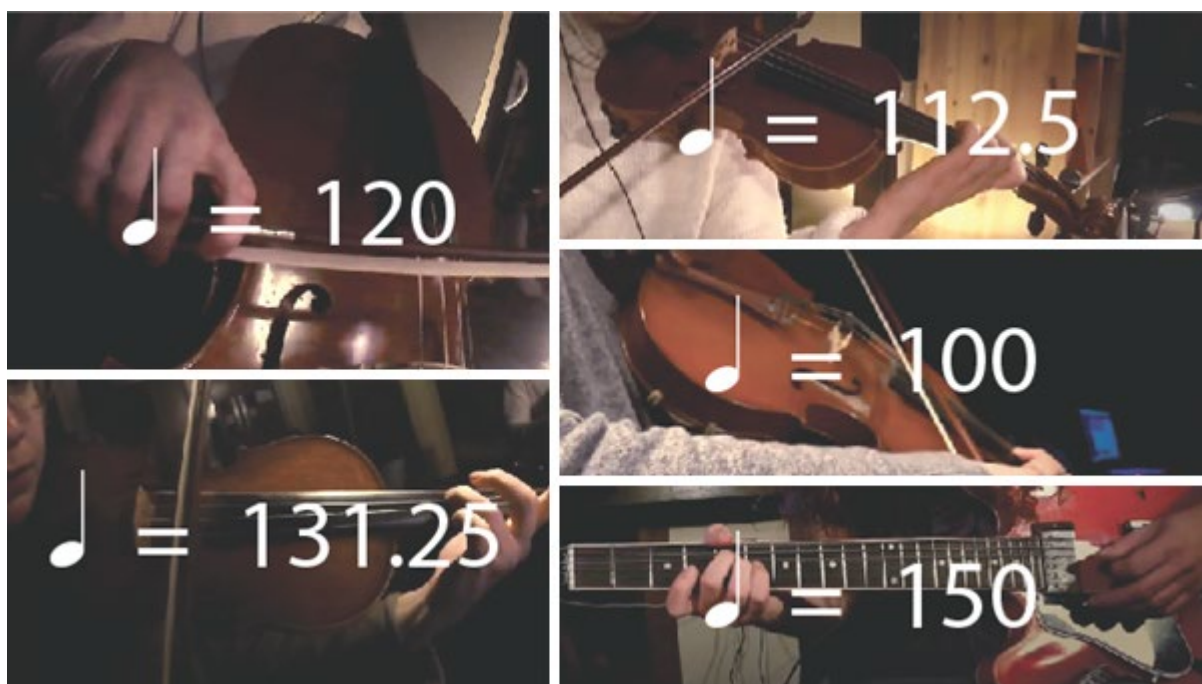


Figure 41: Video layout of *[in]dependence*, displaying tempi

As with previous works, the addition of video enhances accessibility by providing the listener with visual communicative information which can enhance expanded rhythmic cognition by way of perceptual entrainment. In the case of *[in]dependence*, gestural material is particularly emphasised by the bowing of the string quartet (an observation also made in respect to *Maggini*, as a previous string quartet work) – this exaggerated gesture assists with differentiating temporal layers, the asynchronous bowing also draws parallels to discussions made on the visual impact of guitar fingering demonstrated in the video presentation of *5:4 Guitar*, as well as particular physicalities of *Drum Kit* and *Disconnect*.

As with other works, this piece can draw parallels to network theory as the ensemble are organised in accordance to the wheel model, each performer appearing as a node of the network and connected to the central node, in this case the laptop as ensemble leader (in the case of the premiere performance, concepts of central and outer nodes were also represented literally by way of physical space). Performers are again provided with printed notation and audio scores containing click tracks and spoken cues to maximise performance accessibility.

Section A (0:10, score p. 2, system 1)

The piece begins with a motif featuring a bowed crescendo note followed by diminuendo pizzicato pulses. This is unison pitch across the ensemble so as to immediately emphasise

the conflicting pulses, and notated parts are identical however due to the polytemporal nature these become asynchronous. This approach is similar to the dynamic material found in section A of *Disconnect*, however utilising the strings' ability to produce long, sustained tones as well as pulse-based pizzicato material. As the section progresses further notes are added, until at 1:21 a chord progression (Gm, Ab, Bb) is implied across the ensemble (score p. 4, system 2) to form a transition to new material.

Following this, performers move exclusively to pizzicato at 1:41 (score p. 5, system 2), performing cycles of single-bar ostinati, this material similar to other cell-based cyclical material in the portfolio (though most notably *Cycles*), also demonstrating recombinant teleology within the work by way of its multiple repeating cells across the ensemble during the wider hypermeasure. The nature of the tempi's mutual compatibility enables moments of rhythmic unison to be achieved by way of meter; in the case of these cycles, 13 bars of 9/8 + 1 bar of 4/4 at 131.25bpm (violin 1) = 15 bars of 7/8 + 1 bar of 9/8 at 112.5 (violin 2) = 11 bars of 9/8 + 1 bar of 5/8 at 100bpm (viola) = 24 bars of 5/8 at 120bpm ('cello), which can be used to create temporal convergence, as well as later be used to construct hypermeasures.

Section B (2:59, score p. 9, system 1)

This section moves to the quartet performing waves of crescendo and diminuendo (for one bar each respectively) of quaver double stops over the guitar's repeated arpeggio – this most closely resembles sections A and B of *Disconnect*. Although the cyclical nature of the conflicting tempi restricts unison harmonic movement across the group, the 'cello's notes of C and G to E and B strongly imply C major to E minor chord movement, most likely due to the bass range at which they are performed; this observation was also made with respect to implied harmony in *Cycles* (section 4.3, p. 129). Within these repeated cycles, a new, more dissonant chord is superimposed over the quintet; this is placed in such a position to enable all players to move to and from this chord in rhythmic unison, while avoiding complex rhythms in each part. An example of this can be heard throughout the section, with the clearest instance on the score at 3:18 (score p. 13, system 1, and in Figure 42, highlighted to show the unison harmonic movement). This displays one of the main benefits of calculation-based tempo selection; while performers execute their parts in straight quavers, the temporal relationships of these allow for accessible unison movement to new and from new harmony.

Figure 42: Use of temporal compatibilities to create unison harmonic movement

Section C (4:37, score p.13, system 2)

The next section moves to faster, pulse-based material. All instruments play straight quavers in order to establish pulse-clarity while a rhythmic motif is present (displayed in Figure 43). Though at different tempi, temporal relationships again allow for this rhythmic figure to be executed in rhythmic unison across the guitar, viola, and ‘cello, while maintaining human performance accessibility (contrasting to how this technique is utilised in *Translate*).

Figure 43: Using mutually compatible tempi to create rhythmic unison

Similarly to section B, there is an underlying chord progression of C and Bb which is superimposed across multiple parts, which can be seen on score p. 14, system 1. This section demonstrates clear approaches to hypermeasure, as can be seen on the score; p. 13, system 2 shows the beginning of a hypermeasure (all performers executing their first beat in rhythmic unison), and a new hypermeasure begins on p. 14, system 2.

The melodic line from Section B re-enters at 4:59 (score p. 14, system 2), performed by both violins, yet via staccato attacks. The compositional intention with this was not to have the pitches move in rhythmic unison, but instead to have these move ‘approximately’ together; this makes for a somewhat unsettling, ‘blurred’ rhythmic quality, which could be likened to micro-timings which occur naturally in human performance as discussed in reference to groove, or even reflect back to my earliest investigations involving delay. Rhythmic material is then fragmented at 6:35 (score p.19, system 2) where performers take on sparser and more erratic staccato material and ostinati, utilising a similar subtractive technique previously heard in *Cycles*, before this finally reduces to the same material, however fingered as natural harmonics. This was an experimental technique inspired by a math rock band Don Caballero, who employ a similar approach at 2:25 of their track *Stupid Puma* (Don Caballero, 1995); this results in a more percussive output with less defined (and due to the harmonics, sometimes altogether different) pitch material.

Section D (8:37, score p. 25, system 1)

The guitar introduces this section at 8:11, beginning a new motif that clearly outlines a chord progression from Dm (1 bar of 7/8), Eb (1 bar of 5/8) and C (1 bar of 4/4) in its own tempo which leads into section D, forming a large-scale hypermeasure. This comprises of the chords repeated a total of 6 times (with an A7 chord replacing the C on the final repetition as a V7-i cadence) before starting over, with all performers in unison. This hypermeasure allows all tempi to lock together at the start of a new cycle, and within this ostinati are performed by the quartet. The 'cello performs straight crotchet material which outlines the chord progression, however against the guitar this does not completely match the harmonic rhythm of the chords at low-level; the slower tempo of the 'cello results in it not completely 'keeping up' with the changes asserted by the guitar (however mitigated due to the guitar's changing meters), however during the large-scale hypermeasure it maintains a close enough rhythmic distance to give the illusion of synchronised harmonic rhythm. Against this, other instruments provide repeated ostinati which (as with *Cycles* and *Disconnect*) comprise of notes which are homogenous enough to avoid conflict with moving harmony. This then presents a multi-layered rhythmic strata or hierarchy, wherein a large-scale hypermeasure can be divided into instrumental component parts which interact to collectively move through a harmonic progression. This exemplifies several techniques explored across this portfolio; at high-level, all tempi are able to synchronise with the first beat of each large-scale hypermeasure. Within this, the guitar governs a cyclical chord progression, against which the 'cello is able to provide what could function as a 'bassline'; although this does follow the chord progression, as previously stated this is somewhat of an approximation as a temporal 'drift' occurs within the part, reconciled by the restart of the hypermeasure. At the lowest level then, the remaining violins and viola perform repeating ostinati which transcend these chords, providing a homogenous harmonic texture which does not conflict with the changes.

During this section, the guitar, violin 1 and 'cello undertake improvised solos in sequence. This occurs in a similar format to *Disconnect*, where the click track is removed and performers have the opportunity to play melodic material while responding to the texture as a whole, also serving to alter the structure of the ensemble from a network perspective. Considering the ensemble in this respect, as with *Disconnect* the solos serve to release the improvising performer from the group, giving them opportunity to interact however they choose with the underlying material, allowing performers to assert individuation before

returning to the network. Reflecting on the recording, distinct approaches are made by each performer; the guitar solo focuses largely on a Dm tonality, outlining the A7 chord when this appears at the end of each hypermeasure, the violin solo again stays within a Dm tonality, with less emphasis on the A7 chord, and the ‘cello moves between outlining all chords in free time to focusing on a D phrygian tonality – this therefore demonstrates individuation in practice; performers are able to adopt their own approach when executing the work, preventing them from maintaining a process which could be considered as procedural as that of the laptop. Following these solos the ensemble moves to a crescendo of this chord progression, before modulating to new chords (Bb, Gm and A) at 11:15 – these chords arranged using the same compositional approach as the previously discussed progression, using new harmony to create a climax. The piece then closes with a variation of Section B.

[in]dependence displays development and refinement of techniques across the portfolio, including approaches to structure on multiple hierarchical levels, texture, and rhythmic and harmonic synchrony. Particularly, the approaches to handling traditional chord progressions in a polytemporal setting are developed to a fully formed technique by way of hypermeasure (demonstrated during section D). Similarly to ensemble works such as *Cycles* and *Disconnect*, performance accessibility is managed effectively by utilising audio scores to ensure printed notation is as minimal as possible. Improvisation is also featured more prominently, being refined since its initial attempt in *LabO* by way of this occurring within clearly defined frameworks, allowing for the piece to have additional variation during performances.

This piece therefore represents the culmination of the wide variety of techniques developed across this research; the calculation-based temporal systems developed early in the portfolio forming a fundamental basis for this and all other works, upon which an increasingly refined approach to temporal consonance and dissonance can be observed. Against this, familiar harmonic language can be applied with careful consideration to arrangement, as well as opportunities for improvisation.

Conclusion

Throughout this research, a wide variety of new techniques have been developed and employed to expand the field of polytemporal composition and performance. The works within the portfolio display multiple approaches to polytemporal composition and expanded rhythmic cognition, informed by fundamental concepts of meter, pulse, and hierarchical rhythmic organisation; the deep understanding gained of these principles, and how they can be manipulated to generate rhythmic consonance and dissonance, has led to a series of practical techniques that were utilised to develop new completed works. By using calculations to select mutually compatible tempi, concepts of temporal consonance and dissonance can be fully exploited by composing using multitracks a DAW – this takes concepts initially pioneered by Nancarrow and develops these using new technology, presenting a more efficient, flexible, and dynamic workflow. In this way, instrumental parts can be easily engineered to balance rhythmic synchrony and asynchrony, and as such this can extend to multiple levels including structural or harmonic progressions across any given duration.

The impact of polytemporality in a live performance setting requires alternative approaches to ensemble, and as such the concept of ensemble has been examined to discover its implications; this was investigated particularly with reference to issues faced concerning non-verbal communication (and by association improvisation) and control structures where performers are communicatively restricted. While potential issues do impact the nature and indeed definition of ensemble, many benefits have been identified, particularly from a performance accessibility perspective. Instrumental parts exist independently from each other, and as such can be disconnected from other performers with regard to meter and differing repeated cycles. Audio scores also proved a fundamental augmentation to the printed score, yielding increased accessibility by way of opening up many options for click tracks, cues, and backing tracks, not ordinarily possible in a band or conductor-led performance situation (but familiar to studio musicians). As a result, this material has developed its own unique language for performance, which can be taught to musicians – at the time of writing, the Leon String Quartet were rehearsing for a second live performance of *[in]dependence* at 2019's Canterbury Festival.

Additionally, accessibility was also observed to be open to enhancement for the listener by way of video presentation; in the same way that non-verbal communication can aid performance, this can be equally impactful for the audience. As such, providing the audience with visual stimuli enables increased expanded rhythmic cognition. A new form of traditional western notation was also developed, handling the issues presented by notational conventions to produce a temporally accurate visual representation of the work which, while impractical as a means of performance, further enables listeners to understand the temporal complexities of the works.

The compositions produced as a result of this research display certain unique characteristics and have been very well-received where performed. Musicians have found the material to be interesting both as a listening experience and to perform (reflecting back to previous comments on performance language), and it is hoped that this research will yield future developments for this highly distinctive mode of composition. Going forward, I would look to methods of structural variation within compositions in order for works to be less bound to the exact repetitions stipulated by the click tracks, as well as increasing ensemble size (an orchestral polytemporal work I feel would be highly impactful). This research also highlights tension between audio and notation, particularly surrounding available technology both in terms of audio sequencing and production of printed notation. This has been demonstrated to result in highly manual processes; a future point of research therefore would be to look to the development of software which could incorporate my calculation-based systems and design methodologies to facilitate composition, playback, and notation of polytemporal concepts.

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