At Home In Alterity:
Systems And Hybridity In Microtonal Tonality

Joe Bates

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Abstract

This PhD explores how I use microtonal tonality to make strange chords sound like home and familiar chords sound strange again. It consists of a commentary that accompanies a portfolio of twelve musical compositions. In these compositions, I use alterity to facilitate music that resists the 'attention economy' (Odell, 2019). My desire to escape the semiotic saturation of digital discourse prompted a search for music that is abstract, ambiguous, discursive, and live. This commentary traces the course of that search, from Neoplatonic systematic thinking to a hybrid practice of intonation.

The systematic approach to quartertone tonality found in the earliest compositions in this portfolio uses intervallic cycles to create interrelated scales, an approach that echoes that of microtonal composers of the 1920s, especially Ivan Wyschnegradsky. Chapter I lays out this system, considers the nature of xenharmonic tonality, and shows how the process of composition made me reconsider my understanding of this tonality as complete and autonomous.

Consequently, in later works I increasingly explored diatonic harmony and Just Intonation. Chapter II examines how I used these resources to recontextualise familiar harmony, using relational Just Intonation tonality and combination tone harmony.

Chapter III focuses on the epistemic changes that precipitated my adoption of a hybrid intonational practice. Drawing on Mira Benjamin (2019), I consider how my use of digital instruments in the composition process resulted in a tendency toward abstract systematisation. I discuss how building a new synthesiser, the Hyasynth, helped me develop an embodied approach to intonation. This transformation in my practice becomes the focus on the commentary, which argues that systematic thinking is a valuable but ultimately limited way to approach microtonal composition.

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Acknowledgements

This PhD began in a difficult moment. I applied shortly after a terrible car accident, I was accepted during the first COVID lockdown, I began during the second lockdown. Throughout this all, my partner Jesse has been an incredible source of support and love. This PhD would not have been possible without her. I look forward to bothering her with microtones throughout a long life together. I am also very grateful for my family's support: my parents, my sisters, and my niece and nephew. I owe many thanks to Fiona and Karen, for hosting me in York on so many occasions, and to their cats, for gradually learning not to fear my clumping boots.

My supervisor, Martin, has my gratitude both for his support and encouragement, and for his honesty and pragmatism. This project has changed enormously over its course, in part thanks to his deep well of knowledge, and his annoying habits of giving apposite answers and asking pertinent questions. Towards the end of this doctorate, I have been privileged to be Mira Benjamin's workshop sidekick; I thank her for her stimulating writing and sound advice. Similarly, Khyam Allami's mentorship on the LSO Soundhub scheme proved both practically fascinating and intellectually eye opening.

Finally, any PhD in composition is a collaborative effort, and I have been blessed with a host of kind, fun, and talented collaborators. Especial thanks are due to: Sam Cave, for his unerring ear for the best voicing of a chord; to Angela Wai Nok Hui, for the absurd enthusiasm she brought to an extremely physical and challenging part; to Sam Whitby and his cello for being a superb sounding boards, and, in Sam's case, for occasionally losing to me at chess; to Alex Mackay, for his wonderful recordings and picket line company; and to Caroline Delume, for going above and beyond in helping me fix her theorbo part.

Caroline's Ensemble Linea colleagues who performed my piece – Keiko Murakami, Deepa Goonetilleke, Johannes Burghoff – contributed, along with the rest of the musicians and composers at CIEL 2023, to the high point of my degree: a week of superb company, food, and music making. I greatly value the interest Ernst Spyckerelle and Jenna Vergeynst took in my work and their generosity in returning to it in the months after the course.

terra invisus have been superb collaborators, taking on the most challenging piece in this portfolio with openness and enthusiasm. I am proud to be on their debut disc. The performers from the LSO Soundhub Showcase – Darren Bloom, Pasha Mansurov, Heather Roche, Angela Wai Nok Hui, and Colin Alexander – showed remarkable flexibility and astonishing skill in adapting to a particularly eccentric and thorny piece.

The Riot Ensemble and the National Youth Choir of Great Britain both supported my composition throughout lockdown, preserving my sanity and developing works important to this portfolio. Marianne Schofield, Oliver Wass, and Séverine Ballon contributed greatly to this project, recording pieces that predate this portfolio. I thank my workshop partners, the Ligeti Quartet (twice!), Quatuor Diotima, and Jeanne-Marie Conquer, for the huge amount I learnt from them.

Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references.

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Introduction

‘Resisting the Attention Economy’

I came of age alongside social media. Throughout my adult life, it has engulfed me, mediating my relationships and shaping my understanding of the world. Social media companies have commercial imperatives at odds with my values: they aim to capture our attention with an onslaught of information chosen for its capacity to provoke an emotional response. This barrage of emotive content typically takes the form of brief posts that are dense with meaning. Social media is thick with disparate affecting messages, forming a symbolic web of memes, images, tropes, and in-jokes. The result is semiotic saturation: a state in which every image or statement is part of a network of familiar meaning. The complexity of this network is entertaining, engaging, and deliberately distracting. In our distraction, we donate our attention to social media companies and isolate ourselves from unmediated connections.

Artist Jenny Odell responds to this in *How To Do Nothing: Resisting the Attention Economy*.[1] In proposing that we learn to do nothing, she does not suggest a withdrawal from the world but an act of ‘commitment, discipline, and will,’ a ‘refusal,’ that can disrupt the systems that trammel our collective attention.[2] For Odell, this means learning to refocus our attention on the ecological and social fabric of the physical world around us. For me, refusal means turning towards music.

Music against the internet

Amid the simulated hubbub of digital space, music cuts through. While music is exploited as part of the discourse of social media, music’s most particular aspects resist the attention economy.

Music is a time-based medium; music’s form is a constituent aspect of its meaning.[3] The distracting power of social media relies, in part, on the atomisation of time into units of consumption. Few commit to reading for an hour a day; many spend that long on shorter content. In contrast to social media, music turns your awareness towards time, animating its passing through structure and syntax. It rewards focused and extended attention rather than the scattered consumption of information. Music is hard to abbreviate without losing meaning and is difficult to integrate into short posts.[4]

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[1] Jenny Odell, *How to Do Nothing: Resisting the Attention Economy* (Brooklyn, NY: Melville House, 2019).
[2] Odell, xvii.
[3] Julian Johnson, *Who Needs Classical Music? Cultural Choice and Musical Value* (Oxford; New York: Oxford University Press, 2002), 39.
[4] TikTok provides an interesting counterexample. The symbiotic relationship between the app and the music industry has shaped popular song writing; composers now often ensure that songs have passages suitable for excerpting on TikTok.

The abstraction of music, particularly instrumental music, also makes it hard to integrate into social media. The truncated bursts of content that make up social media news feeds tend to be images and text, which convey information quickly. They are semantically dense; this contributes to the semiotic saturation of social media. By contrast, abstract music is semantically sparse. Kofi Agawu discusses the construction of meaning in music in terms of semiosis, the creation of signs. Building on work by Roman Jakobson, he distinguishes between two forms of musical semiosis, 'extraversive' and 'introversive.'[5] In extraversive semiosis, musical meaning is created through references to the symbols of a broader musical culture, while in introversive semiosis, meaning is created through the relationships of the elements within a piece of music. These aspects lie on a spectrum, Agawu argues, with meaning generated through the play between them.[6] Due to its abstraction, this semiotic play is less able to contribute to the web of symbols that ensnares our attention. Without concrete referents that can be quickly articulated, music resists being placed in the digital discourse.

Finally, music is a live art form, even in an age of recording and electronic music. The social conventions of live music spaces protect them from attention economy. The use of phones is often either discouraged or rendered impractical by dancing. Concerts provide space for relatively unmediated and undistracted connection. By contrast, much social media is consumed silently on a screen. To facilitate this form of silent, atomised consumption, music must always be at most an ancillary aspect of social media.

Not all music possesses these qualities in equal measure. Julian Johnson discusses the distinctiveness of what he calls music-as-art.[7, 8] Johnson asserts that music-as-art has a 'discursive' form, in which 'formal consistency is part of the music's meaning.'[9] Not all music operates in this way, nor, I would argue, does all music-as-art.[10] Music which is not much altered by the omission of sections, or the addition of a fadeout, evinces a flexibility of temporal form that suggests a non-discursive approach to structure. Similarly, music can prioritise its abstract aspects to greater or lesser extents. Most obviously, music can involve words that lend it semantic meaning. More subtly, music might emphasise its referential aspects, its extroversive semiosis, using quotations or tropes that place it in an intertextual network. The extent of this musical extroversion can be placed on a spectrum, with examples of very extroversive music including sample-based albums like The Avalanches's *Since I Left You* or polystylistic music like the work of Alfred Schnittke.

I am not asserting a hierarchy of value between these approaches. Non-discursive, text-based, and referential music are artistically valuable. But I want to amplify those aspects of

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[5] V. Kofi Agawu, *Playing with Signs: A Semiotic Interpretation of Classic Music* (Princeton: Princeton University Press, 2014), 23.
[6] Agawu, 24.
[7] Johnson, *Who Needs Classical Music?*
[8] Johnson uses the term 'music-as-art' synonymously with 'classical music,' a problematic elision that is unnecessary in my discussion.
[9] Johnson, *Who Needs Classical Music?*, 39.
[10] This is one of several points where I disagree with Johnson's evaluative claims.

my music that most resist the attention economy, that oppose its emotive semiotic saturation. This research project stems from that imperative, from a desire to create discursive live music suffused with abstract meaning. In the pursuit of these qualities, I have turned towards a microtonal tonality.[11]

Microtonal Tonality

Contemporary tonality

I am attracted to tonality both for its sensual, consonant qualities and as a structuring principle that can enable discursive syntax. But the musical objects of common practice tonality are freighted with semiotic associations that I find challenging to navigate. In 1949, Theodore Adorno complained that:

> 'Even the duller ear perceives the shabbiness and tiredness of the diminished seventh chord or of certain chromatic passing notes in the salon music of the nineteenth century. For the technically experienced ear, vague discontent of this kind is transformed into a canon of prohibitions. If all is not deception, this canon now disbars the means of tonality, which is to say, the whole of traditional music. Not only are these sounds obsolete and unfashionable. They are false. They can no longer fulfil their function.'[12]

Adorno argues that the use of these tonal objects is almost predetermined due to the weight of history and, as such, they strive against the technique of the modern composer who would use them.[13] Despite working in a cultural and historical moment very different to Adorno's, I recognise this problem. I worked with tonal material for years and found that it had an almost overwhelming impetus. I felt steered towards a conventional tonal syntax and hemmed in by strong semiotic associations. When I unmoored tonal resources from their associated syntax, they quickly became hackneyed or, as Adorno has it, shabby.

While concerns of this kind have led composers towards various forms of atonality, many composers still craft moving new work out of this well-worn material. Thomas Johnson's suggestion that tonality might act as topic[14] transforms Adorno's concept of falseness into a positive identification of the semiotic potential of tonal objects, which he argues have become 'marked' in Twentieth Century classical music.[15] For Johnson, it is precisely the

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[11] Throughout this thesis, I use the term 'microtonal' to refer broadly to music that is not 12EDO. While I dislike centring 12EDO in this way, the Western 12EDO norm is the inescapable context within which my music functions.
[12] Theodor Wiesengrund Adorno and Robert Hullot-Kentor, *Philosophy of New Music* (Minneapolis London: University of Minnesota press, 2006), 32.
[13] Adorno and Hullot-Kentor, 33.
[14] 'Topics' are the musical signs studied in topic theory, which is a semiotic approach to music analysis.
[15] Thomas Johnson, 'Tonality as Topic: Opening A World of Analysis for Early Twentieth-Century Modernist Music', *Music Theory Online* 23, no. 4 (December 2017), https://doi.org/10.30535/mto.23.4.7.

ability of tonal *figurae*[16] to be 'false' – to be used in a way that defies their associated function – that confirms their character as signs. My music has been influenced by composers like Thomas Adès and Cassandra Miller, who shape tonal *figurae* into signs with a dense network of signifiers.[17]

Microtonality as topic

This approach to tonality – tonality as topic – is paralleled in recent microtonal work. Contemporary composers such as Oliver Leith, Mica Levi, and Dan Trueman have used microtonality as part of a topical language that operates in relation to familiar tonalities, both pop and common practice. Robin Haigh describes his use of this language as part of an aesthetic of 'millennial nostalgia… that is essentially concerned with injecting otherwise familiar or unassuming things with uncanny or strange properties.'[18] In Haigh's music and, he argues, the music of many of his peers, microtones enact 'strange transformations' on tonal language, giving the impression of uncanniness.[19] In semiotic terms, the markedness of microtonal pitch is used to highlight tonal *figurae*. This both lends these *figurae* a markedness of their own, placing them in microtonal quotation marks, and produces distinct topics related to distortion: the aesthetic of warped tape, JPEG compression, and detuned oscillators. Through this process, the falseness of tonal resources that Adorno identifies is amplified in the service of a particular aesthetic, one informed by the deformations of electronic reproduction.

It was in the context of this appealing sound world that I took my first steps into microtonality. My interest was sparked by an imagined melody that overspilled familiar tunings. I transcribed it within the only microtonal framework I understood, quartertones, leading me to a more thoroughgoing interest in quartertone harmony. In my initial experiments with microtonality, I used quartertones to distort familiar tonal resources, typically altering diatonic chords by a single quartertone. I saw these chords as sitting between two possible interpretations. ◂ Figure 0-1 shows the opening of *A Noise So Loud* (2018), whose initial chord could be a distortion of either a B♭7 or a Gm, depending on whether one views the G♯ as 'resolving' up to the A♭ or down to the G𝄮. In the reduction in Figure 0-2, I show how this ambiguity is retrospectively resolved by the pseudo-resolution of the distorted B♭7 to a distorted E♭Maj7. For me, this technique promised agency over the tonal resources I was distorting, freedom to navigate chains of alternative resolutions. I felt that these resolutions lacked the strong semiotic associations of conventional tonal harmony,

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[16] Johnson describes *figurae* as components of a topic, musical figurations like an arpeggio or a syncopated rhythmic pattern. In combination, these can become 'marked' from their surroundings, taking topical significance.
[17] Edward Venn, 'Thomas Adès's "Freaky, Funky Rave"', *Music Analysis* 33, no. 1 (March 2014): 65–98, https://doi.org/10.1111/musa.12020; James Weeks, 'Along The Grain: The Music Of Cassandra Miller', *Tempo* 68, no. 269 (July 2014): 50–64, https://doi.org/10.1017/S0040298214000060.
[18] Robin Haigh, 'Composing Millennial Nostalgia: Microtonal Techniques as Tools to Express a Twenty-First Century Malady in Tonal Music' (PhD Commentary, University of York, 2022), 14, https://etheses.whiterose.ac.uk/31286/.
[19] Haigh, 17–21.

due to the disrupting force of the quartertones, and thus offered a kind of musical ambiguity that rejected the charged emotions of internet discourse.

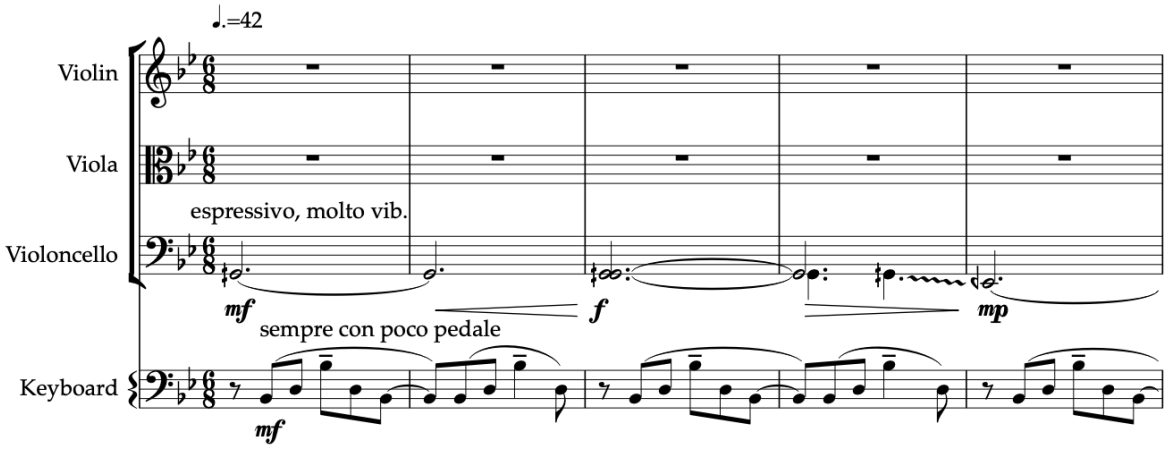

Figure 0-1: bars 1-5, *A Noise So Loud.*

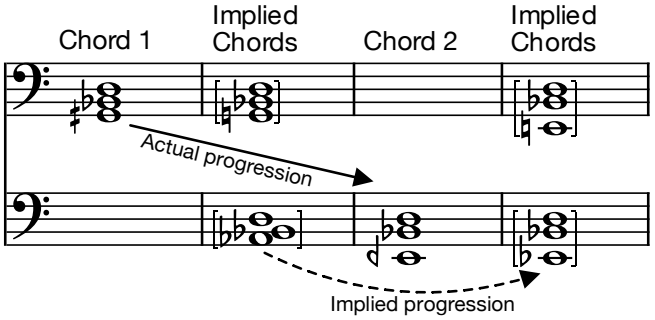

Figure 0-2: *A Noise So Loud*, harmonic reduction showing actual and implied progressions.

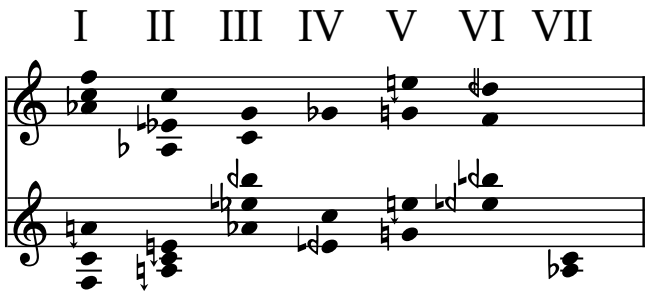

Figure 0-3: pre-set Sound Icon chords, *Us Alone*.[20]

I also explored this approach within the harmonic series, rather than with quartertones. In *Us Alone* (2017), performers bow upturned pianos, dubbed Sound Icons by Horațiu Rădulescu. The Sound Icons are prepared with a series of notes and chords, including major and minor chords and chords that are close distortions of them (see Figure 0-3). Chord II in

[20] This figure uses Helmholtz-Ellis Just Intonation notation. See Appendix One for further details.

Sound Icon I (the upper stave in Figure 0-3), for example, is a 19:28:48,[21] which sounds close to a major chord built on the 19th harmonic.

Systematic Microtonality

While this approach blunted the emotive diatonic resources it relied on, as intended, it was parasitic upon their tonal logic. I had no independent theory of resolution: sources of tonal tension abounded, but my only means to resolve them was the stability of common-practice tonality. I was engaged in a topical language of tonality and microtonality in which I felt inept. I liked the chords I was using, but I wanted to release them from the symbolic implications of conventional tonality. The extroversive semiosis of topical microtonality recalled too closely the semiotic saturation of internet discourse: indeed, this likeness is part of its appeal for millennial composers. I sought a systematic approach in which microtonal objects could generate their own syntax, a new tonality that could make these strange chords sound like home.

My quartertone predecessors

My systematic approach to the tonal potential of quartertones echoes the work of the microtonal composers in the 1920s. Julian Carillo, Alois Hába, Charles Ives, and Ivan Wyschnegradsky contributed to a brief boom of microtonal theory and composition that focused on subdivisions of twelve-tone equal temperament (henceforth, 12EDO).[22, 23] These composers sought to understand these new musical resources, which they regarded as a natural extension of the chromatic saturation of the early Twentieth Century. This approach was short-lived; from the 1940s most Western composers with a systematic interest in microtonality pursued Just Intonation, or high-order and prime EDOs.

One exception is Alain Louvier, whose work on the quartertone scales is a predecessor to my own.[24] His work and mine recall the pioneering experiments of Ives and Wyschnegradsky, both of whom examined the neutral chord, a triad in which the third lies between the major and minor third and thus exactly bisects the perfect fifth. Ives, in his brief quartertone ruminations, said that the viability of a quartertone tonality would be a central determinant of their impact.[25] His contribution focused on two chords, which he dubbed fundamental

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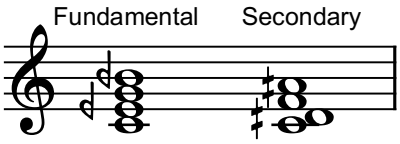
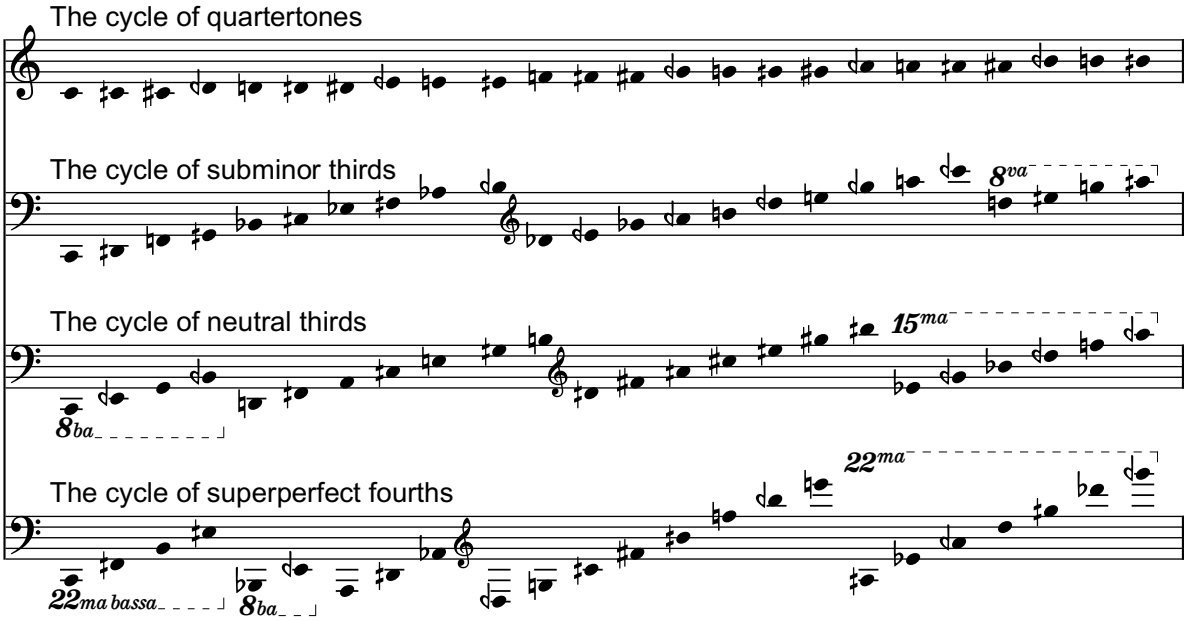
[21] This is a frequency ratio. It can be understood as showing the intervals between the harmonics of a shared fundamental.
[22] EDO stands for 'equal divisions of the octave.' This term is more precise than referring to the number of tones in an equal temperament, which may equally subdivide some other interval than the octave.
[23] Alejandro L. Madrid, *In Search of Julián Carrillo and Sonido 13*, Currents in Latin American & Iberian Music (Oxford ; New York, NY: Oxford University Press, 2015); Suzette Mary Battan, 'Alois Hába's "Neue Harmonielehre Des Distonischen, Chromatischen, Viertel-, Drittel-, Sechsten, Und Zwölftel-Tonsystems"' (New York, Eastman School Of Music, University of Rochester, 1980); Charles Ives, *Essays Before a Sonata, and Other Writings*, ed. Howard Boatwright, illustrated, reprint ed. (Norton, 1962); Ivan Wyschnegradsky, Noah Kaplan, and Rosalie Kaplan, *Manual of Quarter-Tone Harmony* (Brooklyn, NY: Underwolf Editions, 2017).
[24] Alain Louvier, 'Recherche Et Classification Des Modes Dans Les Tempéraments Égaux', *Musurgia* 4, no. 3 (1997): 119–31.
[25] Ives, *Essays Before a Sonata, and Other Writings*, 117.

and secondary.[26] These chords, shown in ◂ Figure 0-4, are comprised of bisected fifths and fourths, respectively. Both chords use just one interval class between adjacent notes: a neutral third (350¢) in the fundamental and a subminor third (250¢) in the secondary (for a glossary of the microtonal nomenclature in this commentary, see Appendix One).



◂ Figure 0-4: Ives's fundamental and secondary quartertone chords.



◂ Figure 0-5: Wyschnegradsky's quartertone cycles.[27]

Wyschnegradsky notes that by ascending through these interval classes one cycles through all the pitch classes in 24EDO; he observes the same cyclical quality in the quartertone (producing the quartertone chromatic scale), and the superperfect fourth.[28] These cycles are shown in ◂ Figure 0-5.[29] He creates scales from the cycle of neutral thirds and the cycle of superperfect fourths, positing a similarity between the cycle of neutral thirds and the cycle of fifths, and between these two scales and the diatonic scale.[30] Oddly, Wyschnegradsky

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[26] Ives, 114.
[27] In the musical example, the first four notes and last four notes of the cycle of superperfect fourths are transposed by two octaves to keep the cycle within a comfortable range.
[28] Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*, 4–5.
[29] The spelling of the cycle of subminor thirds creates a challenge. Notating each interval as a third would render the fourths as double diminished fifths: C – E𝄫 – G𝄫. The more intuitive spelling creates an unequal subdivision of the fourth into a subminor third and supermajor second. Throughout this commentary and in the notation of compositions, I have tended to prefer the spellings that give the simplest accidentals (i.e. 𝄲 rather than 𝄫), with exceptions made to show enharmonic equivalence.
[30] Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*, 22–23.

does not extrapolate this logic to the cycle of subminor thirds. Ives, however, did gesture towards the possibility of a scale based on subminor intervals, noting that 'the chords of five-quarter-tone intervals offer possibilities for a minor lesser scale' without illustrating what such a scale might look like.[31]

Another important context for quartertone intonation lies in maqāmic music, which Khyam Allami locates within 'Arabic, Ottoman and Persian art music traditions, and spread across the geographical regions from Morocco all the way to the Uyghur people in Northwest China.'[32] There is substantial debate within this tradition as to whether 24EDO is an adequate conceptualisation of its tuning;[33] nonetheless, many of the sonorities used by Western quartertone composers have been explored in greater detail by musicians working in the maqāmic tradition.[34] Maqāmic music's approach to harmony is, however, fundamentally different from my own,[35] which is deeply encultured within the Western triadic tradition. As such, this portfolio draws little directly from this tradition, though Allami's music, theory, and digital tools have been an important influence.

My systematic approach and its limits

As I sought a more systematic approach to quartertone harmony, I took up Ives's discarded idea, building a theoretical system based on the cycles observed by Wyschnegradsky. This theory, which I called the quartertone axis system, was the basis of several works in 2019 and 2020: *Sparrow*, *Street Through A Window*, and *Muted The Night*. The epistemic appeal of this system inspired me to undertake this PhD. Like the theorists of the 1920s, I considered quartertones with an abstract, systematising, and idealist mindset. This outlook resembles that of the Neoplatonic theorists, like late-antique philosopher Boethius, for whom abstract systems precede sounding practice, which is regarded as a necessarily incomplete instantiation of such systems.[36] As I used the quartertone axis system over the course of this PhD, I ran up against its limitations, prompting me to reconsider the system and the Neoplatonic mindset that engendered it.

This broadened my research, whose research questions fall into two groups. First, I examine the resources of my approach to microtonal tonality. Can microtonal chords sound like home? How can microtonal tonality structure music over time? What forms and syntaxes might it enable? Secondly, I question how my microtonal system is constituted. What are its

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[31] Ives, *Essays Before a Sonata, and Other Writings*, 115.
[32] Khyam Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music' (PhD Commentary, Birmingham City University, 2022), 47.
[33] Allami, 157.
[34] Farraj and Shumays, for example, show the nuance of the tuning of the pitch roughly 350¢ above the tonic: Johnny Farraj and Sami Abu Shumays, *Inside Arabic Music: Arabic Maqam Performance and Theory in the 20th Century Middle East* (New York, NY: Oxford University Press, 2019), 167.
[35] Farraj and Shumays, 156–60.
[36] Christian Wildberg, 'Neoplatonism', in *The Stanford Encyclopedia of Philosophy*, accessed 20 March 2024, https://plato.stanford.edu/archives/win2021/entries/neoplatonism/; Anicius Manlius Severinus Boethius, Calvin M. Bower, and Anicius Manlius Severinus Boethius, *Fundamentals of Music*, ed. Claude V. Palisca, Music Theory Translation Series (New Haven: Yale University Press, 1989).

edges, and how might it interact with other systems? How do material and social conditions affect its use, and what do such interactions reveal of its nature? What kinds of knowledge might be involved in its production and practice? My findings are relevant to those seeking novel microtonal resources, wishing to better understand tonality, or considering what it means to create musical systems.

Research questions

Overarching imperative: to write music that is abstract, discursive, live, and ambiguous as a way of resisting the attention economy.

Means: the creation of new works of music using microtonal tonality.

Questions:

1. The resources of my approach to microtonal tonality.
    a. How can microtonal chords sound like home?
    b. How can microtonal tonality structure music over spans of time? What forms and syntaxes might it enable?
2. The nature of systematic approaches to microtonal tonality.
    a. What are the edges of a system, and how might tonal languages interact?
    b. How do material and social conditions affect its use, and what do such interactions reveal of its nature?
    c. What kinds of knowledge might be involved in its production and practice?

Figure 0-6: research questions.

Structurally, this commentary traces the path of the portfolio it accompanies, charting an outward expansion from an idealist system to a syncretic approach. My early compositions explored the quartertone axis system, which I lay out in Chapter I, considering its harmonic resources and the questions it raised for my compositional practice. These questions lead me to Just Intonation (Chapter II), first, to re-examine diatonic harmony, then as a resource for building scales, and finally as a framework for recontextualising harmonies alongside their combination tones. In Chapter III, I examine my move towards hybridity, considering how my epistemology and technique have been reconfigured through the instruments I use in microtonal composition.

I. Making strange chords sound like home: quartertone tonality

This chapter describes my approach to quartertones in three parts. In Part A, I lay out a xenharmonic tonality, the quartertone axis system. In Part B, I consider its application within the earlier works of this portfolio, contrasting a pre-axis system piece, Lain Lines, *with axis-system pieces,* Odd Coils, Switchback, Nocturne, *and* Straight Line Through A Landscape. *In Part C, I explore the limits of this system, re-examining the pieces discussed in part B alongside failed experiments,* Fugue In B Flat Subminor, *and* Nocturne Variations.

A. Quartertone Axis Theory

Xenharmonic tonality – The generalised circle of fifths – Turning 24EDO intervallic circles into scales – The character of these scales and their relationships to one another

Xenharmonic Tonality

Tonality is synonymous to many with the diatonic tonality of 12EDO.[37] What features might tonality have if one were to consider it in the abstract? Is a microtonal tonality possible? Trivially, a microtonal tonality might involve an alternate tuning of the familiar heptatonic system, like a Pythagorean Just Intonation scale. Or it could be found in the detunings many record producers use to achieve a warmer, richer sound.[38] But my systematic approach to quartertone harmony aims to create a musical discourse that allows for resolution within strangeness.

This strangeness is what Ivor Darreg refers to as 'xenharmonic': the perceptual difference of music from encultured expectations.[39] These encultured expectations vary according to prevailing intonational practice: xenharmony means something different to a gamelan performer than it does to me. This PhD takes place against the context of recent Western music which, despite varying intonational practices across genres and instruments, is typically conceived of in 12EDO and performed in varying approximations thereof.[40] A xenharmonic tonality must be sufficiently different from this commonplace.

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[37] Brian Hyer, 'Tonality', in *The Cambridge History of Western Music Theory*, ed. Thomas Christensen, 1st ed. (Cambridge University Press, 2002), 727–28, https://doi.org/10.1017/CHOL9780521623711.025.
[38] Martin Russ, *Sound Synthesis and Sampling*, 3. ed (Amsterdam: Elsevier, Focal Press, 2009), 421, 442.
[39] Ivor Darreg, 'Defining One's Terms', *Tonalsoft.Org* (blog), 1988, http://www.tonalsoft.com/sonic-arts/darreg/dar27.htm.
[40] For example, Knipper and Kreutz summarise the available literature to argue that 'In case of performed melodies in 12-tet on a string instrument, dispersions of intervals were found in a range of ±10–20 cents.' Till Knipper and Gunter Kreutz, 'Exploring Microtonal Performance of "…Plainte…" by Klaus Huber for Viola d'amore in Third-Tone Tuning', *Musicae Scientiae* 17, no. 4 (December 2013): 376–97, https://doi.org/10.1177/1029864913487543.

Of the many who have theorised tonality,[41] I have found Dimitri Tymoczko's *A Geometry of Music* the most helpful, as his concern with stylistic breadth makes his theories more immediately applicable in non-12EDO contexts.[42] Tymoczko lays out five aspects of tonality:

> '1. *Conjunct melodic motion*. Melodies tend to move by short distances from note to note.
>
> 2. *Acoustic consonance*. Consonant harmonies are preferred to dissonant harmonies, and tend to be used at points of musical stability.
>
> 3. *Harmonic consistency*. The harmonies in a passage of music, whatever they may be, tend to be structurally similar to one another.
>
> 4. *Limited macroharmony*. I use the term "macroharmony" to refer to the total collection of notes heard over moderate spans of musical time. Tonal music tends to use relatively small macroharmonies, often involving five to eight notes.
>
> 5. *Centricity*. Over moderate spans of musical time, one note is heard as being more prominent than the others, appearing more frequently and serving as a goal of musical motion.'[43]

His emphasis on harmonic consistency, which he argues is culturally specific to recent Western music,[44] is distinctive, as is his helpful distinction between 'macroharmony' and 'scale.' Tymoczko clarifies that a scale is a unit of measurement that defines the nature of a melodic step, while macroharmony is the total collection of notes over a given period.[45] These are often the same thing, but may differ in, for example, bitonal music.[46]

Of these five aspects, all are agnostic to the tuning system they are part of except for acoustic consonance. Consonance, like tonality, is much theorised, with James Tenney's work on the 'Consonance/Dissonance Concept' being influential amongst those interested in intonation.[47] Especially useful to my work is Michael Bruschi's recent dissertation, which examines tonality in the work of Easley Blackwood, a composer whose work, like mine, seeks tonal resources in xenharmonic equal temperaments.[48] Bruschi helpfully distinguishes

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[41] Hyer, 'Tonality'; Brian Hyer, 'What *Is* a Function?', in *The Oxford Handbook of Neo-Riemannian Music Theories*, ed. Edward Gollin and Alexander Rehding, 1st ed. (Oxford University Press, 2012), 92–139, https://doi.org/10.1093/oxfordhb/9780195321333.013.0003; Fred Lerdahl and Ray S. Jackendoff, *A Generative Theory of Tonal Music* (The MIT Press, 1996), https://doi.org/10.7551/mitpress/12513.001.0001; Roger Scruton, 'Tonality', in *The Aesthetics of Music* (Oxford University Press, 1999), https://doi.org/10.1093/019816727X.001.0001.
[42] Dmitri Tymoczko, *A Geometry Of Music: Harmony and Counterpoint in the Extended Common Practice* (New York: Oxford University Press, 2011).
[43] Tymoczko, 4.
[44] Tymoczko, 7.
[45] Tymoczko, 15.
[46] Tymoczko, 16.
[47] James Tenney, 'Appendix 3: Excerpt from History of "Consonance" and "Dissonance" (1988)', in *From Scratch: Writings in Music Theory*, ed. Larry Polansky et al. (Urbana: University of Illinois Press, 2015).
[48] Michael Bruschi, 'Hearing the Tonality in Microtonality' (PhD Dissertation, Yale, 2021).

between sensory and cognitive definitions of consonance.[49] Theorists who favour sensory definitions, such as Hermann von Helmholtz, emphasise the nature of the sound in question, comparing it to, for example, the low order ratios of the harmonic series.[50] Cognitive definitions emphasise the listener's reaction to the sound, considering their encultured expectations.

Bruschi favours the latter: he defines dissonance as '*unexpectedness relative to statistically learned cultural/stylistic norms,*'[51] while noting that sounds deemed as consonances by a culture are often those that exhibit sensory consonance.[52] Bruschi prioritises culture in the formation of expectation, to the extent that he argues that a listener must parse non-12EDO music in the terms of 12EDO diatonicism.[53] But he also notes that expectations can be set by the rhythm and meter of a piece of music and that these might 'consonate' otherwise dissonant or xenharmonic material.[54] I will describe these two forms of expectation-setting as introversive and extroversive.

Bruschi's emphasis on the enculturation of the listener in 12EDO diatonicism is contextually appropriate to his study of Blackwood's music. Blackwood uses an extended version of conventional diatonicism, reinforcing xenharmonic tonal centres primarily through metrical emphasis. I would argue that music which reinforces a novel tonality more thoroughly may allow for greater introversive expectation setting. This is gestured towards in a study by Psyche Loui, David L. Wessel, and Carla L. Hudson Kam: 'Humans Rapidly Learn Grammatical Structure in a New Musical Scale.'[55] They created a novel music grammar within the Bohlen-Pierce tuning and found that 'after 25-30 min of passive exposure to the melodies, participants showed extensive learning as characterized by recognition, generalization, and sensitivity to the event frequencies in their given grammar, as well as increased preference for repeated melodies in the new musical system.'[56]

How might I combine Bruschi and Tymoczko's views of tonality and consonance into a model of tonality that could apply in xenharmonic music? The diagram in Figure I-1 proposes a fusion. It suggests that tonal expectations are generated through introversive and extroversive semiosis as well as by sensory biases towards consonance. The figure designates four of Tymoczko's aspects of tonality alongside syntax, which Bruschi emphasises, as the introversive setters of tonal expectation. It also suggests that tonal expectations, once formed, can create an impression of sensory consonance. Not all these factors need to be present for tonal expectation to be created. Rather, the strength of the tonal expectation will depend on the factors that contribute to it. In xenharmonic music,

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[49] Bruschi, 131.
[50] Bruschi, 123.
[51] Bruschi, 125.
[52] Bruschi, 131–32.
[53] Bruschi, 134.
[54] Bruschi, 126, 131.
[55] Psyche Loui, David L. Wessel, and Carla L. Hudson Kam, 'Humans Rapidly Learn Grammatical Structure in a New Musical Scale', *Music Perception* 27, no. 5 (1 June 2010): 377–88, https://doi.org/10.1525/mp.2010.27.5.377.
[56] Loui, Wessel, and Kam, 377.

encultured tonality and acoustic consonance mitigate against the strength of tonal expectation, with introversive features being needed to consonate unfamiliar harmonies.

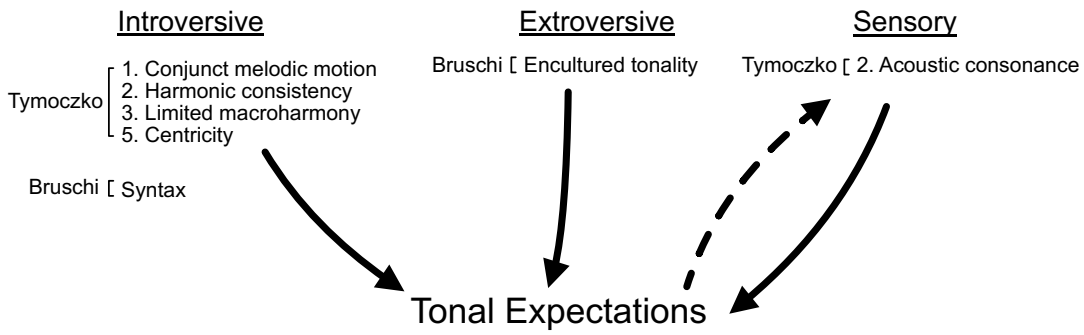


Figure I-1: a model of tonality.

In my approach to quartertone tonality, I initially considered only its pitched aspects, neglecting syntax and encultured tonality. These non-pitched elements were important in my development of the system and precipitated my eventual expansion of it. This chapter will trace the course of that development.

The circle of fifths and the diatonic scale

I began my thinking about quartertone tonality with the observation that the neutral triad was an exact bisection of the perfect fifth, and thus had a particular relationship to the circle of fifths. The circle of fifths is the only non-chromatic, complete intervallic circle in 12EDO.[57] In other words, it is the only series of intervals that:

1. Uses only one interval class (intervallic),
2. Cycles through every pitch class without repetition (complete), and
3. Does not simply cycle through all the notes in scale order (non-chromatic).

By selecting adjacent notes in the circle of fifths, one can generate the 12EDO diatonic scale (Figure I-2), or the 12EDO pentatonic scale (Figure I-3).[58] These modes have unique properties, enumerated by scale theorists such as Norman Carey, David Clampitt, John Clough, Jack Douthett, and Gerald Myerson.[59] The most salient for this portfolio is that they are 'Maximally Even,' meaning that they fill the octave as regularly as possible, with no areas of lesser or greater chromatic concentration. One hallmark of this property is that these scales have only two step sizes: whole tones and semitones in the diatonic scale, minor thirds, and whole tones in the pentatonic scale. One can use the circle of fifths to

[57] If treated interchangeably with its inversion, the circle of fourths.
[58] Henceforth, I will refer to these simply as 'the diatonic' and 'the pentatonic,' unless distinguishing between them and diatonic/pentatonic scales in other systems.
[59] Norman Carey and David Clampitt, 'Self-Similar Pitch Structures, Their Duals, and Rhythmic Analogues', *Perspectives of New Music* 34, no. 2 (1996): 62, https://doi.org/10.2307/833471; John Clough and Jack Douthett, 'Maximally Even Sets', *Journal of Music Theory* 35, no. 1/2 (1991): 93, https://doi.org/10.2307/843811; John Clough and Gerald Myerson, 'Variety and Multiplicity in Diatonic Systems', *Journal of Music Theory* 29, no. 2 (1985): 249, https://doi.org/10.2307/843615.

conceptualise connections between transpositions of a scale: adjacent scales, with only one differing note; and complementary scales, with as few shared notes as possible.

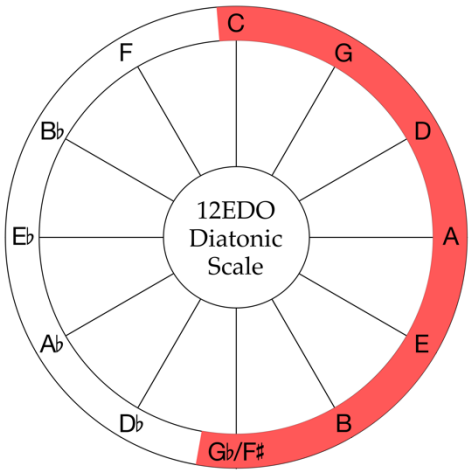


Figure I-2: the diatonic scale on the circle of fifths.

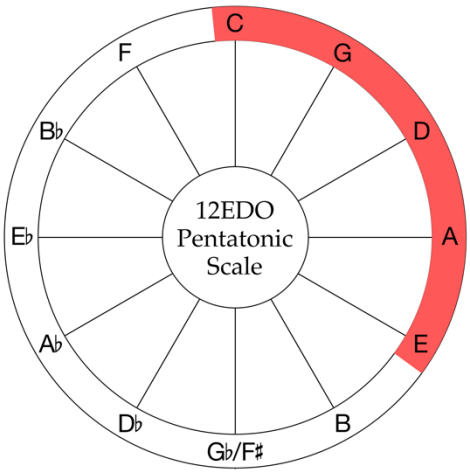
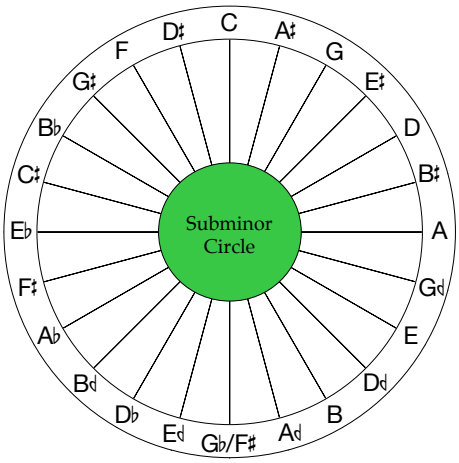


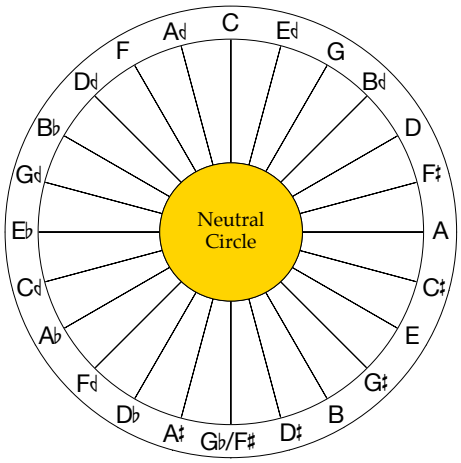
Figure I-3: the pentatonic scale on the circle of fifths.

Intervallic circles in 24EDO

My system extrapolates these ideas into 24EDO, though the logic can be applied to any equal temperament.[60] In 24EDO, as Wyschnegradsky observed,[61] there are three non-chromatic, complete intervallic circles: the circles of subminor thirds (250¢), neutral thirds (350¢), and superperfect fourths (550¢) (◂ Figure I-4 to ◂ Figure I-6).

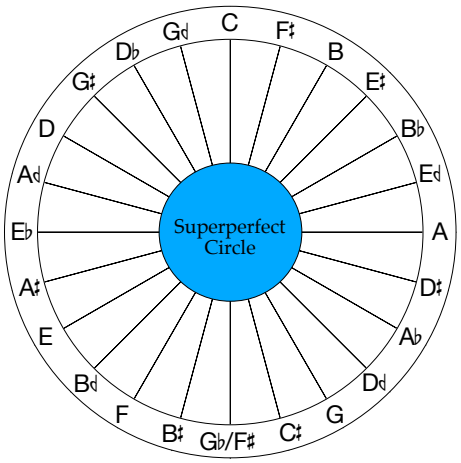


◂ Figure I-4: subminor circle.



◂ Figure I-5: neutral circle.

[60] See Appendix Two for a fuller generalisation of this system.
[61] Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*, 4–5, 19–23.



◂ Figure I-6: superperfect circle.

Each of these 24EDO circles is a subdivision of a 12EDO intervallic circle. The neutral and subminor circles relate to the circle of fifths: the neutral divides ascending fifths, the subminor divides descending fourths. The superperfect circle divides a descending chromatic scale.

The choice of the inversion of the cyclical intervals, known as generators,[62] is arbitrary. To avoid distinguishing between inversions, I refer to these circles by their interval quality: the subminor, neutral, and superperfect circles. I depict the subminor circle as a descending circle as this aligns it with the circle of neutral thirds on alternate notes, clarifying their relationship to each other and to the circle of fifths.

Making scales in 24EDO

I use these circles to generate scales in 24EDO: the neutral, subminor, and superperfect scales. Initially, I conceptualised all these scales through the lens of the diatonic scale, giving each seven notes. This idea was particularly appealing when working with the neutral scale. Given a cardinality of seven,[63] the third mode of the neutral scale resembles the major and minor scales, with its third, sixth, seventh degrees falling exactly between major and minor intervals:[64]

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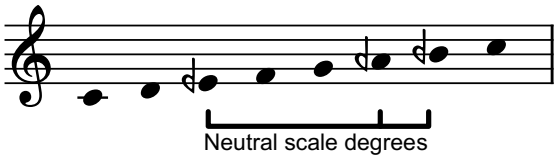
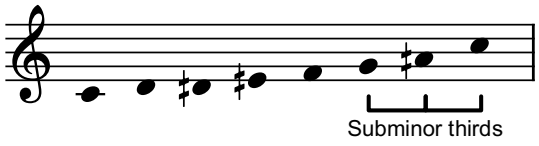
[62] Norman Carey and David Clampitt, 'Aspects of Well-Formed Scales', *Music Theory Spectrum* 11, no. 2 (October 1989): 195, https://doi.org/10.1525/mts.1989.11.2.02a00030.
[63] The term 'cardinality' denotes the number of notes in a scale.
[64] The scale is similar to the maqām rāst; Allami objects to Eurocentrism of viewing its intervals as distortions of major and minor. The point is well made, but due my own deep enculturation in diatonic harmony, it has taken many years to be able to hear these intervals on their own terms when placed in a triadic context. Farraj and Shumays, *Inside Arabic Music*, 166; Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music', 156–57.

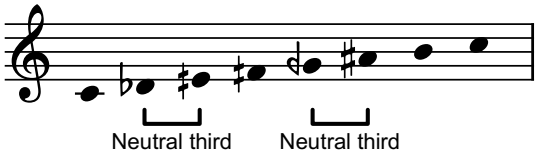


◂ Figure I-7: heptatonic neutral scale.

The comparability of this scale to the diatonic scales of common practice harmony has been noted by previous theorists, such as Louvier, who calls the scale the *mode imparfait*.[65] He does not note its relationship to the subminor and superperfect scales, because he restricts himself to scales with seven notes or fewer. At this cardinality, the subminor and superperfect scales work less well. I first conceptualised these scales in these heptatonic versions. I was conceptually reliant on the precedent of the diatonic scale and used a seven-note cardinality by default. I found these scales hard to work with, as both have steps that sound like leaps: a subminor third in the subminor and a neutral third in the superperfect (◂ Figure I-8, ◂ Figure I-9).



◂ Figure I-8: heptatonic subminor scale.



◂ Figure I-9: heptatonic superperfect scale.

The work of scale theorists Franck Jedrzejewski and Erv Wilson provided me with a lens through which to re-examine the cardinality of these scales. Wyschnegradsky identifies the superperfect scale as an analogue of the diatonic scale, ascribing it a cardinality of thirteen notes.[66] Jedrzejewski supports Wyschnegradsky's analysis with the conceptual framework of modern scale theory.[67] Jedrzejewski defines a generalised diatonic scale using a set of unique criteria that are shared by both the 13-note superperfect scale and the diatonic scale.

I found some of his criteria unhelpful compositionally. He defines diatonic scales as having a cardinality of half the total chromatic cardinality, plus one. This ensures that Jedrzejewski's diatonic scales grow larger as the total chromatic increases. For me, these larger scales lose their coherence, containing too many pitches to be heard as a single collection.

However, one of Jedrzejewski's criteria appealed to me and clarified my approach to my three scales: being maximally even. As noted earlier, maximally even scales fill out the octave evenly, have only two step sizes, and place the smaller step sizes evenly throughout the scale. This property is also discussed by Erv Wilson, for whom it is a characteristic of

[65] Louvier, 'Recherche Et Classification Des Modes Dans Les Tempéraments Égaux'.
[66] Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*, 23.
[67] Franck Jedrzejewski, 'Generalized Diatonic Scales', *Journal of Mathematics and Music* 2, no. 1 (March 2008): 21–36, https://doi.org/10.1080/17459730801995863.

'Moment Of Symmetry,' or MOS, scales.[68] The result is a scale that can be broken down into similar polychords, where each occurrence of an interval class always spans the same number of scale degrees. For example, in the heptatonic neutral scale, a perfect fourth always spans four scale degrees (Figure I-10). Scales of this type enable consistent harmonic and melodic motion throughout all parts of the scale.

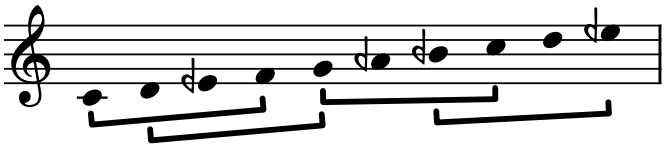


Figure I-10: perfect fourths in the heptatonic neutral scale.

To investigate this quality, I found maximally even versions of each of my scales and the two step types that make them up:

Scale Type	Cardinality	Small step size	Large step size
Subminor	5	Whole tone	Subminor third
	9	Quartertone	Whole tone
	15	Quartertone	Neutral tone
	19	Quartertone	Semitone
Neutral	7	Neutral tone	Whole tone
	10	Quartertone	Neutral tone
	17	Quartertone	Semitone
Superperfect	5	Semitone	Superperfect fourth
	7	Semitone	Neutral third
	9	Semitone	Subminor third
	11	Semitone	Neutral tone
	13	Quartertone	Semitone

Table 1: scale cardinality and step size.

I found the scales with a cardinality above thirteen prohibitively large, while those with scale steps larger than a tone sounded like they used leaps as steps. This left five options:

[68] Terumi Narushima, *Microtonality and the Tuning Systems of Erv Wilson* (London: Routledge, Taylor & Francis Group, 2018).

- Subminor: 9 notes
- Neutral: 7 or 10 notes
- Superperfect: 11 or 13 notes

I preferred the heptatonic neutral for its resemblance to the major and minor scale, which creates opportunities for tonal transformation. I preferred the 13-note superperfect scale because the addition of the twelfth and thirteenth notes add perfect intervals to a scale otherwise nearly devoid of consonances.

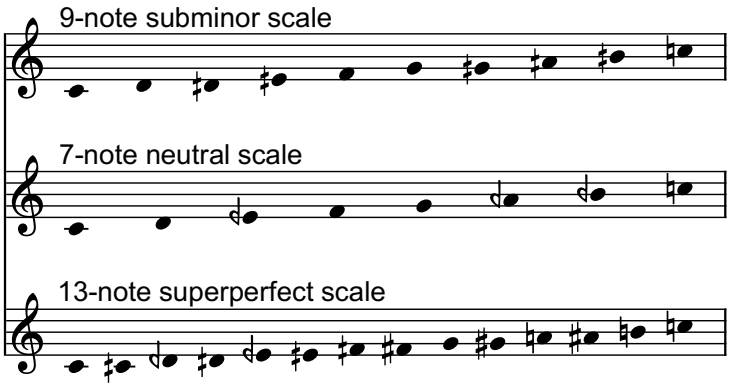


Figure I-11: three nearly even quartertone scales.

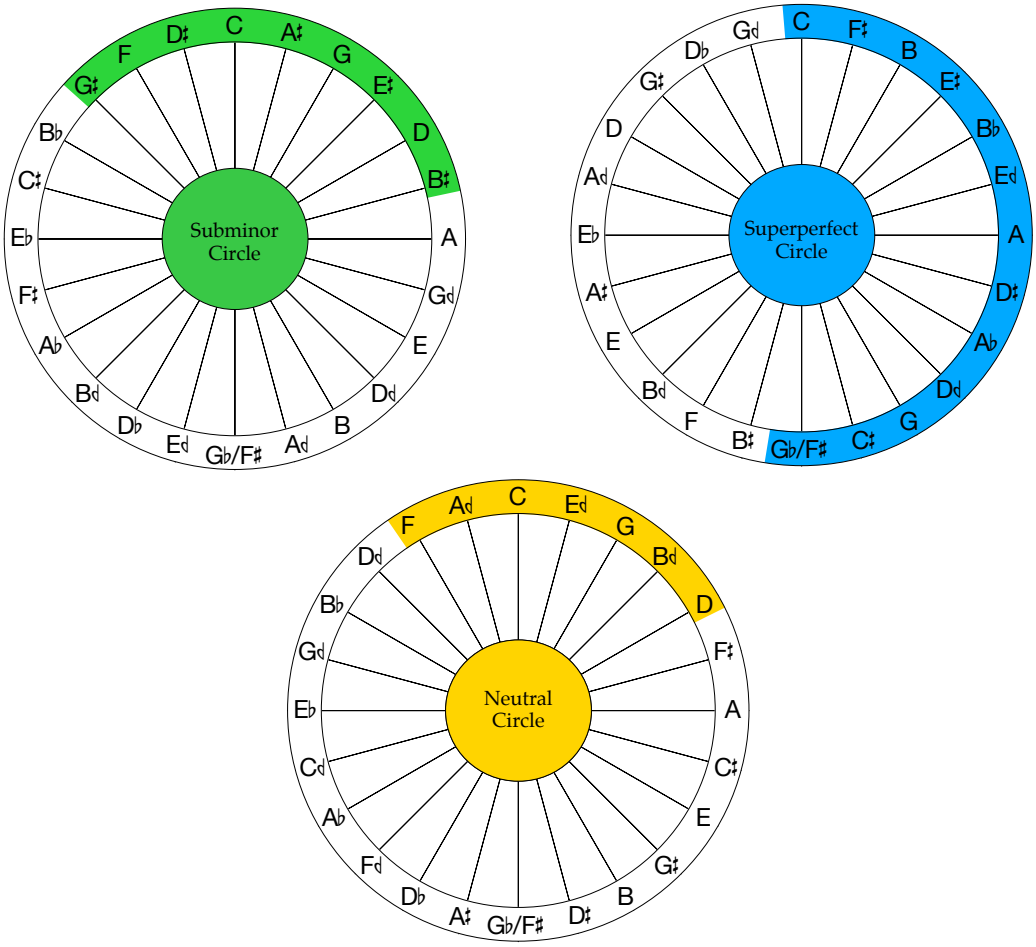


Figure I-12: three nearly even quartertone scales on their intervallic circles.

The intervallic character of quartertone scales

In addition to the six interval classes of 12EDO, 24EDO provides six more:

Interval	Cents	Inversion	Cents
Subminor 2nd	50	Supermajor 7th	1150
Neutral 2nd	150	Neutral 7th	1050
Subminor 3rd	250	Subminor 7th	950
Neutral 3rd	350	Neutral 6th	850
Supermajor 3rd	450	Supermajor 6th	750
Superperfect 4th	550	Superperfect 5th	650

Table 2: the interval classes of 24EDO.

Figure I-13 below shows the number of each interval class in each scale. It shows that the superperfect is an all-interval scale, the subminor contains eight of twelve interval classes, and the neutral contains six of twelve.

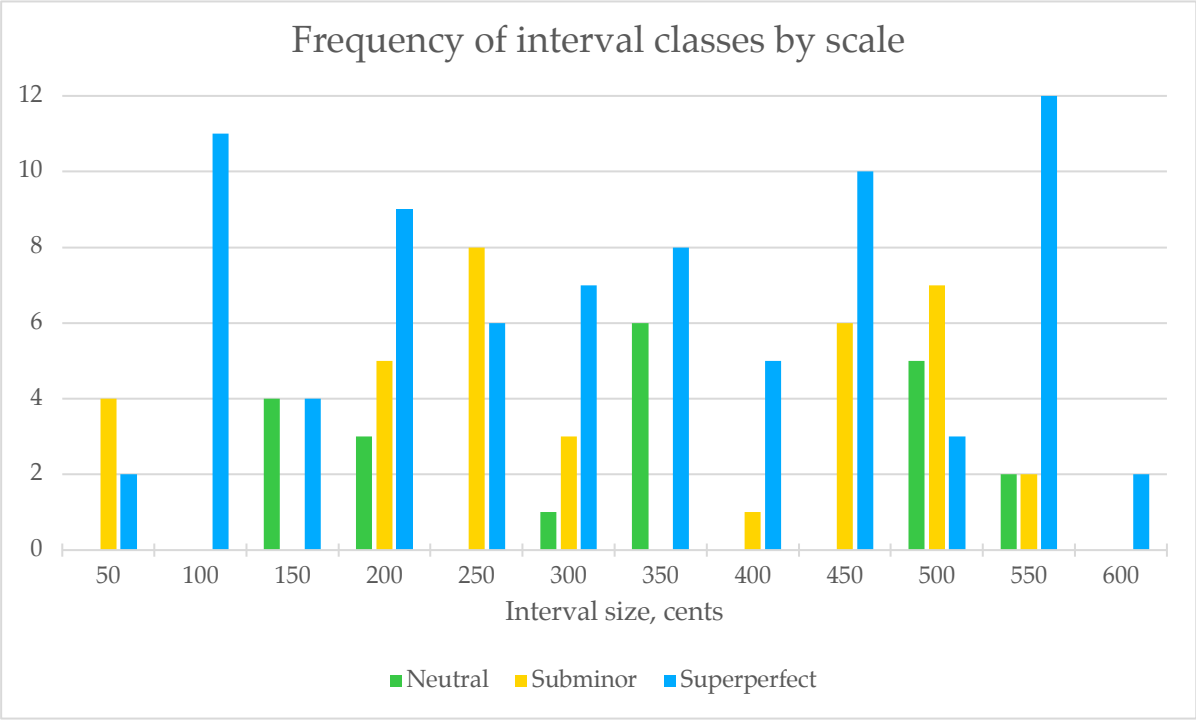


Figure I-13: interval classes in 24EDO scales.

In Table 3, this information is summarised, showing which interval classes are common in which scales. Interval classes characterise the scales whose name they share: subminor intervals predominate in the subminor scale, neutral intervals in the neutral scale, and superperfect intervals in the superperfect scale. Crucially, perfect intervals are most common in the neutral and subminor. Perfect intervals are the most consonant interval class

in 12-based equal temperaments, providing the harmonic stability that allows for resolution.[69] The rarity of perfect intervals in the superperfect makes it hard to use, despite its mathematical similarities to the diatonic scale that Jedrzejewski and Wyschnegradsky identified. I follow Ives who, when considering a quartertone harmony, dismissed it because 'it has no fifth—that inexorable thing—a part of the natural laws which apparently no aesthetic principle has yet beaten out.'[70]

Cents	Interval Class	Scale
50	Quartertone	Subminor
100	Semitone	Superperfect
150	Neutral tone	Neutral
200	Tone	Superperfect
250	Subminor third	Subminor
300	Minor third	Superperfect
350	Neutral third	Neutral
400	Major third	Superperfect
450	Supermajor third	Subminor, superperfect
500	Perfect fourth	Neutral, subminor
550	Superperfect fourth	Superperfect
600	Tritone	Superperfect

Table 3: 24EDO interval classes and their associated scales.[71]

I understood these scales more clearly by expanding my thinking from dyads to trichords. While there are twelve invertible pairs of dyads, there are 144 trichords, making a comprehensive approach like the one above undesirable. For my music, however, thirds-based trichords, triads, play a central role, due to their relative consonance and their ability to generate harmonic direction. 24EDO has five available thirds, giving 25 triads. Analysing the triads available in each scale is revealing:

[69] Tymoczko, *A Geometry Of Music: Harmony and Counterpoint in the Extended Common Practice*, 4.
[70] Ives, *Essays Before a Sonata, and Other Writings*, 113.
[71] Interval classes are here matched to the scales in which they make up the greatest proportion of the total number of available interval classes. In the case of close ties, both scales are listed. The whole tone is a close tie between all three scales; the greater cardinality of its occurrence in the superperfect is used as a tie breaker.

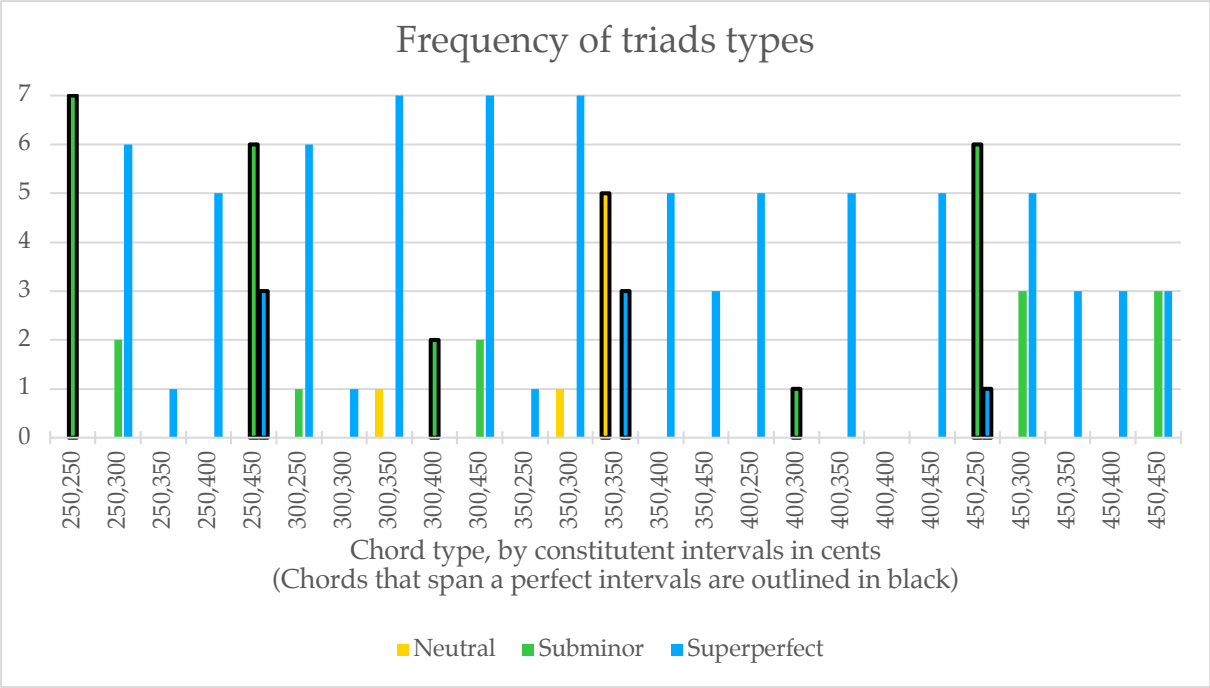


Figure I-14: triads in 24EDO scales.

	Kinds of third-based triads	Number of third-based triads
Neutral	3	7
Subminor	10	33
Superperfect	21	85

Table 4: quantity of third-based triads in 24EDO scales.

The more notes there are in a scale, the more available triads. However, the superperfect scale has proportionally few triads that span a perfect interval: its seven perfect-spanning chords are contained within its three perfect fifths. By contrast, the subminor contains 22 perfect-spanning triads; the neutral contains five; their greater number and variety is apparent in ◂ Figure I-15. These neutral and subminor triads have been particularly important in my music and so are worth naming, see ◂ Figure I-16. I call them the subminor stack, the subminor triad, the supermajor triad, and the neutral triad (for more nomenclature, see Appendix One).[72]

[72] The term 'subminor stack' is inspired by the work of Philip Tagg and will be explored in greater detail later in this chapter. Philip Tagg, *Everyday Tonality II: Towards a Tonal Theory of What Most People Hear*, 2017, 292.

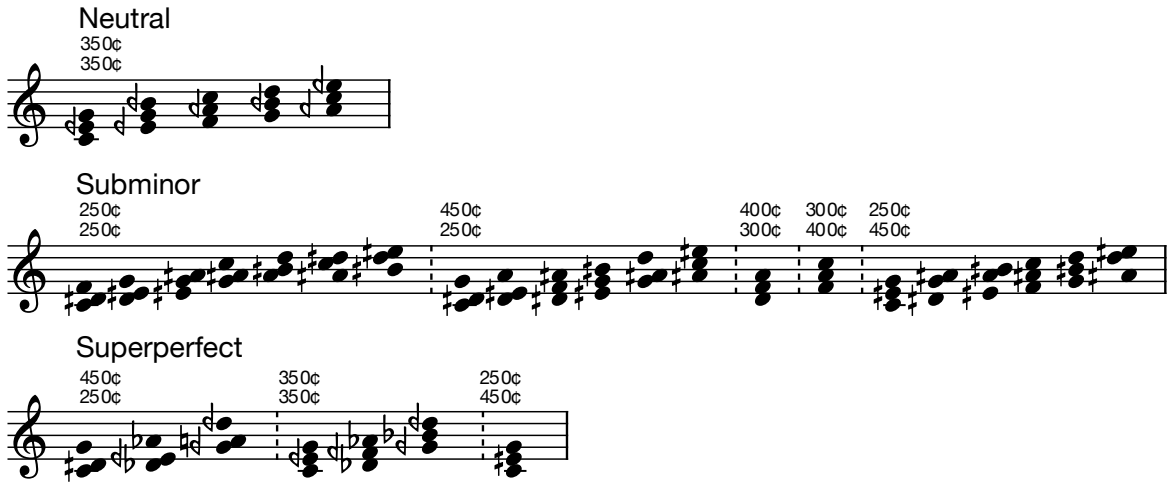


Figure I-15: perfect-spanning triads in 24EDO scales.

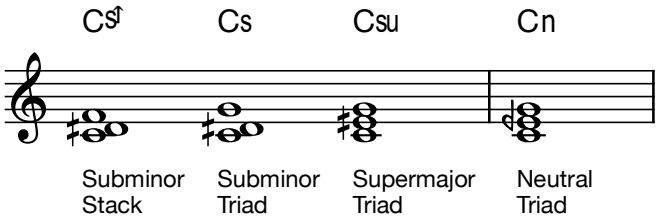


Figure I-16: the primary triads in the subminor and neutral scales.

While the cardinality of the scale increases the variety of available triads, this increase is not linear. This is demonstrated by giving all scales a cardinality of nine, which shows that the distribution of intervals in the subminor generates many more triads:

	Kinds of third-based triads	**Number of third-based triads**
Neutral	5	15
Subminor	10	33
Superperfect	11	18

Table 5: quantity of triads in 9-note 24EDO scales.

This work reveals something of the harmonic character of each scale. The neutral scale is intervallically consistent; its triads are dominated by neutral thirds and by chords that span fifths or semi-diminished fifths. The subminor scale is harmonically rich, with a wide variety of triads. It is also quite consonant: 22 of its 33 triads span a perfect interval. The superperfect scale has harmonic diversity but little consonance, with few perfect intervals. It has little consistency; its kinds of triads are fairly evenly distributed in number.

Scalic interrelation in 24EDO

These scales presented a problem. The neutral and subminor contained more of the harmonic resources that I found interesting but were also more harmonically constrained than the all-interval superperfect scale. My solution was a system of scalic interrelation that connected the neutral and subminor scales, allowing the harmonic resources of both scales to be easily intermingled.

The neutral and subminor scales both contain the circle of fifths, linking them to each other and to the diatonic scale. Every alternate note in the neutral and subminor circles is part of a circle of fifths, meaning that neutral and subminor scales occupying an isomorphic section of the circle will have a spine of fifths in common (see Figure I-17). An isomorphic diatonic scale will also share these four notes. The other notes in the subminor and neutral circles are separated from one another by a tritone. As such, neutral and subminor scales also share with their tritone transpositions a spine of perfect fifths (Figure I-18).

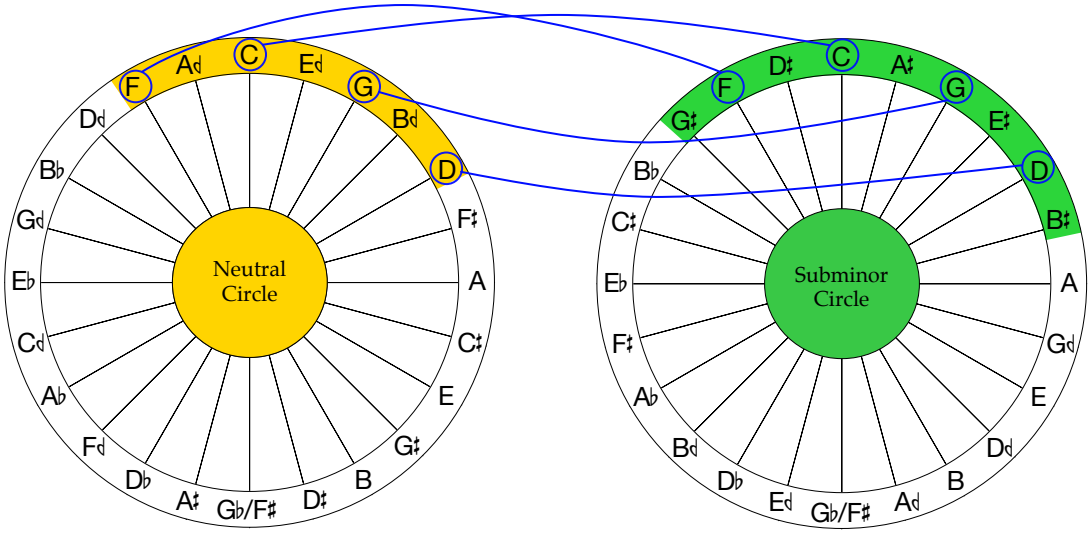


Figure I-17: shared notes in isomorphic neutral and subminor scales.

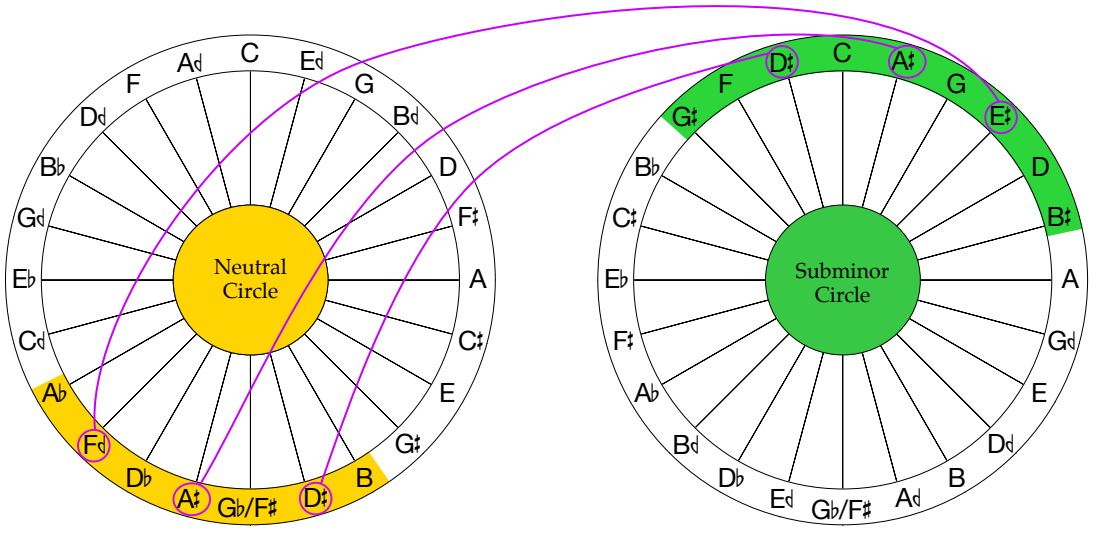
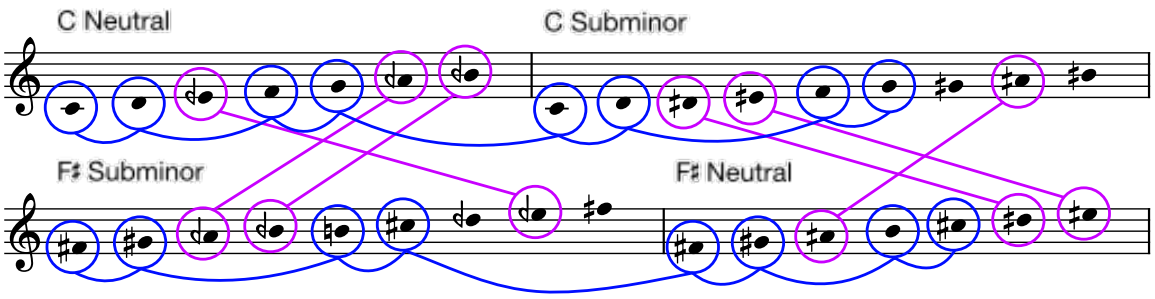


Figure I-18: shared notes in tritone-related neutral and subminor scales.

I use this feature of the subminor and neutral circles to create a complementary group of four scales, joined by spines of fifths separated by tritones:



◂ Figure I-19: four tritone related 24EDO scales.

This collection contains all 24EDO triads that span a perfect interval and all interval classes within 24EDO other than the tritone and semitone. However, as the tritone and semitone are the primary intervals of modulation between these scales, they play an important role in the system.

This is a flexible system that uses microtonal pitch classes economically. Only five microtonal pitches are needed in a pair of tritone related scales. These pitches are oriented in a circle of fifths, making them easier to play for string players, who can finger these pitches in the same position on each string. The concept of equally subdividing a fourth or fifth is readily explicable to players, helping them tune otherwise complex intervals. Symmetry plays a key role in this system, as both generators – the neutral and subminor thirds – can be used to create symmetrical triads. These triads play a key role in my conceptualisation of the system, acting as tonic triads; they are the most consonant triads available in either scale.[73]

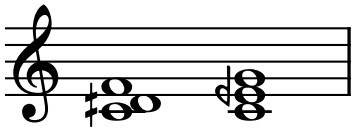


Figure I-20: the symmetrical tonic triads of the subminor and neutral scales.

The superperfect scale is not related to this system, as it is generated by subdivisions of the major seventh rather than subdivisions of perfect intervals. The superperfect circle has its own axis relationship, with each note in a superperfect scale being a quartertone away from an equivalent in a tritone-related scale. This is the same kind of relationship that the diatonic scale has with its tritone transposition, where every pitch is a semitone away from a counterpart.

[73] In the subminor, this assertion is less straightforward: replacing the upper note of the generator-based triad with a note a perfect fifth away from its root also provides a consonant triad. As these triads approximate, within 24EDO, a 6:7:8 and a 6:7:9 chord, I view the first as being marginally more consonant.

Ernő Lendvai's interpretation of Béla Bartók's music investigates this 12EDO relationship; Lendvai's work was an important influence.[74] I have adopted his terminology, describing tritone related scales as 'pole' and 'counterpole' within an 'axis' system.[75] In 24EDO, there are three such axis systems: the diatonic axis described by Lendvai, the superperfect axis, and the neutral-subminor axis. Due to the lack of consonance available in the superperfect axis, the neutral-subminor axis is the almost exclusive focus of my quartertone work and will hereafter simply be referred to as 'the quartertone axis system' or 'the neutral/subminor axis system.'

B. Syntax And Structure In The Quartertone Axis System

> *The problem of unsystematic tonality in* Lain Lines *– The axis system as a structural device in* Odd Coils *– Two approaches to syntax in the axis system, intensional and extensional – Intensional syntax in* Switchback *and* "Four Chords" *– Both syntaxes in* Nocturne *and* Straight Line Through A Landscape.

The benefits of the axis system can be seen by comparing *Lain Lines*, the first work in the portfolio, with the first two movements of *Odd Coils*. *Lain Lines* is a string quartet that I developed in 2020-2021 from a sketch written in 2019 that preceded my development of the quartertone axis system. In *Odd Coils*, I use the quartertone axis system; its first two movements do so strictly and exclusively. These movements illustrate how the quartertone axis system facilitates consistent macroharmony and how this contributes to creating tonal structures capable of consonating xenharmonic sonorities. When I conceived the system, I was concerned almost entirely with pitch choice and harmonic relationships. Once I began working with this tonal material, however, syntax proved important in forming and consonating 24EDO tonal relationships.

Static harmony in *Lain Lines*

I built *Lain Lines* around a four-chord progression that is looped throughout the first half of the piece, ending in bar 37 (Figure I-21). The loop's arpeggiated cello line underpinned the original workshop material (bars 17-46 in the final version). I finished the piece by reworking the pacing of this passage, adding an introduction based on the same chord sequence (bars 1-16), and adding a final passage of melodic material for the cello (bars 46-64).

The harmonic language of this chord sequence bears the hallmarks of my older quartertone style, underpinned by voice leading and references to diatonic harmony. Each chord is a diatonic chord altered by one or two quartertones. The harmonic motion of the sequence relies on careful voice leading, particularly of the line that the cellist performs on the D string, which contains most of the passage's quartertones. While I employ pitch classes outside the loop to ensure smooth voice-leading, they are a form of free quartertone chromaticism that do not bear structural weight. Instead, the piece's syntax is structured by

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[74] Ernö Lendvai, *Béla Bartók: An Analysis of His Music*, Repr (London: Kahn & Averill, 2007).
[75] Lendvai, 5.

the simple tonic-dominant alternations of the loop. This results in a static harmonic structure; the piece has no alternative tonal centres to this loop.

Instead, structure is provided by contrasts in texture and tessitura. The opening section progresses from static homophonic harmony to the arpeggiated texture of the central section. That arpeggiated section uses close voice leading to ascend through gradually accelerating extensions and inversions of the harmonic loop up to a climax of tessitura in bar 37. The passage that follows this is the only moment of harmonic motion in the piece. I used close voice leading to shift to a new chord: a D major triad with the F♯ replaced by a G𝄲. This becomes a pedal; the addition of a G♮ in maintains tension that is resolved by its disappearance in the piece's final bar.

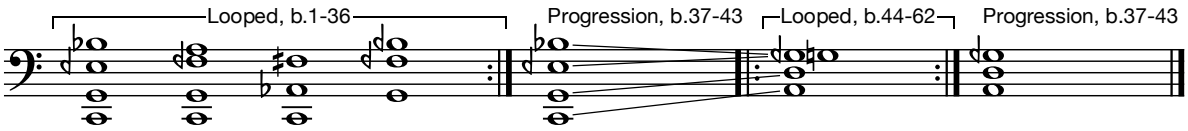

Figure I-21: harmonic reduction of *Lain Lines*.

Despite its simple and static harmonic structure, the close voice leading allows for complex microtonal progressions to emerge which, along with the textural changes, provide sufficient interest for a short work. I disguise the obviousness of its dependence on distorted diatonic harmony underneath the more complex progressions in the violins. But this approach left me boxed in, with few options other than textural change to animate the piece's form. Its harmonic language provided insufficient material for my compositional practice in the longer term. In particular, I lacked options for harmonic resolution. The piece's final chord is consonated only by contrast with the chord that precedes it, which features a dissonant quartertone. The quartertone axis system offered a tonal language in which moments of resolution might be found without the need to prepare them with such grating harmony.

Discursive logic in *Odd Coils*

Odd Coils was written in 2021 and 2022 for guitarist Sam Cave. The guitar's fourth-based tuning made it easy to devise a scordatura that accommodated the quartertone axis system. I created a symmetrical scordatura, echoing the symmetries of the quartertone axis system's generator-based harmony, and of an earlier piece for double bass, *Sparrow*.

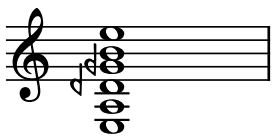

Figure I-22: the scordatura used in *Odd Coils*.

To begin, I created a list of chords (Figure I-24). My first list used the fingerings of conventional guitar chords, as I knew these would be easily playable. This approach was unsuccessful. Many guitar chords double notes at the octave between the strings III and VI

(G and A) or between the I and IV (E and D). As these strings were now tuned differently from one another, these chords now contained harsh altered octaves.

Instead, I considered which scales within the quartertone axis system contained the open strings: the retuned D𝄳 and G𝄳 and the conventionally tuned E, A and B (shown ringed in Figure I-23). This included both pole-counterpole sets on E/B♭, and the isomorphic scales on C𝄳 subminor/F♯ neutral and G𝄳 subminor/C♯ neutral (shown as concentric colour arcs in Figure I-23). I looked for playable triads on every degree of each scale, eliminating those without sympathetic fingerings. This left me with a page of chords which I sent to the guitarist (Figure I-24). In an initial workshop, we worked through these chords, identified the most successful and built strategies for harmonic motion and figuration. This process, of identifying quartertone axis system harmonies within a scordatura set-up, then trialling them with the player, became a common first step in my work.

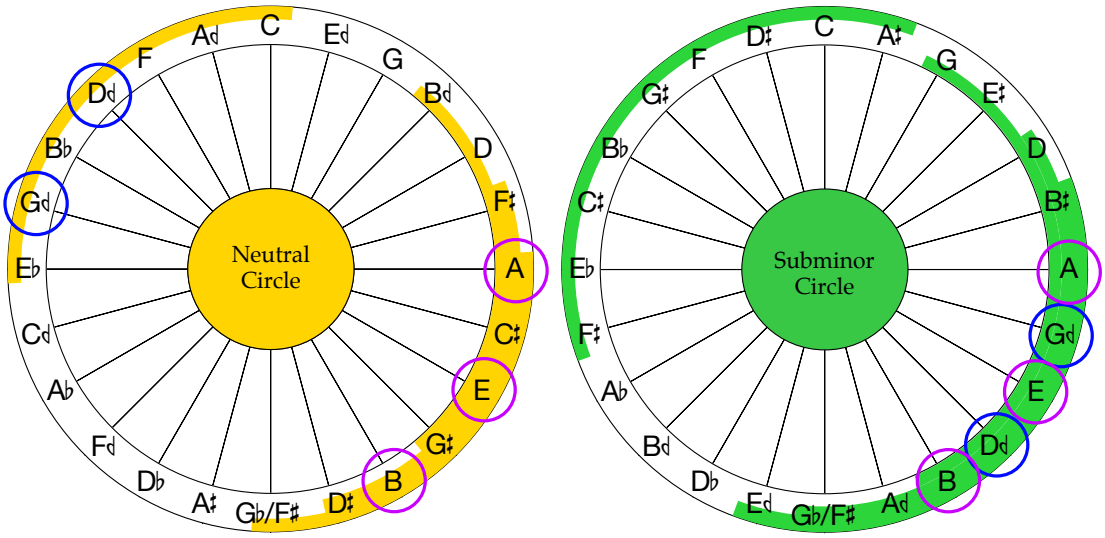

Figure I-23: the scalic plan of *Odd Coils*.

The open strings are circled; blue circles indicate detuned strings. The three scales are shown in concentric coloured rings. The outermost ring shows the four scales of the E-B3 axis, the middle ring shows isomorphic scales on C♯ and G𝄳, the inner ring shows isomorphic scales on C𝄳 and F♯.

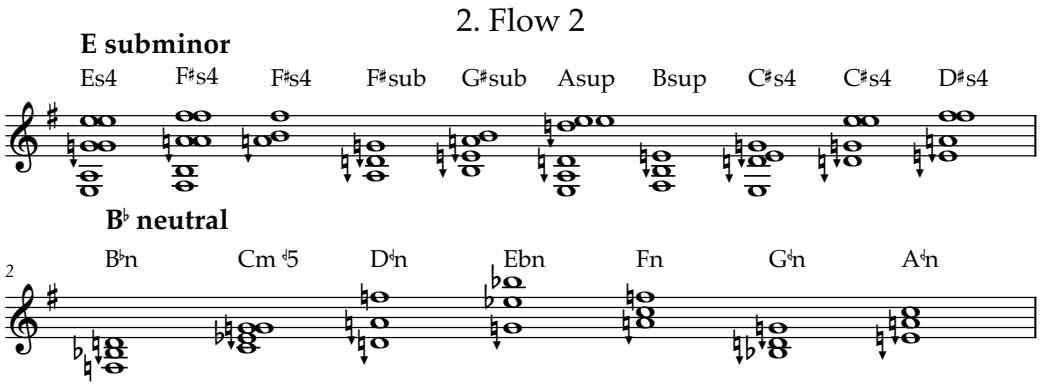

Figure I-24 *continues on next page.*

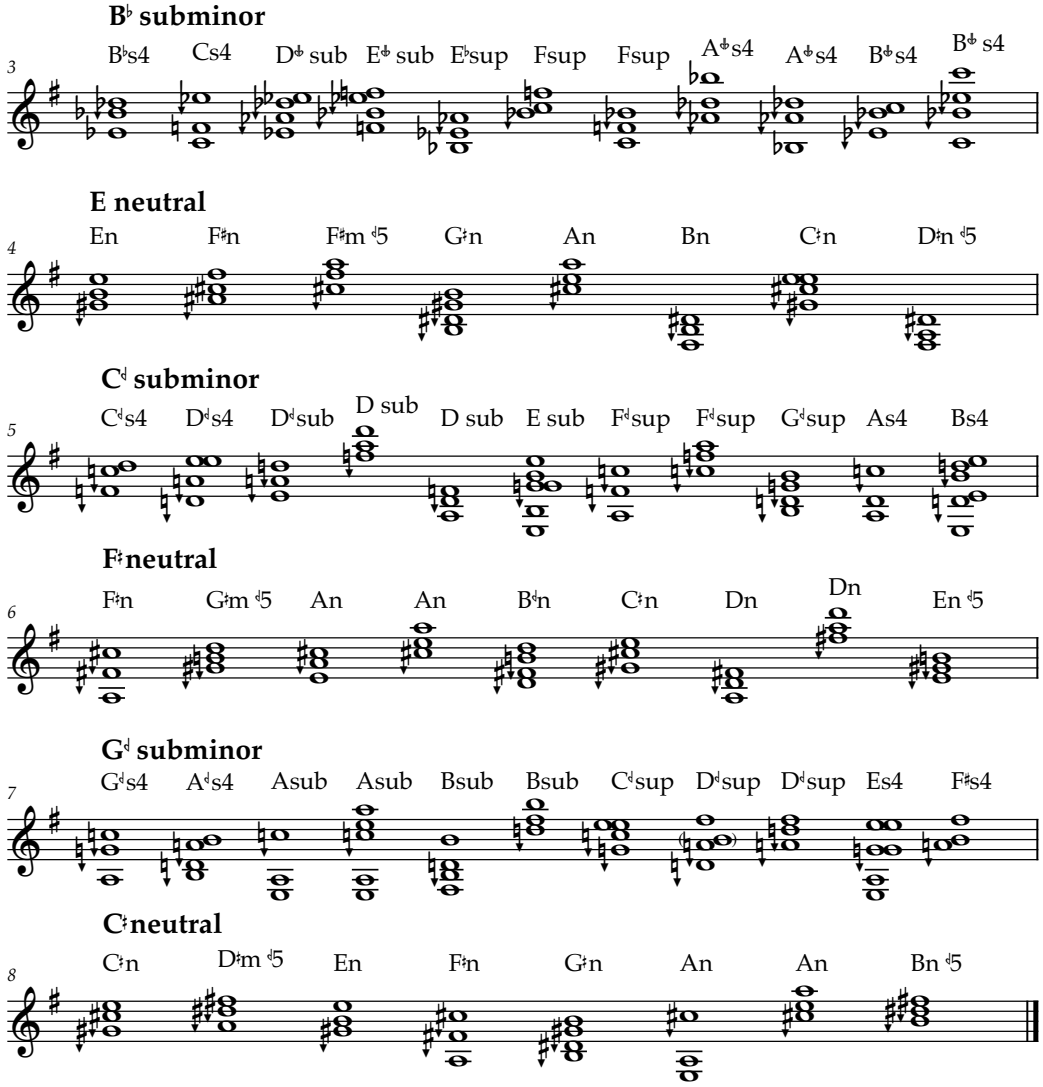

Figure I-24: trial chords for *Odd Coils*.[76]

The success of the chords in the E/B♭ counterpole sets encouraged me to orient the piece around this axis. I sketched both the first and second movements, "Folding" and "Chorale," as chord sequences before working them into full textures. I used the E/B♭ axis structurally, creating ABA modulation patterns. "Folding" moves from E subminor to B♭ neutral and then back, "Chorale" does the reverse. I use the quartertone axis system to create a system of harmonic motion that I had found elusive in my previous approach to quartertone harmony. In this sense, my systematic approach facilitates a more discursive music, in which alternative tonal centres animate the piece's structure.

I also found more harmonic resources available on the level of the phrase. In "Folding," for example, the piece moves through all six neutral chords of the neutral scale as it progresses its way upwards from B♭ neutral to towards E subminor (see ◂ Figure I-25). The consistent harmonic language allows for phrasal parallels. The first phrase, from bar 1-16, can be

[76] This is the sketch I used in sessions with the guitarist and, as such, the chord notation is rather rough. It doesn't use the more consistent microtonal chordal notation specified in Appendix One.

described in William Caplin's terms as a 'sentence.'[77] The half of the sentence, its presentation phrase in bars 1-8, features alternations between neutral chords a whole tone apart, first on the tonic, then on the mediant. The continuation phrase, beginning in bar 9, breaks this pattern, moving through chords related by neutral thirds, with a faster harmonic rhythm. This shift prepares the move to E subminor in bar 11, introducing new quartertone accidentals: F𝅘𝅥, C𝅘𝅥, and G𝅘𝅥. A series of subminor chords leads to a subminor climax in bar 18. The second half of the piece mirrors the opening. Two phrases feature alternating, adjacent subminor chords, which descend rather than ascend. It is in the second phrase, however, that the harmonic rhythm shifts, precipitating a further descent towards the home key of B♭ neutral.

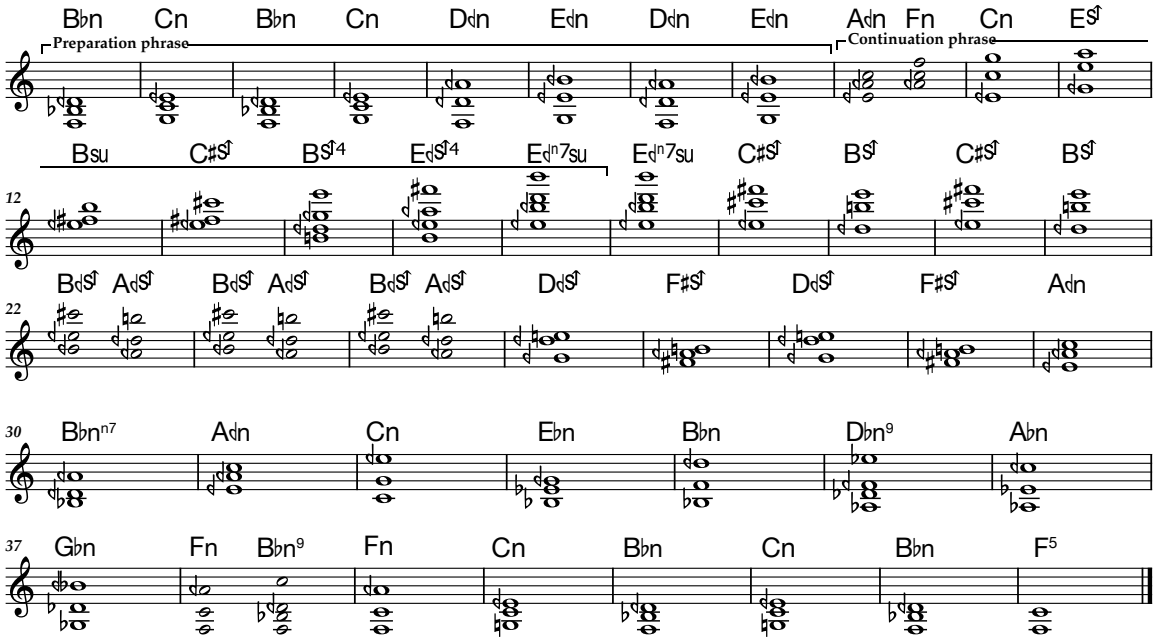

Figure I-25: the harmonic structure of "Chorale", *Odd Coils*.

There is a stark contrast between the approach to harmonic structure in "Chorale" and in *Lain Lines*. The bar-to-bar harmony in "Chorale" has, in Tymoczko's terms, greater harmonic consistency than that of Lain Lines. Structurally, however, there is greater contrast, in the form of an opposition between the neutral and subminor scales and the tritone relationship between their tonics.

The macroharmony is more limited. As *Lain Lines* is densely chromatic, new pitch classes have little structural importance; they cannot be introversively marked, as they fail to stand out against the chromatic background. In bar 20, for example, we hear a D𝅘𝅥 for the first time. This acts as a downwards resolution of the D♯ of the previous bar, but doesn't hold a special weight of its own or mark a broader harmonic shift. In "Chorale," by contrast, I establish microtonal intervals as part of a consistent language of microtonal tonality in the piece's

[77] William Earl Caplin, *Classical Form: A Theory of Formal Functions for the Instrumental Music of Haydn, Mozart, and Beethoven* (New York: Oxford University Press, 1998), 9–12.

opening, with limited macroharmony and periodic phrasing. This allows the arrival of new, subminor pitches in bar 11 to be introversively marked by its harmonic and syntactic contrast with the material that precedes it. The combination of consistency and contrast contributes to the discursive musical language, in which tonal objects generate structural meaning through introversive semiosis.

This process allows me to create a resolution to a microtonal chord at the piece's end. As in *Lain Lines*, this is partly achieved through tessitura; I use a registral arc to place B♭ neutral as the lowest chord in the piece. But, as explored above, the piece's tonal syntax also marks the B♭ neutral chord as a tonic. This is possible because the microtonal intervals of the chord are no longer marked in contrast to the non-microtonal intervals of the piece. The alterity of the microtones is still audible, but rather than hearing each microtonal interval as a marked 'other,' it is the musical discourse as a whole that appears strange.

Additive classical syntax

These examples illustrate the importance of syntax in constituting the tonal language of the quartertone axis system. The syntax of *Odd Coils* produces phrases that can be described with Caplin's inventory of theme types – sentence, period, and small ternary.[78] This phraseology has strong genre implications, placing the piece within a classical style despite its xenharmonic pitch content.

I undercut this classicism with rhythmic distortion. This distortion is typically additive or subtractive and is reminiscent of Olivier Messiaen's treatment of melodic sentences.[79] To my ears, this enlivens the otherwise staid classical phraseology in a manner analogous to the microtonal distortion of diatonic resources that characterised my earlier quartertone style.

In "Chorale," for example, the opening sentence is constructed of bars approximately eight quavers long. But only seven of sixteen of the bars are in $\frac{4}{4}$; the remainder are either nine, seven or six quavers long. In the other movements of *Odd Coils*, I use less pronounced distortion. The opening movement, "Folding," features a pair of sentences at its opening whose $\frac{12}{16}$ regularity is undercut by their abbreviated phrase lengths: they 7 and 6 bars long, respectively. The movement's middle section changes metre, entering an unstable $\frac{7}{8}$ with occasional additive and subtractive bars. The third movement, "Overneath," is more metrically stable, in part because it is aimed at non-professional players. But the constant time signature hides important metric irregularities. In bar 16, at the end of the first sentence, the melody takes up seven beats, displacing the melody of the coming sentence by a quaver, while the accompanying figure remains in $\frac{6}{8}$. This syncopation is remediated by a measure of $\frac{5}{8}$ in the melody in bar 20, allowing the whole passage to be written in $\frac{6}{8}$. The same procedure recurs in bars 34-38.

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[78] Caplin, 9–21.
[79] Olivier Messiaen 1908-1992, *The Technique of My Musical Language / by Olivier Messiaen* (Paris: A. Leduc, 1956), 44–49.

Intensional and extensional syntax

In my music, this additive classical syntax contrasts with loop-based structures that are reminiscent of popular music. Theorist Philip Tagg distinguishes between these two approaches in his books, *Everyday Tonality II* and *Music's Meaning*, which theorise tonality in popular music.[80] Tagg coins neologisms to distinguish between two diachronic levels of musical syntax: diataxis and syncrisis.[81] Diataxis concerns the narrative form of a piece, the extended relationships between sections. Syncrisis concerns the musical form in the 'extended present,' the structures of short-term elements of musical syntax.

Tagg distinguishes between music that prioritises diatactical and syncritic syntax, which he characterises as extensional and intensional, respectively.[82] This draws on Andrew Chester, who claims that classical music tends to focus on the extension of the musical logic of its component phrases through time; it is 'extensional.' By contrast, he argues, rock music treats harmonic and melodic aspects as constants to be inflected.[83] Tagg pithily describes intensional structures as 'places to be' and extensional ones as 'means to an end.'[84] In my music, extensional syntax uses patterns of tension and release to move the music from one harmonic centre to another, while intensional syntax uses loops that elaborate a stable harmonic neighbourhood.

Looping structures often use other kinds of teleology alongside an intensional syntax. A soloist's elaborations may create moments of climax and release; changes in timbre, dynamic and instrumentation might provide structural markers. Chester comments that extensional and intensional development are usually combined to varying extents, and that the manner of their combination acts as a hallmark of any given genre.[85]

When Julian Johnson identifies Western classical music with a discursive musical logic, he might be referring to something similar to Chester's idea of extensional logic. But, taking his definition of discursiveness at face value, I find it compatible with an intensional musical logic. Johnson defines discursive music as making 'formal consistency […] part of the music's meaning' – in Tagg's terms, creating meaning through diataxis.[86] But a syntactic focus need not preclude diatactic significance, particularly given the ways in which different parameters of musical discourse might engage to different extents in intensional and extensional syntax. My work is influenced by musicians working within the intensional language of song form who warp it in ways that create dramatic, meaningful structures – Anna Meredith and Mitski, for example.

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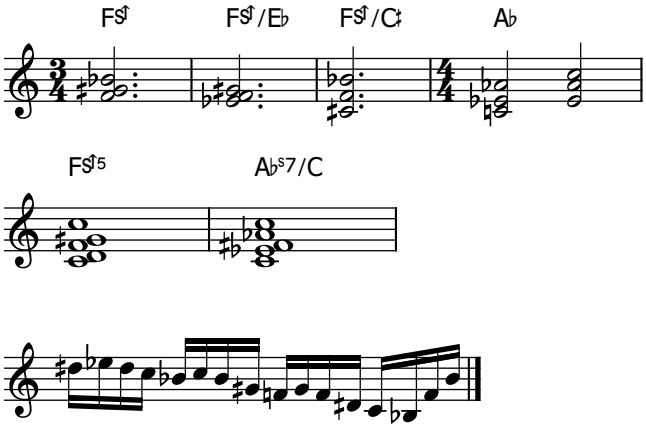
[80] Philip Tagg, *Music's Meanings: A Modern Musicology for Non-Musos* (New York: Mass Media Music Scholar's Press, 2013); Tagg, *Everyday Tonality II*.
[81] Tagg, *Music's Meanings*, 383–85.
[82] Tagg, *Everyday Tonality II*, 354–55.
[83] Andrew Chester, 'Second Thoughts On A Rock Aesthetic: The Band', *New Left Review* I, no. 62 (1970): 78–79.
[84] Tagg, *Everyday Tonality II*, 425.
[85] Chester, 'Second Thoughts On A Rock Aesthetic: The Band', 79.
[86] Johnson, *Who Needs Classical Music?*, 39.

Intensional syntax in *Switchback*

Switchback is an electronic piece based on looped chord sequences and percussion patterns, with an intensional harmonic language that nonetheless creates diatactical drama. Passages of accumulation are followed by textural changes that highlight the beginning of new sections. *Switchback*'s timbre, syntax, and structure are typical of beat-based electronic genres; it is part of a broad contemporary tradition of electronic music. Its use of microtonal pitch and irregular rhythmic structures locate it more precisely within the subgenre of xenharmonic electronic music by composer/producers including Sevish and Amelia Huff.

The piece uses only the subminor scale on B♭, resulting in limited harmonic variety. Attention is instead focused on the play of rhythm and timbre. The piece is oriented around three loops of decreasing length, which define the syncritic elaboration of three sections (see ◂ Figure I-26). The edges of the loops are elided by sustained melodic material, while their regularity is disguised by additive rhythms (in the first loop) and polymetric accompaniments. The loops are complicated by arpeggiation, percussive patterns, and timbral shifts, which build up over time, demarking three sections. A structural diagram is shown in Figure I-27, with time on the horizontal axis and approximate register on the vertical axis. Section 1 and Section 2 are both followed by contractions of tessitura and perceived loudness, with Section 2 followed by a breakdown that leads into the final section. The intensional elaboration of the loops thus contributes to the diatactical structure of the piece.



◂ Figure I-26: the three primary loops from *Switchback*.

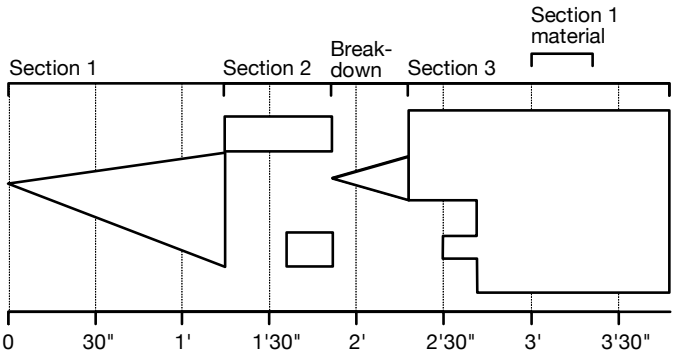


Figure I-27: structural diagram of *Switchback*.[87]

Genre play in "Four Chords"

In *Switchback*, all the genre signifiers – medium, timbre, harmony, and syntax – align to reinforce the piece's position within its xenharmonic electronic subgenre. In other works, the association of intensional syntax with popular music genres is either problematised or dispelled.

In the final movement from *Odd Coils*, "Four Chords," the clash of genre expectations and syntax takes centre stage. It was inspired by the song "Old Friend" by Mitski, which takes a standard sequence of guitar power chords, I – V – vi – IV, and subtly warps it.[88] Mitski adds a beat of chord III at the end of the fourth measure and, as she approaches the chorus, the fourth bar of the sequence gains a beat. The sequence is continually altered to change the emphasis of the lyrics or deny resolution.

"Four Chords" takes Mitski's riff as a starting point, elaborating it as the piece progresses. Each loop leads inexorably back round to its beginning, establishing an intensional structure in which harmony serves to elaborate an unfolding, extended present. This structure is established both introversively, through the riff's repetition, and extroversively: the riff begins with one of the most cliched gestures in contemporary music, whose looped continuation is a well-established trope. The intensional structure is inflected through variations in texture and harmony. The piece uses major, minor, subminor, and neutral scales on A. The recurring riff is in A major, with the occasional minor substitution, its figuration alternates between A subminor and A neutral. This tonal clash is semiotically and harmonically productive.

Semiotically, there is a clash between the riff and its harmonic setting that operates over several layers of expectation. As "Four Chords" is the last movement of *Odd Coils,* the listener has learned to expect quartertone tonality. The cliched riff comes as a surprise, even as a joke. It swiftly establishes its own set of expectations, which are denied twice in the piece's fifth bar, first by the shift to chord III, then by the added quaver. The arrival of quartertone harmony in bar six is a surprise on one level, as it denies the harmonic expectations of the riff, and is expected on another, as all previous movements have used quartertones. The listener might expect this quartertone harmony to prompt a move away from the intensional language of the original material and into a more extensional language reminiscent of the other movements. The indefatigable continuation of the riff provides a final surprise.

Harmonically, the alternation of modal areas allows for complex intensional variation of the underlying riff though harmonic ambiguity and quartertone chromaticism (see ◂ Figure I-28). The symmetry of the subminor stacks used in "Four Chords" results in ambiguity

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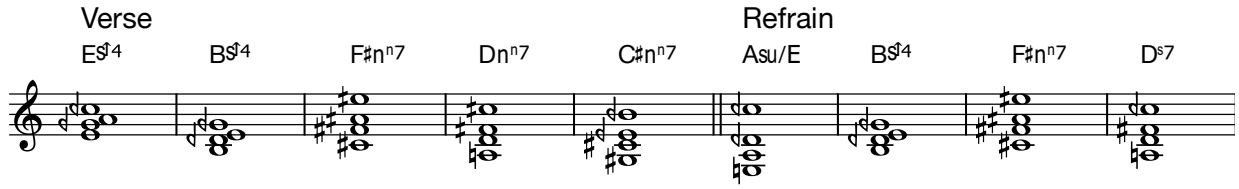
[87] This diagram is inspired by Anna Meredith's approach to electronic music, see: Anna Meredith, 'Anna Meredith: Dynamic Sketches FIBS', YouTube, 2020, https://www.youtube.com/watch?v=p7L-45db5-o.
[88] Mitski, *Be The Cowboy* (Dead Oceans, 2018).

about the roots of the chords, creating a more varied harmonic language that the simple riff would suggest. For example, the subminor chords in the first bar of the verse and refrain loops are voiced differently. In the verse, I voice it as a subminor stack, suggesting a root of E. In the chorus, the G𝅘𝅥 is replaced by a D𝅘𝅥, and the fourth is heard an octave lower, creating the impression of an extended A supermajor chord. Quartertones allow for more complex passing notes and figurations, as in bar 20-21, where the chords are decorated with modal substitutions, or in bars 7-8, where the subminor D𝅘𝅥s and G𝅘𝅥s lead strongly via quartertones to the major C♯s and F♯s. The impression overall is of a shifting and complex harmony with tight voice-leading maintaining coherence.



◂ Figure I-28: harmonic reduction of "Four Chords," *Odd Coils*.

While most of the interest in the work occurs on a syncritic level, harmonic and textural change animate a diatactical structure. Several devices are used to build momentum towards a harmonic change in bar 36. The figuration gradually becomes denser: first, more and more of the bar is taken up by semiquavers, then, in bar 31, demisemiquavers are introduced. This moment is accentuated with a sudden stripping back of the texture, a device for emphasis common in rock music. In bar 36, the chords are reordered, travelling upwards through the sequence. When it reaches the ♭VI, two more chords (♭VII and VII) are added to bring the piece back to a cadence on I. In this final passage, then, I use aspects of a more teleological, diatonic progression to create forward motion, without losing the four-bar harmonic rhythm so crucial to the looped harmony.

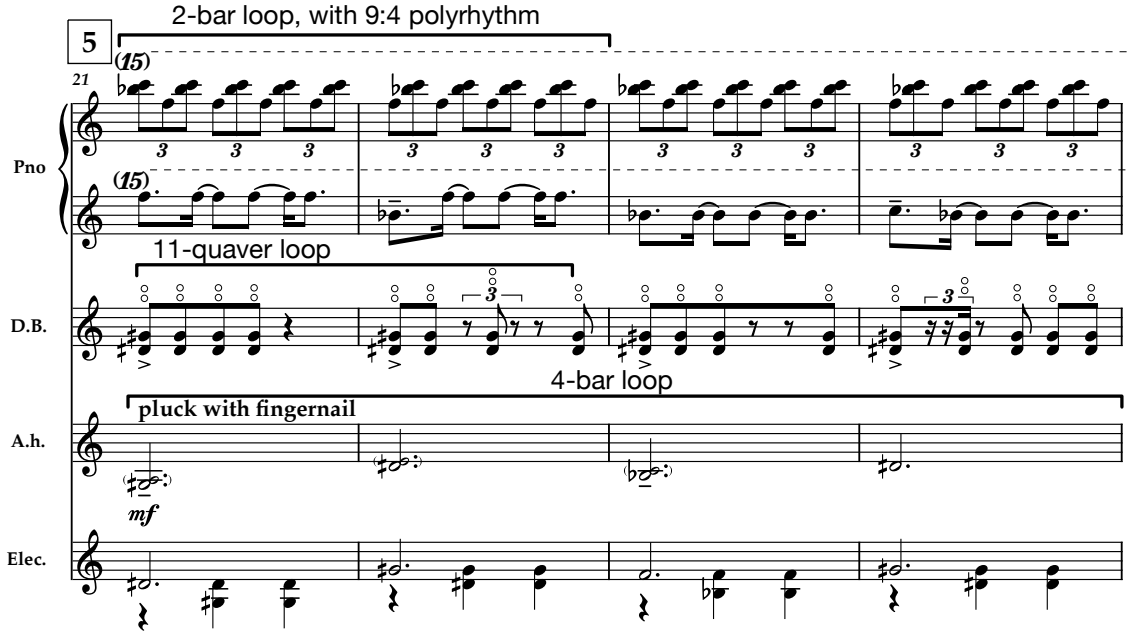
Tagg describes this kind of structure as 'centrifugal', in contrast to the 'centripetal' form.[89] In a centripetal form, the music travels through primary and secondary loops, returning to the 'core' primary loop at the end. In a centrifugal form, the ending differs. It is as if the repetitions have allowed the piece to achieve escape velocity and reach a new harmonic space. In the centrifugal form of "Odd Coils," the repetitions of the loop bear structural weight. They could not be excised without dampening the impact of the moment of change.

Combining syntaxes in *Nocturne*

In *Nocturne*, for piano, double bass, percussion, and live electronics, I combine intensional and extensional logics. I undercut the repetitiveness of the piece's looped structures with polyrhythmic and polymetric detailing. The first loop, for example, builds up over the course of 20 bars. ◂ Figure I-29 shows the polyrhythmic and polymetric loops that accumulate in this passage, which juxtapose two rhythms in $\frac{3}{4}$ with an 11-quaver loop in the double bass. This approach persists through the piece, with the passage from Figure 14

[89] Tagg, *Music's Meanings*, 393.

including a particularly challenging 25:24 cross rhythm, creating a flexible and elusive metric landscape that contributes to an aesthetic of ambiguity.



◂ Figure I-29: cross-cutting loops, bars 21-24, *Nocturne*.

The piece falters, however, when I create transitions from this intensional landscape to a more extensional one. The homophonic melody at Figure 19 is unprepared and sounds somewhat out of place; its jarring arrival serves no musical purpose. I handled the shift out of this section with greater care, combining a semiquaver piano loop with a simple double bass melodic line, unifying the intensional and extensional logics of the previous sections.

Combining syntaxes in *Straight Line Through A Landscape*

In *Switchback* and "Four Chords," intensional syntax is connected extroversively to popular music genres. These pieces show the limits of my reservations about using microtones as a tool of extroversive semiosis that distorts familiar tonal topics. While earlier works had relied on the tonal logic of the evoked topics, these newer works have an independent tonality drawn from my quartertone axis theory. They seem to me less dependent on extroversive semiosis, even if they do not eschew it completely. Such total avoidance is impossible, listeners inevitably draw connections and categorise the musical objects they hear. Nonetheless, I often aim for abstraction; this deliberately referential approach is not one I return to often in this portfolio.

In many of my pieces, intensional and extensional logic sit side by side without evoking a clash of genres. This is the case in *Straight Line Through A Landscape*, a twenty-minute-long piece for mixed quartet. The work is structured by the movement of siphoned water through four interconnected glass demijohns. This creates an element of indeterminacy, as the timing of the flowing water cannot be exactly predicted. Each movement from Movement II onwards needed an indeterminate end, to give time for the percussionist to move the

demijohns. Extensional writing does not work well with indeterminacy, so I wrote intensional passages at each movement's end.

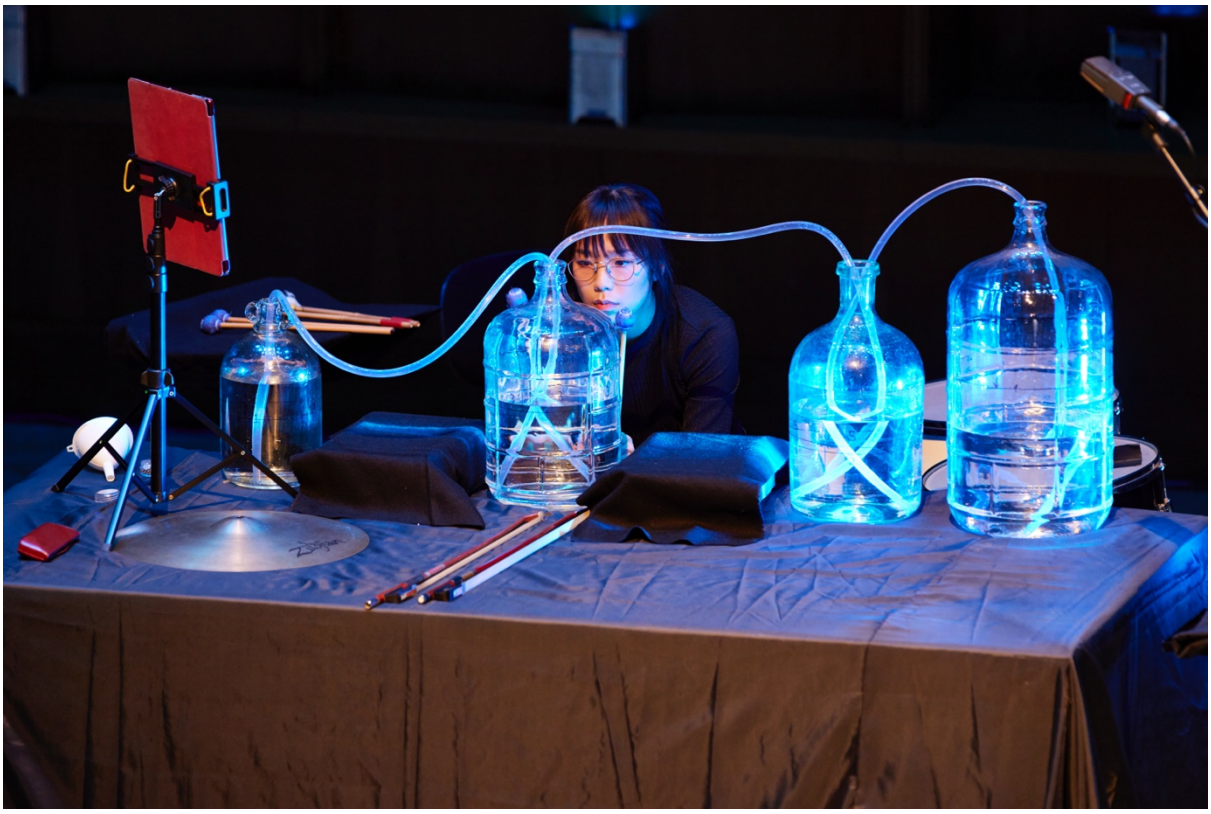
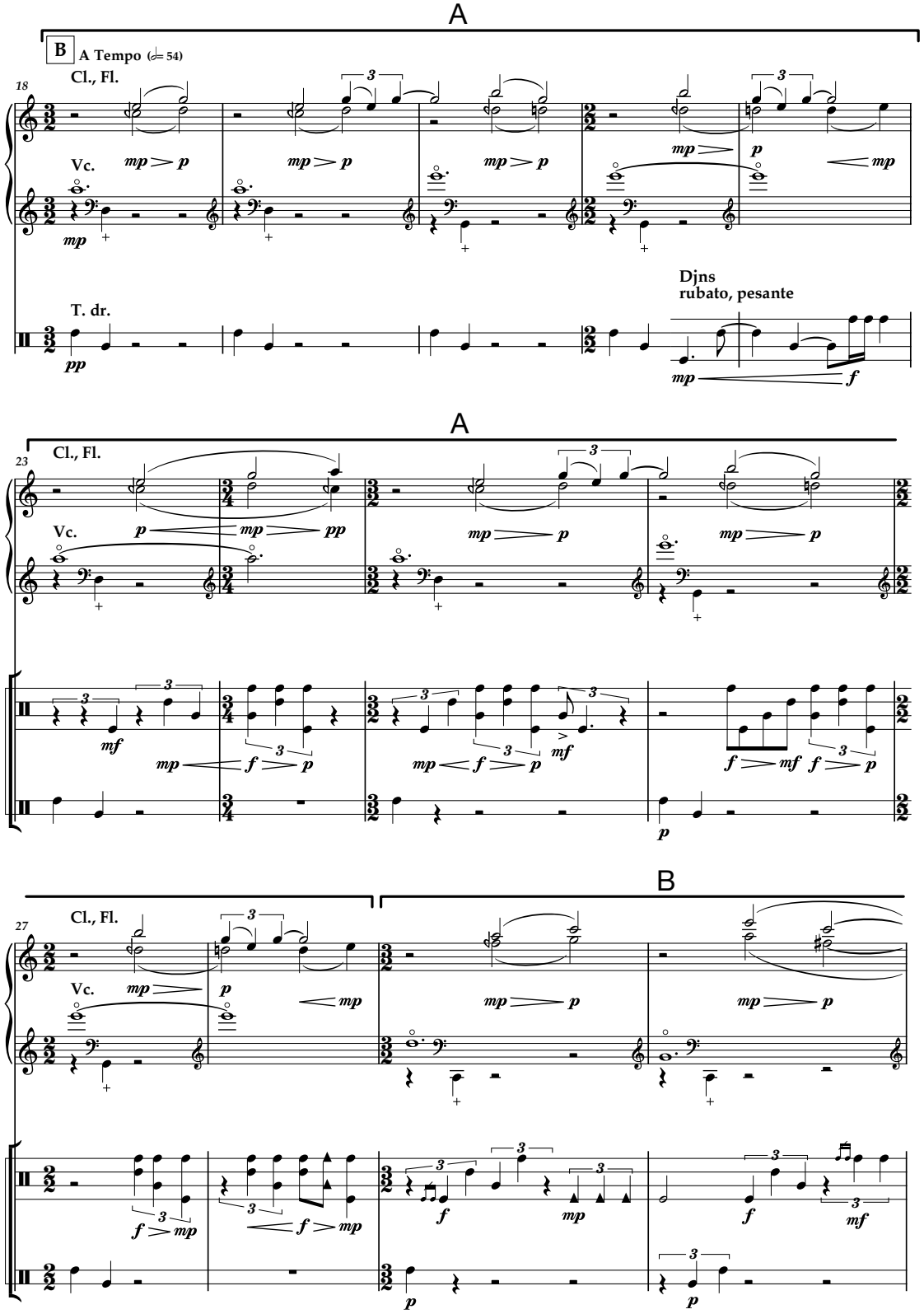


Figure I-30: percussionist Angela Wai Nok Hui with the siphoned demijohns.

The first such passage occurs at Figure B, Movement II (◂ Figure I-31). Following an extensional opening, the intensional passage at Figure B uses a dance-like figure, with a clear pulse, clear and static tonal area, and circular harmonic patterns. Interest is created through the elaboration of the underlying rhythmic and harmonic constants. I structured this section around four phrases in D subminor, with the structure AABB. The first two are what Tagg would describe as a 'shuttle' between two chords: an A subminor and an E minor with a subminor seventh.[90] Quiet, plucked bass notes reinforce the absent tonic of D. In the B section, it cadences onto the tonic, before moving swiftly to more remote harmonies, introducing the harmonically distant F♯ in bar 31. While there is an internal impetus from one chord to the next, these loops are fundamentally non-directional: the end of the B section leads us only to expect the return of the A section.

I create local interest through the build-up of the percussion part and alterations of metre. The percussion part becomes faster and more complex throughout the section, climaxing in bar 32 at the end of the first B section. The pitched instruments accompany the percussionist's solo, with the soloist's phrases crossing bar lines in a way that the pitched instruments never do.

[90] Tagg, *Everyday Tonality II*, 369.



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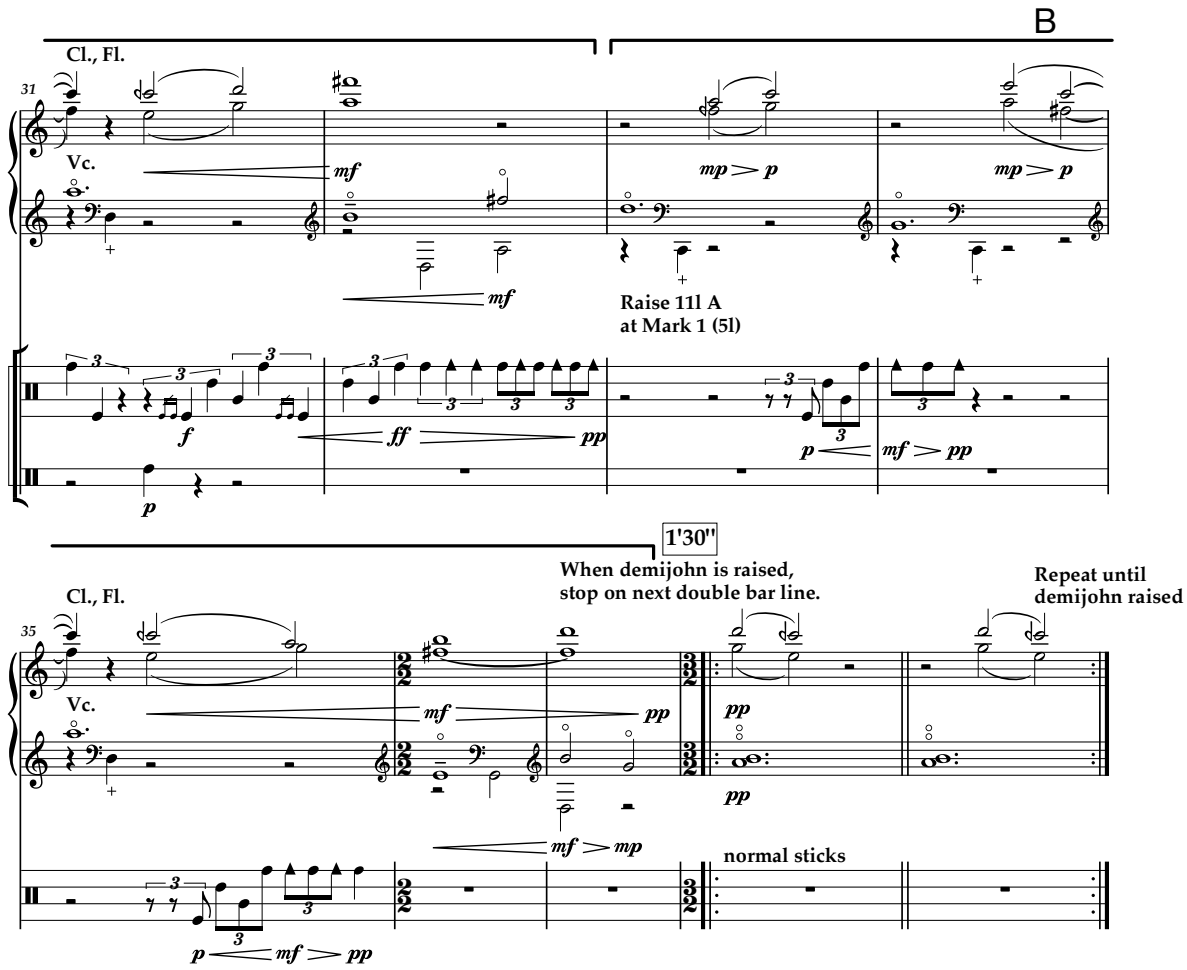

◂ Figure I-31: bars 27-39, Movement II, *Straight Line Through A Landscape*, reduction.

I generate rhythmic interest through additive processes. The loops have a minim pulse and triple metre, but in the A section and the second of the B sections, bars of $\frac{2}{2}$ stretch the final chords, delaying the re-start of the loop. At the beginning of the second loop, I add a beat in its first bar, a destabilising moment that undermines the predictability of the section. When the section comes to rest in bar 38, the $\frac{3}{2}$ pulse is further disrupted by the asymmetry of the rhythm of the chords. The rest at the end of bar 38 leaves us expecting a rest at the end of bar 39, even though this would add a beat to the metre. But after the unstable meter of the previous section, this is expected. When the repeated section stays carefully in $\frac{3}{2}$, the impression is of a limping, odd rhythm, despite its regularity.

I effected a transition out of this section by focusing on the tonally out-of-place F♯s, which act as chromatic alterations of the expected G♮s. In bar 2 of Movement 3, the F♯ propels us into the next movement, facilitating a key change into F♯ neutral. The material I used to create detailing in the intensional section thus becomes a crucial aspect of the diacritical structure.

C. Questioning The Quartertone Axis System

> *Diatonic tonality as an inescapable referent in* Fugue In B Flat Subminor – *Exoticism and cultural contexts – Rethinking scales and triads as zones on an interval circle – Rethinking* "Folding" *– Zonal thinking in* Straight Line Through A Landscape *– The realities of instrumental performance in the quartertone axis system – Composing for piano in* Nocturne *and* Nocturne Variations

The examples in the section above are chosen carefully: they are passages in which the quartertone axis system functioned as planned. But much of my experience of the system illustrated its unruly relationship with encultured expectations and the material reality of instrumental performance. I had seen my 24EDO scales as equivalents to the diatonic scale, able to create an independent, tonic-centred tonal language. In practice, however, my scales could not be separated from the associations of diatonic tonality. My attempts to do so in my fugues proved challenging and illuminating. The autonomy of the axis system was further undermined by the perception of exoticism in its xenharmonic sounds. Understanding this material meant understanding its cultural contexts, not just its microtonal affordances.

I found that the harmonic language of the axis system was best understood through the lens of popular music diatonicism, as interpreted by Tagg. This re-framing suggested aspects of tonal flexibility within the system. While I had moved away from a rigid understanding of the axis system in some earlier works, such as *Odd Coils*, I had not understood the possibilities this change offered. In *Straight Line Through A Landscape*, I was able to use this newly analysed flexibility for expressive purposes. This initiated a shift in my understanding from a Neoplatonic conceptualisation of these scales towards a perspective that emphasised their contingency and relationality.

The ghost of diatonic tonality in quartertone fugues

I planned to write a series of fugues in each of the three 24EDO scales to illustrate aspects of this new tonality. My approach resembled the work of Aaron Andrew Hunt, who wrote fugues in each of the EDOs between 5 and 20.[91] Hunt followed the lead of Blackwood's *12 Microtonal Etudes*,[92] treating each EDO as offering a distinct musical colour. My approach, by contrast, focused on the varied colours available within a single EDO. I thought of fugues as exhibitions of the tonal style in which the subject presents the key melodically, the countersubject shows its contrapuntal potential, and the transpositions of the subject demonstrate relationships between the tonic and its related keys. I hoped writing fugues would teach me more about the quartertone axis system.

In that regard, the experiment was a success. Compositionally, however, it was close to a failed experiment: I only completed one fugue, in B♭ subminor. I wrote nine alternative subjects in the neutral, completing several expositions before calling off the attempt. In the superperfect, I gave up after a single completed exposition. These failures are linked by a clash of introversive and extroversive semiosis that undermined the fugal form.

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[91] Aaron Andrew Hunt, 'The Equal-Tempered Keyboard' (Zwillinge Verlag, 2021).
[92] Jeffrey Kurst, *Microtonal* (Chicago, Illinois: Cedille Records, 2005).

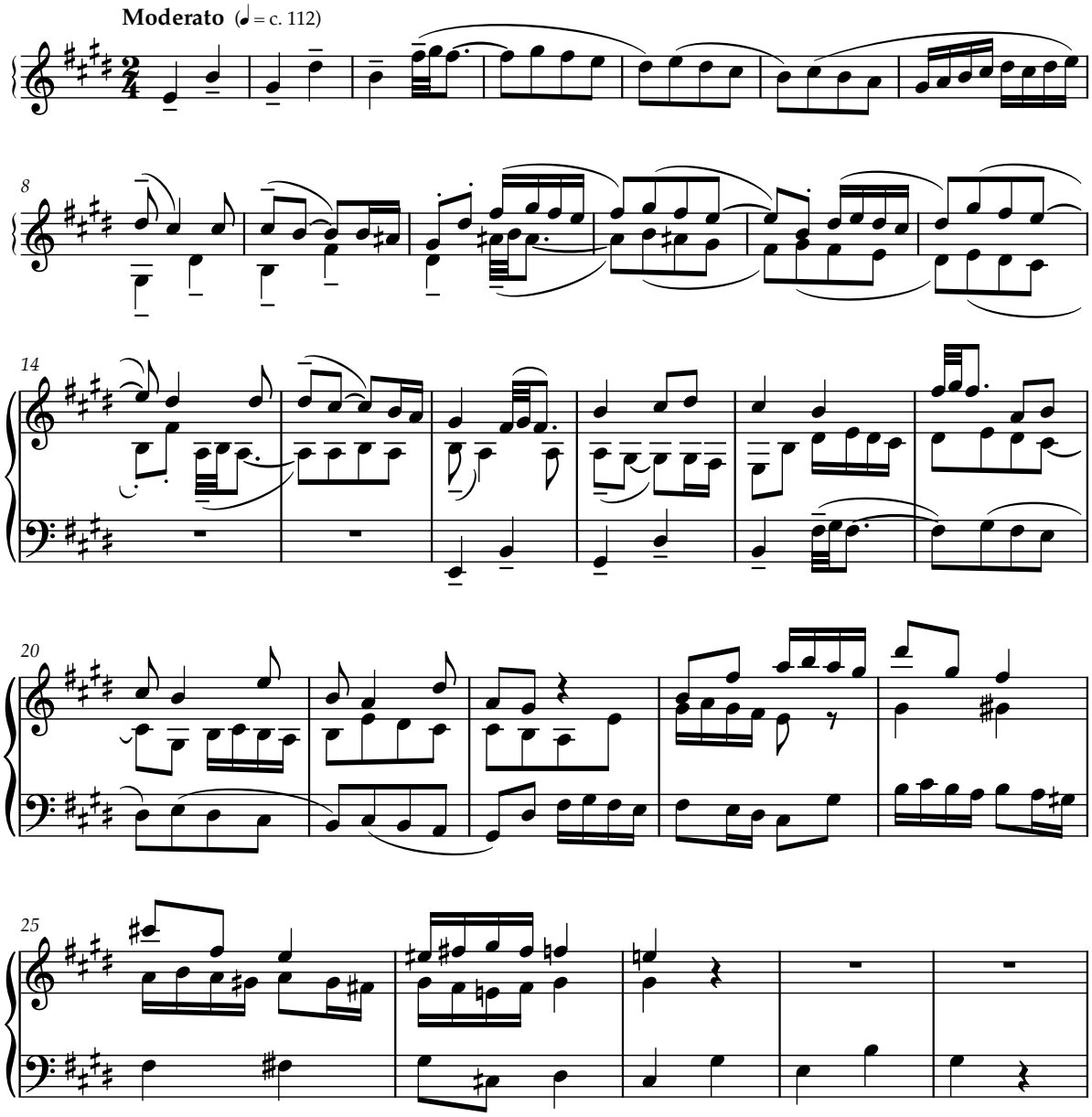
Introversively their tonality was structured by my 24EDO scales, extroversively they were haunted by diatonic tonality.

Fugues are aurally distinctive; the genre is clear as soon as the answer enters. It may be apparent even earlier, as fugue subjects have a distinctive character. Not only do they typically enter in a single voice, span no more than an octave, and include every note of the key, but they also tend to have a somewhat declarative sound, with one or two distinctive motivic aspects suitable for later elaboration.[93] My fugues stuck closely to a traditional, academic model, resulting in a strong extroversive evocation of this topic. I echoed this decision in the notation style, omitting written dynamics.

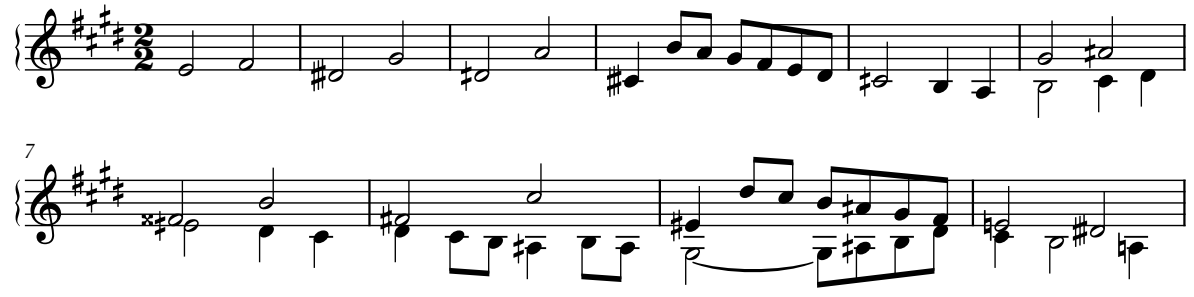
When constructing my fugues, I had to decide what the harmonic relationship would be between the subject and the answer. In diatonic fugues, they are separated by a fifth, which is both the scale generator and the most acoustically consonant interval in the scale. Keys a fifth apart differ by just one pitch class, restraining the answer's tendency to modulate away from the tonic. In my 24EDO scales, by contrast, the scale generators (subminor third, neutral third, superperfect fourth) are relatively dissonant. I decided to separate the subject and answer by these generator intervals, to minimise the number of new pitch classes in the answer. I judged that these unfamiliar scales needed consistent macroharmony to become aurally established. I was also attached to the conceptual neatness of viewing the 24EDO generators as equivalents of perfect fifths. But having subjects enter on non-fifth-related scale degrees cut against the fugal topic and often simply sounded wrong. For the neutral and subminor, the generator interval was too close to the tonic, for the superperfect, it was too dissonant. Other composers of fugues who have pushed the genre's limits – Béla Bartók, Astor Piazzolla, and Dmitri Shostakovich – have preserved the fifth relationships.

My efforts were also undermined by the varying extent to which my 24EDO scales resembled diatonic scales. The associative strength of the fugal topic established a set of tonal expectations that the neutral and superperfect scales were unable to fulfil. The neutral scale foundered on its over similarity to the diatonic scale. Expositions written in the neutral sounded like out-of-tune major expositions, if they stayed largely within the key (◂ Figure I-32), or like out-of-tune minor expositions, if they featured chromatic alterations (◂ Figure I-33). The subject in ◂ Figure I-32 addressed this problem by emphasising the neutral third, the simplest interval which differentiates the scale from its diatonic equivalents, but this approach was insufficient as the counterpoint became denser.

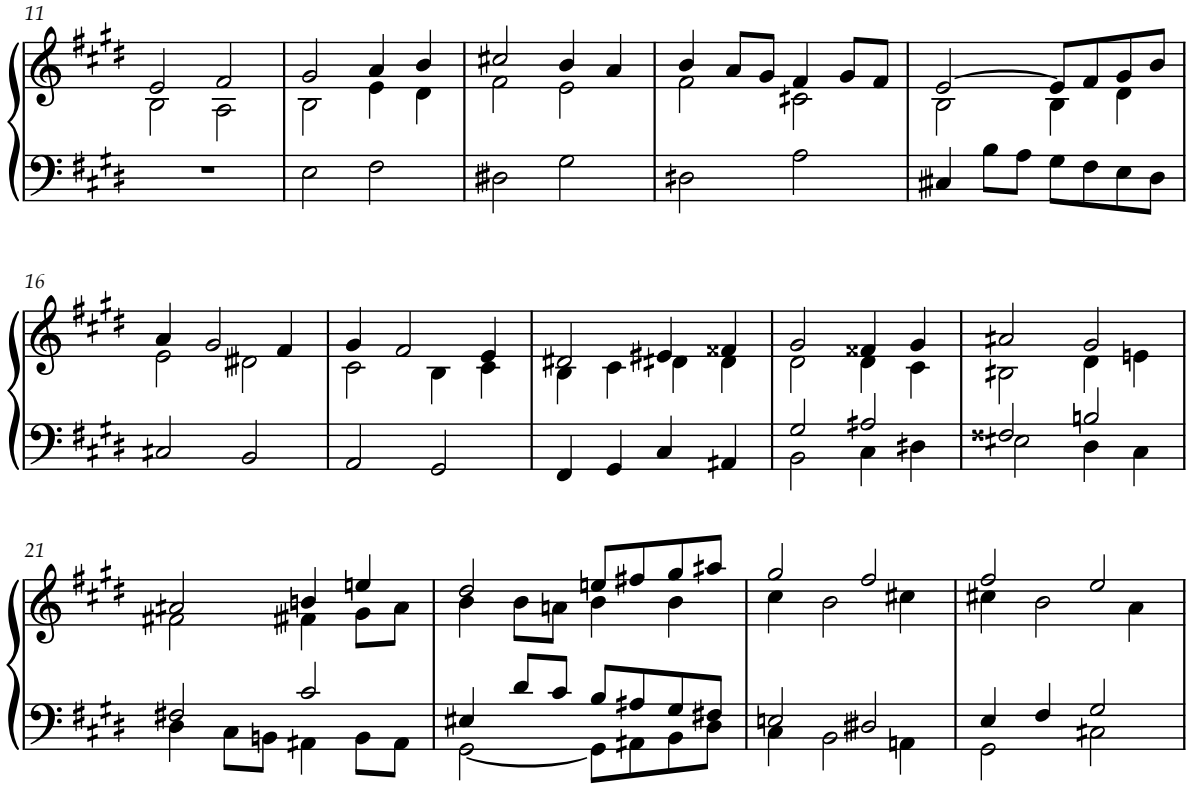
[93] Jesper Rydén, 'On Features of Fugue Subjects. A Comparison of J.S. Bach and Later Composers', *Journal of Mathematics and Music* 14, no. 1 (2 January 2020): 1–20, https://doi.org/10.1080/17459737.2019.1610193.



◂ Figure I-32: within-key neutral fugue exposition, *Fugue in E Neutral 1*.



◂ *Figure I-33 continues on next page.*



◂ Figure I-33: chromatic neutral fugue exposition, *Fugue in E Neutral* 2.

My superperfect exposition (◂ Figure I-34) had the opposite problem: it was too different from the diatonic scale to be used within a fugal framework. Its thirteen-note cardinality made it hard to write a subject that used all the scale's pitch classes and thus establish the superperfect tonality. My subject omits six of the thirteen pitches, resulting in an exposition that sounds more like free quartertone chromaticism than tonality. The dissonance of the superperfect scale was even more troublesome than its cardinality. I tried to create consistency and emphasise consonance by beginning bars with either a superperfect fourth, the generator interval of the scale (the blue brackets in ◂ Figure I-34) or with a consonant interval (the red brackets in ◂ Figure I-34). However, when the counterpoint became denser this became less possible: the consonant intervals in bars 11 and 13, for example, are made dissonant by the addition of the third voice.

The subminor scale proved to be a happy medium, resembling the diatonic scale enough to function within a fugal framework, but not so much that it sounded like a distorted version of it. The most effective moment of the piece, however, comes when the subject is presented in the counterpole neutral in bars 20-23, providing tonal contrast.

This experiment reveals important parts of the answer to my research questions. First, while the neutral-subminor axis can create a coherent tonal discourse, the neutral scale cannot do so on its own. As much as I want to take microtones on their own terms, an encultured knowledge of diatonic tonality inevitably colours the reception of these scales. For Western ears, the neutral scale is too like the diatonic scale to stand alone for long in a triadic context.

This seems particularly the case in a genre like the fugue, which has such strong associations with common-practice tonality. An interesting point for further research would be to write stylistically freer fugues within the neutral-subminor axis system rather than in the individual 24EDO scales.

Second, the perfect fifth – Ives's 'inexorable thing' – remains crucial in creating acoustic consonance and cadential structures. While the generator intervals of the 24EDO scales are important aspects of their tonic structure, they cannot supplant the perfect fifth and its rhetorical force.

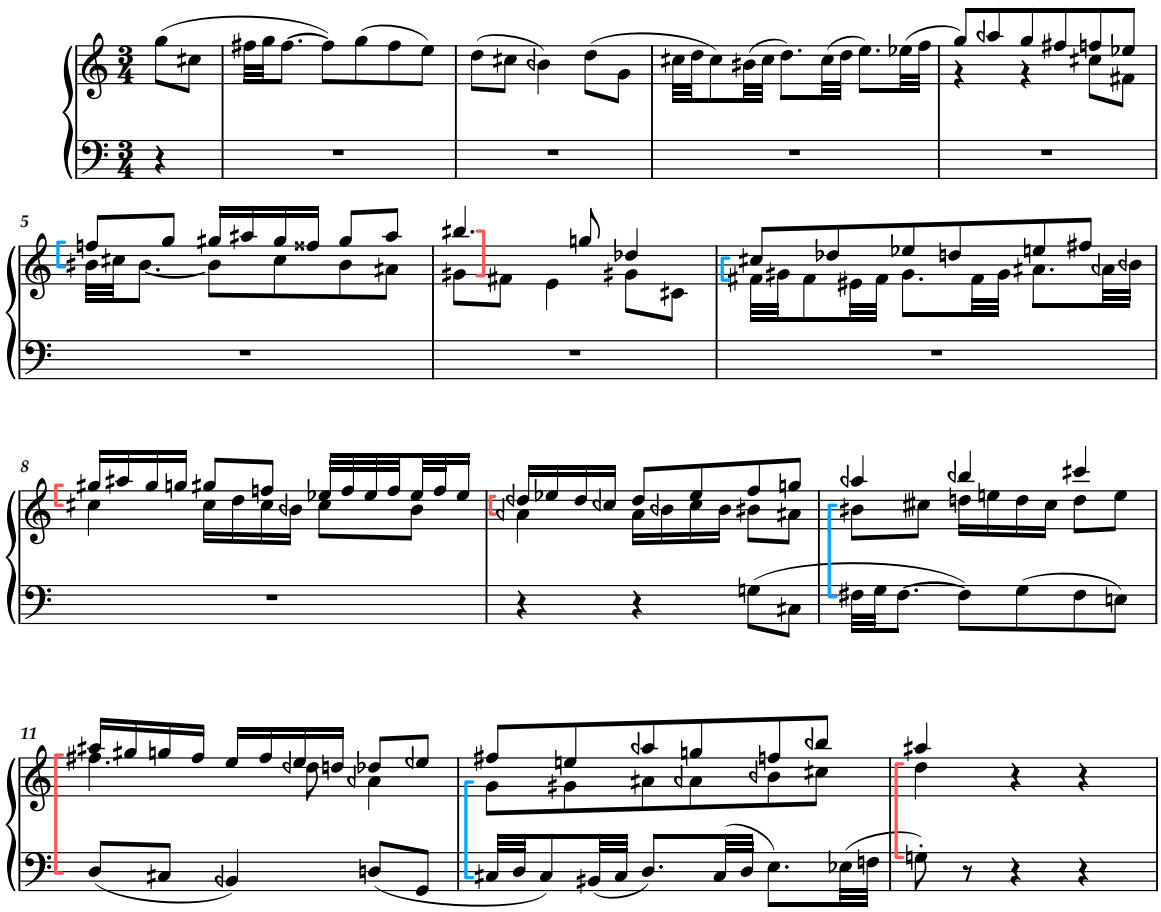


Figure I-34: *Fugue in G Superperfect*, with consonant intervals marked in red, and superperfect intervals marked in blue.

The ghost of exoticism in quartertone harmony

Diatonic topics were not the most troublesome referent for my quartertone music. I have been frustrated to receive occasional comments from listeners that my music sounded "exotic." The Western identification of xenharmonic sounds with exoticism and orientalism has a long history that reaches across experimental and popular traditions. In the 1930s, for example, American experimentalist Henry Cowell was drawn to the microtonal scales he

identified as 'very frequently used in primitive music, and often in Oriental music.'[94] For many listeners encultured in Western music, particular xenharmonic sounds are tied up with crude exoticisms, like the faux muezzins and pseudo-duduks of Hollywood films.

As Daniel Walden shows in "The Politics of Tuning and Temperament," the history of intercultural exchange on the topic on intonation is complex and bound up in the colonial legacies of the Nineteenth and Twentieth Centuries.[95] I am both interested in cultural exchange and cognisant of the history of unequal exchanges within the Western experimental tradition in which I work. As my music does not draw on scales from other cultures, I am keen to avoid the inadvertent evocation of exoticist tropes. My music is rooted in triadic, contrapuntal logics that stem from my musical background in Western classical and popular music. While there are similarities between the neutral scale of the axis system and maqām rāst, my harmonic approach differentiates them.

It has become clear that my music evokes exoticist topics when I accompany xenharmonic pitch with specific timbral and textural signifiers. Texturally, monophonic passages and fast-moving parallel homophony are more likely to be perceived as exoticist, perhaps because they mitigate the triadic structures that most clearly locate my tonality within Western idioms. Timbrally, inharmonic sounds and solo woodwind melodies have proved especially problematic, perhaps recalling imitations of gamelan and duduk to some listeners.

In some passages, like the beginning of Movement II of *Straight Line Through A Landscape* (◂ Figure I-35), these elements coalesce. I do not yet know how to think about such moments. My knowledge of the personal, interior process that led to their sound obviates my ability to hear the exoticism in them, though I understand why it might be heard by others. This inadvertent signification bothers me, despite being pleased with the music. The embeddedness of my music in these networks of cultural signifiers illustrates the limits of my Neoplatonic approach. Wielding this musical material more deftly requires greater understanding of these signifiers, rather than a retreat from them.

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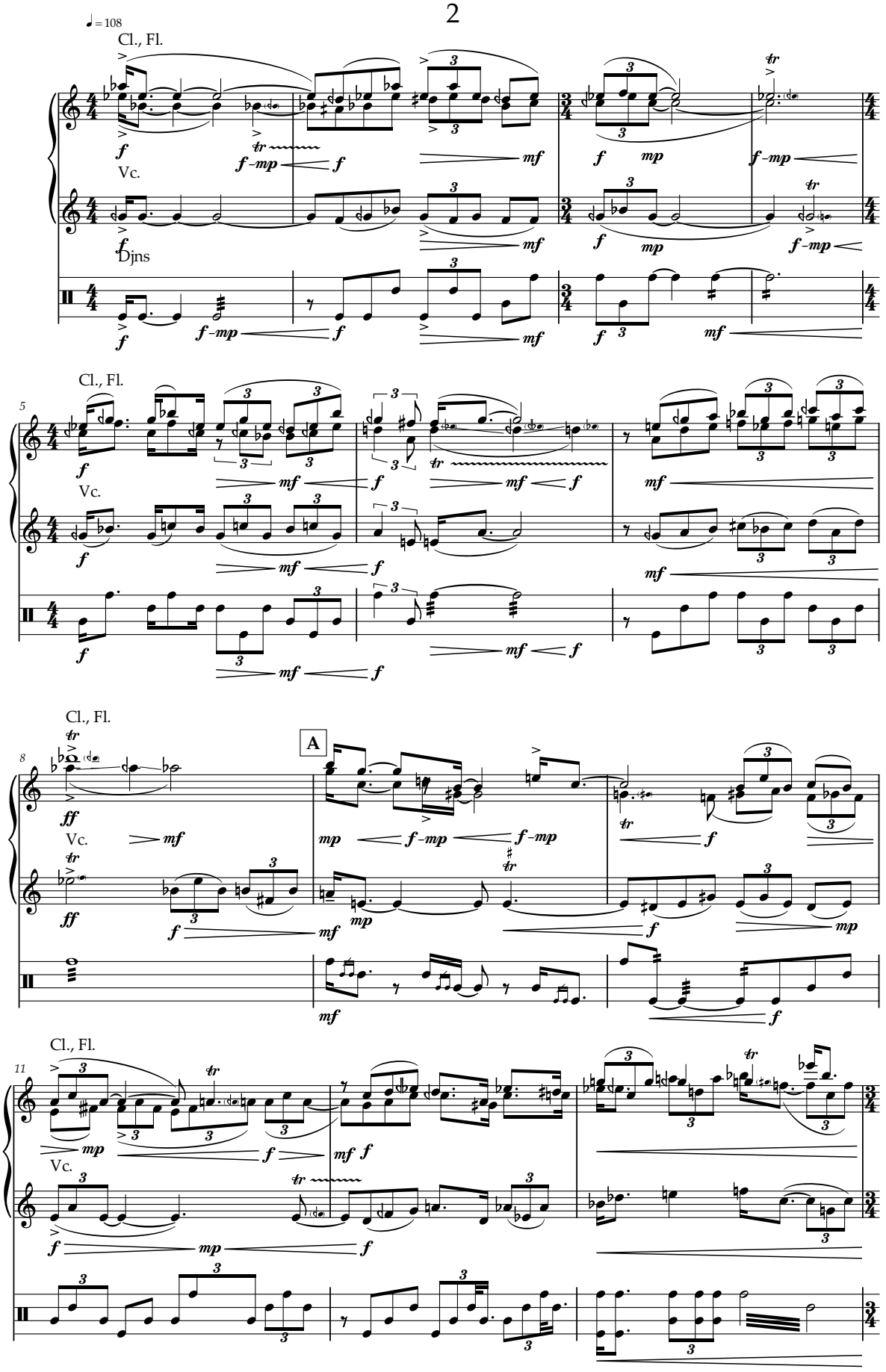
[94] John Corbett, '5. Experimental Oriental: New Music and Other Others', in *Western Music and Its Others*, ed. Georgina Born and David Hesmondhalgh (University of California Press, 2001), 167, https://doi.org/10.1525/9780520923799-007.
[95] Daniel Kitt Schelly Walden, 'The Politics of Tuning and Temperament: Transnational Exchange and the Production of Music Theory in 19th-Century Europe, Asia, and North America' (PhD Dissertation, Harvard University, 2019).



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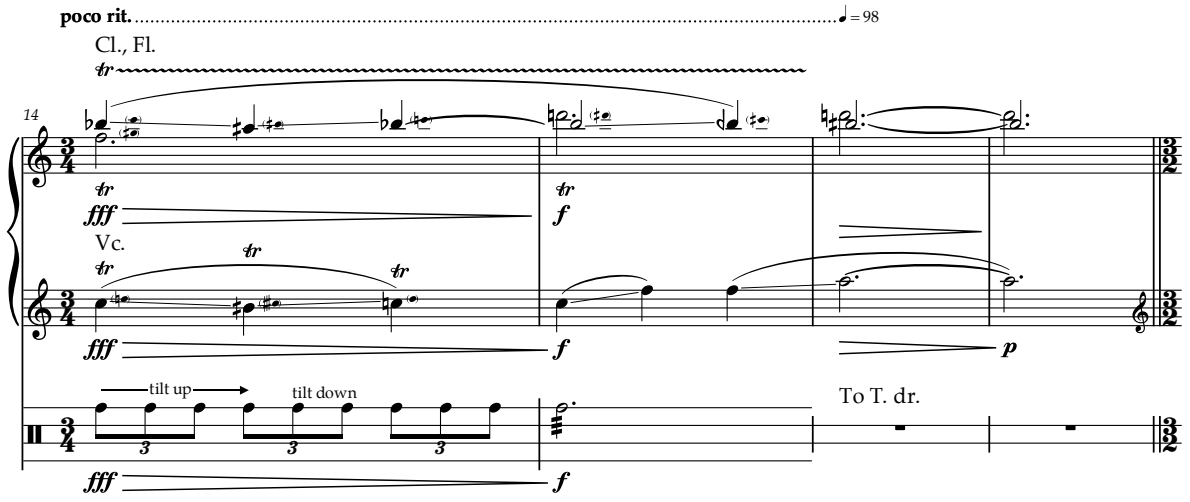


Figure I-35: bars 1-17, Movement II, *Straight Line Through A Landscape*, reduction.

Scales, or a weighted region of an interval circle

It also required a better understanding of my own harmonic instincts. Through engagement with my material and with the work of Tagg, I came to understand that my harmony was more shaped by popular music that I had assumed.

In the earlier works in this portfolio, like these fugues, there was a disjuncture between my understanding of my harmonic material and my use of it. I thought I was using specific modes of fixed scales; I created comprehensive modal taxonomies and coined neologisms. In fact, my use of quartertone material was not so hierarchically oriented around tonics and roots, and demarked less strictly which notes were included or excluded from a scale or chord. My use of the materials resembled less a Neoplatonic model of scalic patterns and more a network of intervallic relationships governed by interval circles. My change in perspective altered my understanding of the scales I was using and the chords I had found within them, suggesting that they were more harmonically flexible than I had anticipated.

In common-practice tonality, the dominance of the major and minor modes and the strong signalling power of the perfect cadence create some certainty about the tonic of a piece. Those resources are not available within my 24EDO scales, making them less tonic-centred. The result is that I am not, as I thought, using my scales as modes constructed around a strong tonic, but as weighted regions of an interval circle. By this I mean both that the scales occupy a specific region of the interval circle and that a narrower part of that region is given more significance, or weight (see Figure I-36). This distinguishes the approach from a mode, in which a specific note is given precedence, and from pandiatonicism, where all notes within the region are treated equally. In my music, this weighted zone has fuzzy edges. I use chromatic notes, which are more likely to be close to the weighted zone than further away, and thus ought to be understood as extensions of the weighted zone rather than as discrete chromatic additions.

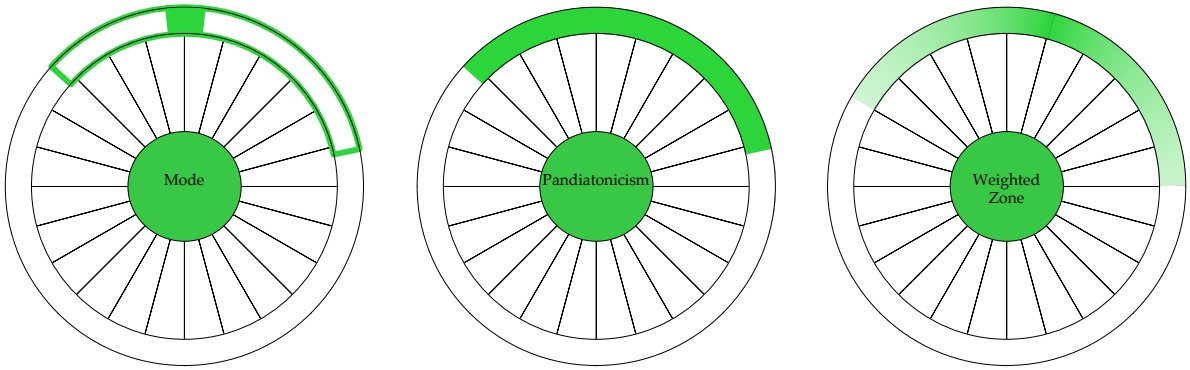


Figure I-36: three different approaches to tonal weighting.

In this way, my approach to tonality is more like popular music tonality than common-practice tonality. Tagg observes that the tonic is often unclear in popular music,[96] with harmonies instead oriented around 'a central area of tonal reference.'[97] In my music and, Tagg argues, in popular music, it is phraseology that creates local tonal centres.[98, 99]

Triads, or symmetrical generator structures

These local tonal centres are generally the 24EDO triads discussed earlier, particularly those made of subminor and neutral thirds. I initially understood these as tonic triads equivalent to the major and minor tonic triads of diatonic harmony. But my 24EDO chords are symmetrical and constructed from the generator intervals of their scale. As a result, in my music they act more like quartal/quintal harmonies.[100] Again, Tagg's analysis both described my existing practice well and shaped my practice going forwards. He insists on treating quartal harmonies as distinct tonal objects, rather than as distortions of triadic harmony.[101] To this end, he coins useful new chord names, such as the quartal and quintal 'stack' (Figure I-37). He identifies three characteristics of quartal harmony that are also present in my axis system: root flexibility, ease of cyclical movement, and a connection between cyclical conjunctness and intervallic identity.

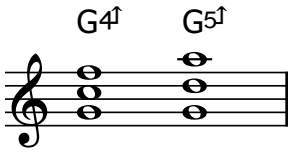


Figure I-37: quartal and quintal stacks on G, with Tagg's chord symbols.

[96] Tagg, *Everyday Tonality II*, 424–25.
[97] Tagg, 295.
[98] Tagg, 424–25.
[99] This is reminiscent of Bruschi's analysis of Blackwood's work: Bruschi, 'Hearing the Tonality in Microtonality', 131.
[100] Henceforth, I will follow Tagg's lead and designate this harmony simply as 'quartal.'
[101] Tagg, *Everyday Tonality II*, 291.

Root flexibility

Tagg observes that, unlike triadic harmony, the root identity of a quartal stack is unstable in inversion.[102] In Figure I-38, for example, the first inversion of the quartal stack on C becomes an F^4.[103] As a result, these chords have 'area of tonal reference that is wider and more fluid that the precise tonic orientation of conventional tertial harmony' – a given pitch class set can be inverted to suggest several different root notes.[104]

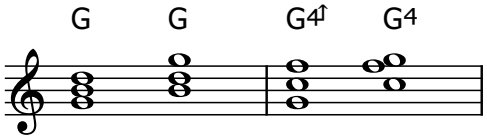
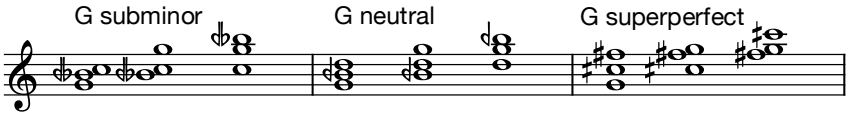


Figure I-38: inverting triadic and quartal harmony.

My subminor chords behave similarly (◂ Figure I-39). In a subminor stack, the lowest note sound like a root. When inverted, the asymmetry of the chord draws the ear towards the perfect fifth, assigning the lower note of the fifth as the root. The middle note of the initial stack, however, is hard to hear as a root, as it does not stand in a perfect relationship to any other note. In subminor tetrachords, however, every note has a perfect relationship with another note. Any note may be heard as a root in some inversion, creating harmonic fluidity.



◂ Figure I-39: inverting 24EDO generator chords.

This suggests that quartal chords' non-identity in inversion has a different cause than Tagg suggests. While the symmetry of the chord is important, more so is the role of the 'inexorable' perfect fifth as the arbiter of a chord's root. This change of emphasis raises a question: can one really hear the subminor stack as a root position triad? It could be heard as a second inversion of a seventh chord rooted on its highest note, a hearing reinforced by the chord's closeness to the Just chord 6:7:8. I treat the subminor stack as being rooted on its lowest note, but the precarity of this interpretation may have contributed to the tonal flexibility I have found in the subminor.

Listening to the inversions of the neutral and superperfect chords confirms the role of the perfect fifth as a signifier of the root (◂ Figure I-39). The neutral triad's structural similarity to major and minor triads means that I hear all three inversions as identities of the same harmony. In the superfourth trichord, by contrast, the closeness of many of the intervals to fifths allows me to always hear the bottom note as a new root.

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[102] Tagg, 294–95.
[103] F^4 is another of Tagg's neologisms: he replaces OMIT3, SUS4 and SUS2 with new symbols 5, 4, and 2, e.g. C^5, C^4, C^2. Tagg, 292.
[104] Tagg, 294–95.

Ease of cyclical movement

Root flexibility is complemented by quartal harmony's relationship to the diatonic scale's generator interval, the fifth. Tagg contrasts movement by fifths in quartal and triadic harmony.[105] Quartal harmonies change one note for each move round the circle of fifths; triadic harmony changes two notes (Figure I-40). Quartal harmony's smooth harmonic movement combines with flexible root identify to allow for rapid fifth-based shifts (as in Figure I-40).

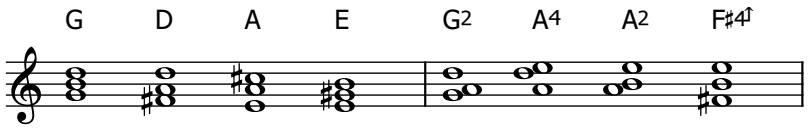


Figure I-40: triadic and quartal motion around the circle of fifths.

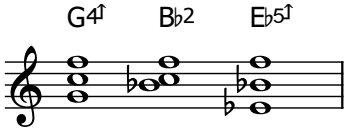
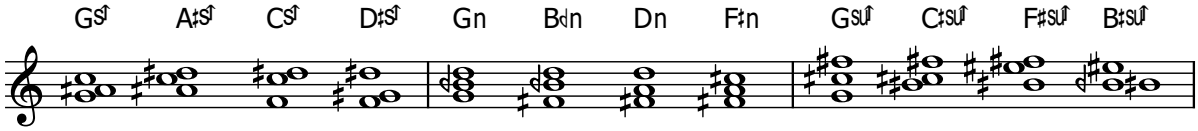
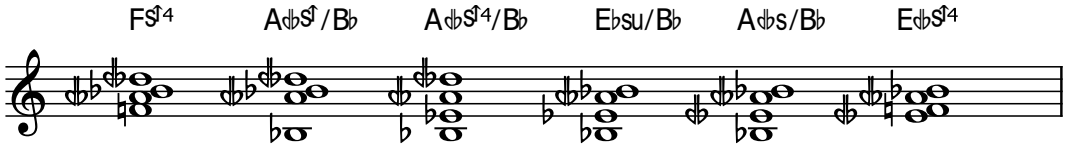


Figure I-41: rapid quartal motion.

The same property is present in my 24EDO generator chords (◂ Figure I-42). The combination of flexible root identity and the smoothness of cyclical motion is most apparent in subminor tetrachords (◂ Figure I-43). Omitting either of the middle notes from the tetrachord leaves inversions of other triads of the subminor, allowing easy transitions.



◂ Figure I-42: generator chords moving around their intervallic circles.



◂ Figure I-43: rapid harmonic motion using subminor tetrachords.

Cyclical conjunctness and harmonic identity

Tagg finds that the more distant on the circle of fifths an additional note is from the quartal stack, the more tertiary the resulting chord sounds.[106] In other words, the greater the cyclical harmonic distance of an additional pitch, the greater the loss of the quartal identity (see Figure I-44). We might describe these chords in terms of how 'cyclically conjunct' they are.

[105] Tagg, 295.
[106] Tagg, 301–2.

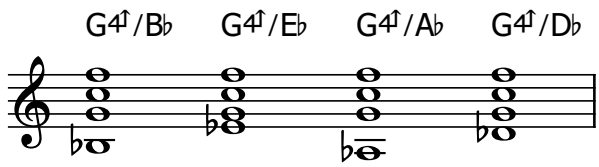
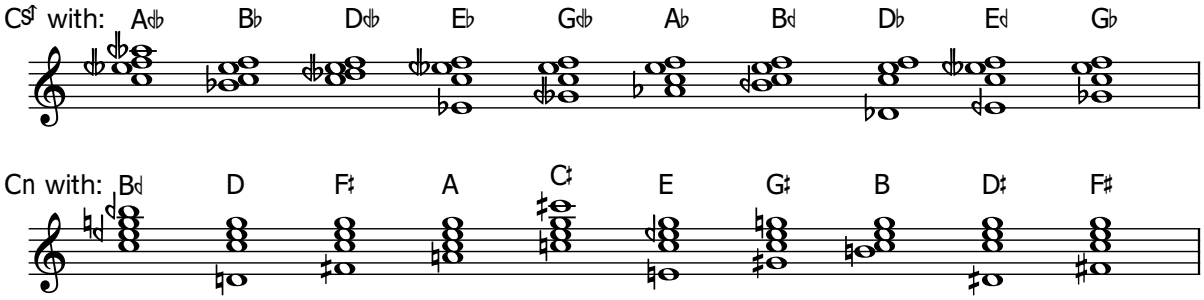


Figure I-44: adding increasingly harmonically distant notes to a quartal trichord.

Similarly, in neutral and subminor stacks, the addition of cyclically distant notes creates dissonant harmonies that are less audibly connected to the character of the original generator stack (◂ Figure I-45). In both cases, however, chords with added notes that are close to a tritone away from the initial chord are less dissonant than nearer notes. This is helpful for my axis system, as it allows for counterpole pitches to be introduced without excessive dissonance.



◂ Figure I-45: adding increasingly harmonically distant notes to a subminor and neutral stack.

Summary

This reframing of my generator chords suggests the importance of thinking of them within their intervallic circles rather than analogously to diatonic tertiary harmony. It emphasises the importance of cyclical conjunctness to intervallic identity and highlights the ease of cyclical movement for generator chords. The inexorability of the perfect fifth, however, ensures that the neutral chord does not have the root flexibility of subminor stack, which has a particularly mercurial harmonic identity.

Reframing "Folding"

My changed understanding of scales and chords prompted me to revisit already-written works. I found that despite thinking that I was writing within a triadic modal system, these pieces could be better understood as using generator chords within a weighted intervallic circle. For example, I wrote "Folding," from *Odd Coils*, using a subminor scale (Figure I-46) which I conceptualised modally (Figure I-48). The first 10 bars use the nine notes of this scale, with an additional D above and a C♯ below, which I thought of as chromatic notes (◂ Figure I-47).

But on reflection, this sharp distinction between chromatic and diatonic is a matter of extent rather than of kind. D and C♯ are better understood as part of a continuity of distance from the modal centre around E (Figure I-49). Along with other pitches more cyclically distant from E, like E𝄮 and C𝄮, D and C♯ play a structural role, propelling the music towards new areas of the subminor circle.

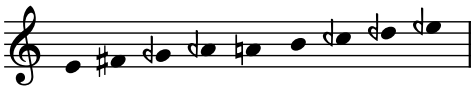


Figure I-46: E subminor scale.

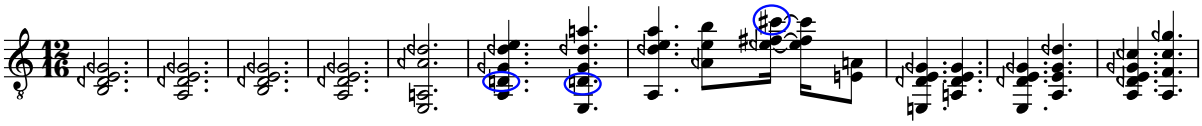


Figure I-47: bars 1-10, "Folding," *Odd Coils*, reduction, with notes outside E subminor circled.

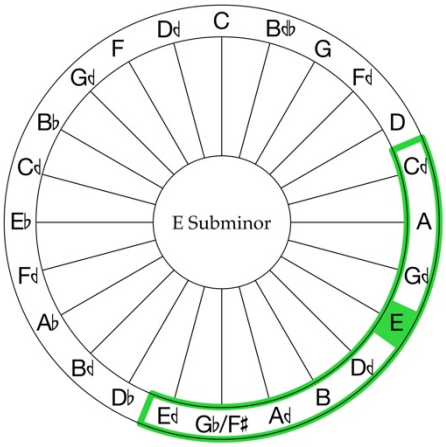


Figure I-48: tonic area of "Folding," Odd Coils expressed as a mode.

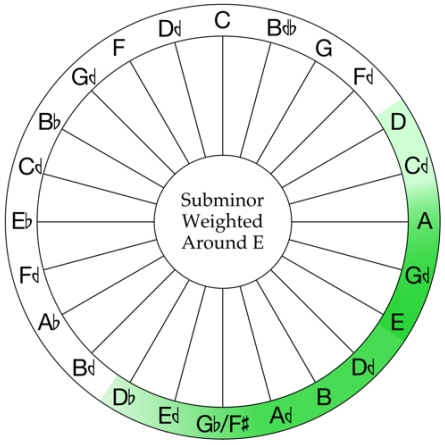


Figure I-49: tonic area of "Folding," *Odd Coils* expressed as a weighted zone.

Figure I-51 shows a reduction of the movement, with the chords depicted on subminor and neutral circles. This makes clear that, in bars 6 and 7, the D and C♯ are part of a broader move away from E that involves pitches both 'in' and 'out' of the E subminor scale. This interpretation is reinforced by an analysis of the durational frequency of each note in the subminor circle (Figure I-50): D and C♯, which are 'out' of the E subminor scale, are used no less than F♯ or E♮, which are 'in' the scale.

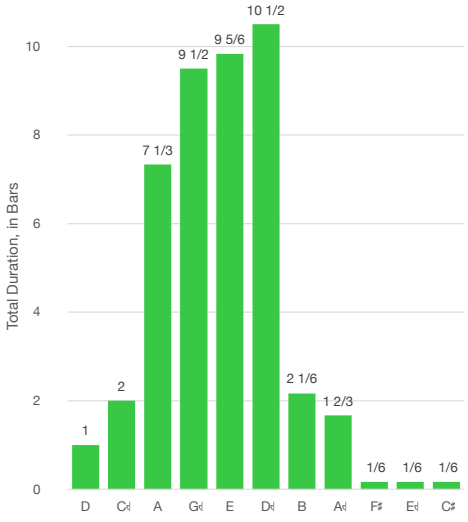
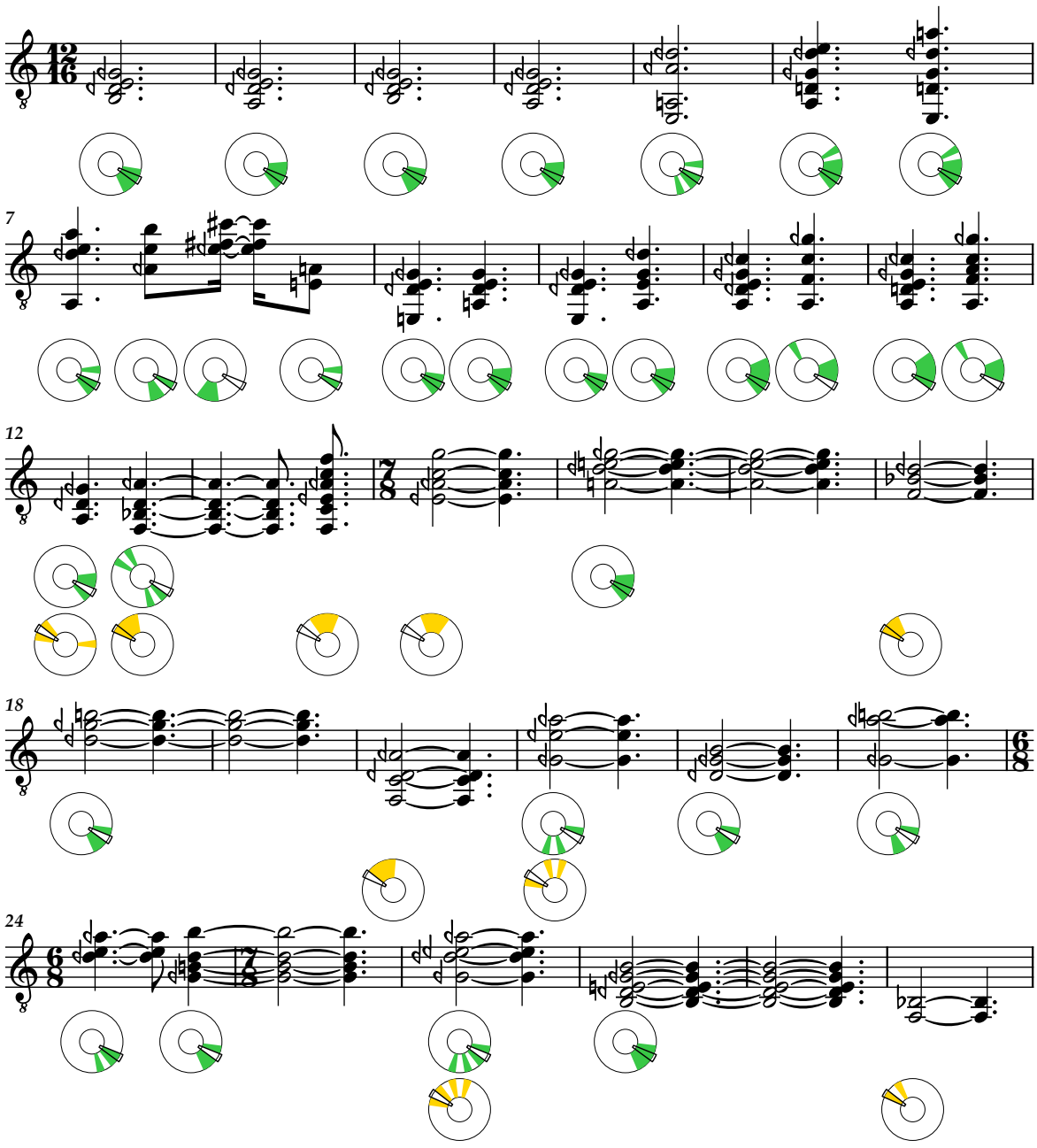


Figure I-50: total duration of subminor notes, bars 1-16, "Folding," *Odd Coils*.

Figure I-51 also shows how I used cyclical conjunctness to contribute to tonal tension. In the opening sentence (bars 1-13), I use cyclically conjunct chords in the first half of both the presentation phase (bars 1-7) and the continuation phrase (8-13). The second half of those phrases, the chords grow more distant from the zonal centre and more cyclically disjunct. This growing tension leads to resolutions on cyclically conjunct chords at the centre of the subminor zone in bars 8 and 15.



◂ Figure I-51: bars 1-29, "Folding," *Odd Coils*, harmonic reduction.

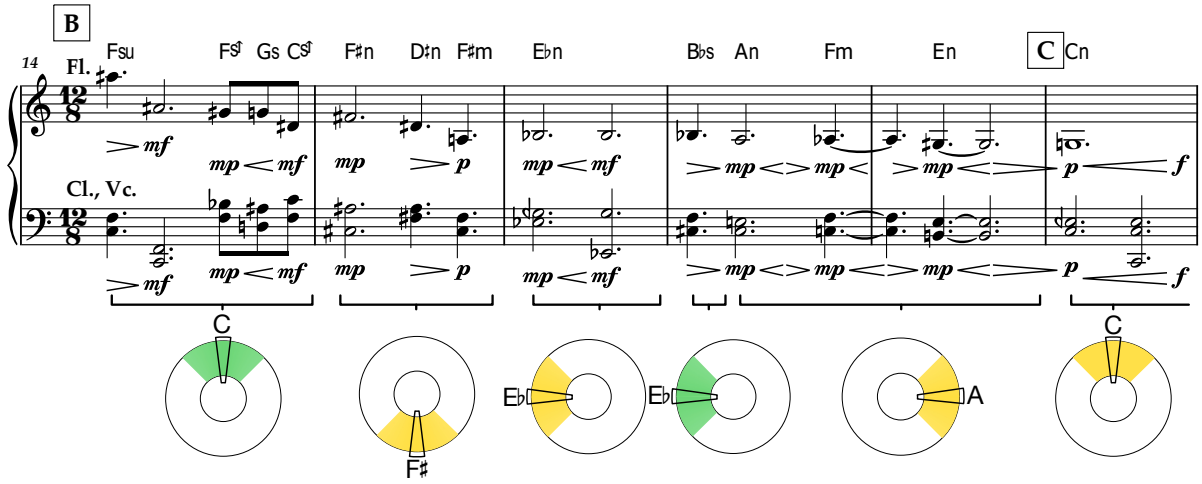
Chords are shown on the subminor (green) and neutral (yellow) circles underneath, with the centre of the circles' weighted zones (E and B♭) being outlined in back. This visualises both the conjunctness of the chords and their harmonic distance from the centres of the weighted zones.

Tonal Flexibility in *Straight Line Through A Landscape*

The change in my understanding of scales and triads is evident in *Straight Line Through A Landscape*, which makes expressive use of a more flexible approach to the quartertone axis system. While the harmonic language remains rooted in the same sonorities and voice leadings as my earlier works, I expanded the harmonic vocabulary. Where I typically oriented earlier works around a fixed pole-counterpole relationship, in *Straight Line Through A Landscape* I explore minor-third modulations as well. I also used more major and minor

chords than my earlier works, finding that they could be placed sensitively within a quartertone harmonic discourse without overpowering the axis system harmonies.

The dense homophonic passage shown in ◖ Figure I-52 is typical of this new approach. It modulates through six circle areas over the course of six bars, with careful voice leading facilitating kaleidoscopic harmonic motion through circle areas separated by minor thirds. It begins with chords around C on the subminor circle, which modulate to their counterpoles around F♯ neutral in bar 15. At the end of bar 15, I substitute an F♯ minor chord for the neutral chord, the raised third driving the music more forcefully into a new circle area of E♭ neutral. In bar 17, I use a chord from the E♭ subminor circle area as a pivot to its counterpole of A neutral. This leads back to the C area of the circle, but now in the neutral circle. The shift back to C is supported by the F minor chord in bar 17. This chord can be understood in two parts: the F-C dyad looks ahead to the harmonic area of C, while the A♭ looks back to the harmonic area of E♭.



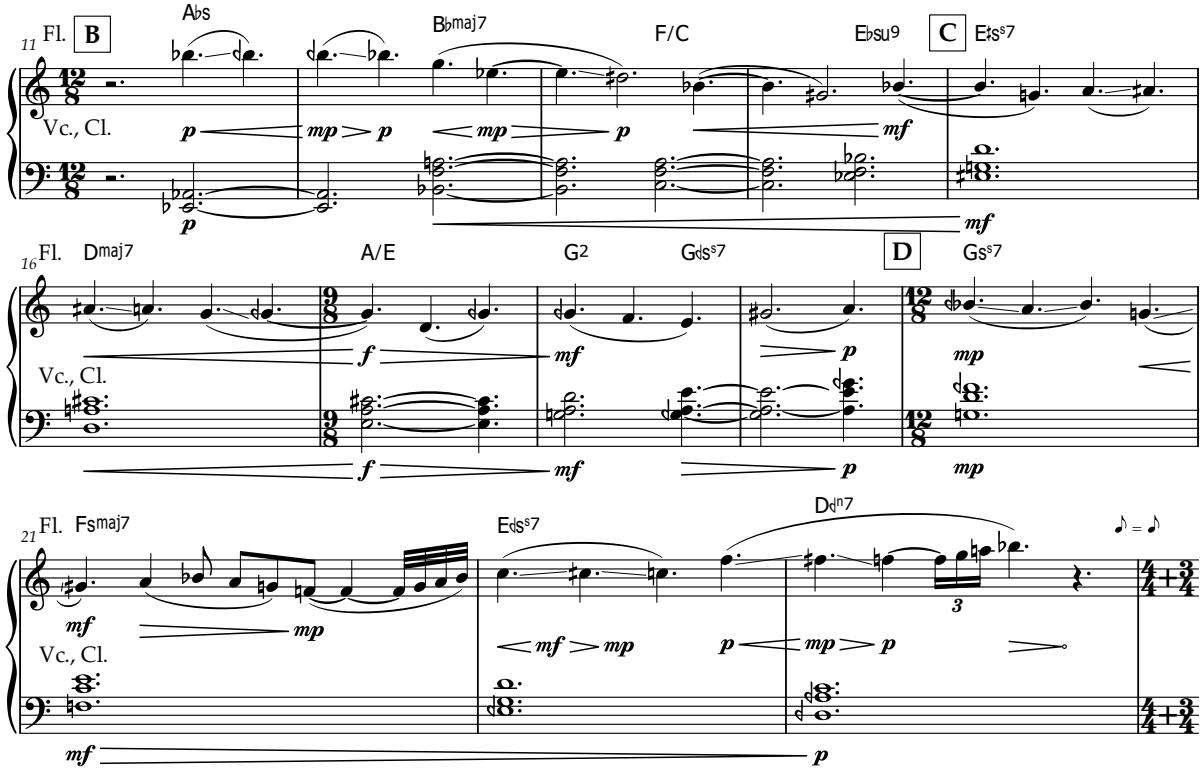
◖ Figure I-52: bars 14-19, Movement IV, *Straight Line Through A Landscape*, reduction.

The weighted harmonic zone of each area is shown below, with the subminor in green and the neutral in yellow.

I support this more mobile harmonic language with a relatively simple bass line, which includes few microtones. This is possible in part because the subminor chords on which the passage is built have weak root identity, giving flexibility about which note I choose to use in the bass. As in my earlier work, I use a consistent harmonic language, comprised almost entirely of neutral and subminor chords. This helps the music cohere despite the shifting tonal zones.

Harmonic consistency allows major and minor chords to appear as moments of expressive harmonic contrast. In previous pieces, I had avoided these chords almost entirely. I found that their familiarity reinforced the strangeness of the quartertone context in ways that undermined the tonicisation of quartertone harmonies. Perhaps in part due to the length of this piece, I was able to present major and minor chords as moments of harmonic strangeness that contrast with the otherwise consistent quartertone harmony.

I generally use these diatonic triads as passing harmonies within predominantly axis-based harmony, but they occasionally play a bigger role. In the passage that follows the section examined above, for example, the arrival of major chords from bar 24 onwards sounds like a moment of harmonic surprise, rather than the emergence of a more conventional harmonic language. At the passage in ◂ Figure I-53, there is a similar chord progression in which diatonic chords predominate in the accompanying cello and bass clarinet line. These diatonic chords do not, to my ear, overwhelm the subminor chords in bars 15, 18-20, and 22-23. This is partly due to the flute line, whose subminor melody is more consonant with the subminor chords than with the diatonic ones.



◂ Figure I-53: bars 11-23, Movement VI, *Straight Line Through A Landscape*, reduction (omitting percussion).

Embracing the quartertone axis system's weak roots and vague tonics made my writing more harmonically mobile and more acoustically consonant, as I started to use the consonances of diatonic harmony. This made the music less macroharmonically consistent, which I was concerned would undermine the quartertone harmony. But the consistency of my treatment of harmony, combined with careful voice leading and a musical syntax that emphasises subminor chords, allowed the quartertone harmony to still sound like home. The 'home' is, in this piece, no longer a specific tonic, but instead a quartertone harmonic discourse that acts as the music's governing language.

This approach was partly possible because of my growing familiarity with the quartertone axis system. Its characteristic harmonic and melodic movement came naturally, allowing confidence in deviating from them where practically necessary or musically pleasing. This fluency was made possible by the explicit, systematic approach I initially adopted, which

oriented me aurally and intellectually. The rigidity of the axis system was part of what helped me move beyond it.

The reality of instrumental performance

One persistent challenge I faced was squaring a fixed, Neoplatonic understanding of this quartertone axis system with the realities of performance. I constructed the system with the aid of microtunable synthesisers and notation software, which could execute it with flawless intonation. In Chapter III, I will consider how my practice of digital intonation has shaped my composition. Here, I will discuss how the friction between performance on acoustic instruments and my idealistic system changed my approach.

Microtonal affordances

Different instruments have different approaches to intonation. My understanding of this was initially informed by Mira Benjamin's distinction, via Patrizio Barbieri, between fixed pitch, free intonation, and enharmonic instruments.[107] This taxonomy did not work for my purposes: it didn't distinguish between brass and woodwinds, or between digital and acoustic instruments.

I have found it more helpful to distinguish instruments by considering three microtonal affordances: flexibility of intonation, ease of retuning, and accessibility of overtones. These stylised categories summarise multiple affordances, including both the nature of the instrument and the interaction of the instrument with typical practices of intonation. This list of affordances is not complete; for example, it excludes facility with multiphonics. Rather, it focuses on the aspects of microtonality that are important for my work.

In Figure I-54, these categories are shown, followed by a brief definition, then some of the considerations that the category is design to encompass. Figure I-55 shows the affordances as spectrums. I have – impressionistically and subjectively – placed the instruments used in this portfolio on each of these spectrums.[108] Instruments at the far left of the first two spectrums were generally easily integrated into my quartertone axis system. The piano stands out as being at the right of all three spectrums and was thus especially hard to integrate. Access to the harmonic series was not very important for my quartertone music but will be discussed in Chapters II and III.

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[107] Mira Benjamin, 'Thick Relationality: Microtonality and the Technique of Intonation in 21st Century String Performance' (University of Huddersfield, 2019), 26, http://eprints.hud.ac.uk/id/eprint/35116/.

[108] Voice is omitted from the 'ease of retuning' spectrum, as it is not clear what it would mean for the voice to be retuned.

Microtonal Affordances

Flexibility of intonation: inflecting pitch during performance.

- How easy is it to select any chosen pitch from the pitch continuum? If keyed or fretted pitches must be bent, how far can they be inflected, and for what duration? If alternative fingerings are required, how great is the timbral alteration?

Ease of retuning: altering the fundamental pitches of the instrument.

- How quickly can pre-set pitches be changed? How precise can retuning be? How long does a retuning last? How easy is it to play once the instrument is retuned?

Accessibility of overtones: playing the harmonic series.

- How high up the harmonic series is the instrument capable of playing? How stable are these harmonics?

Figure I-54: three microtonal affordances.

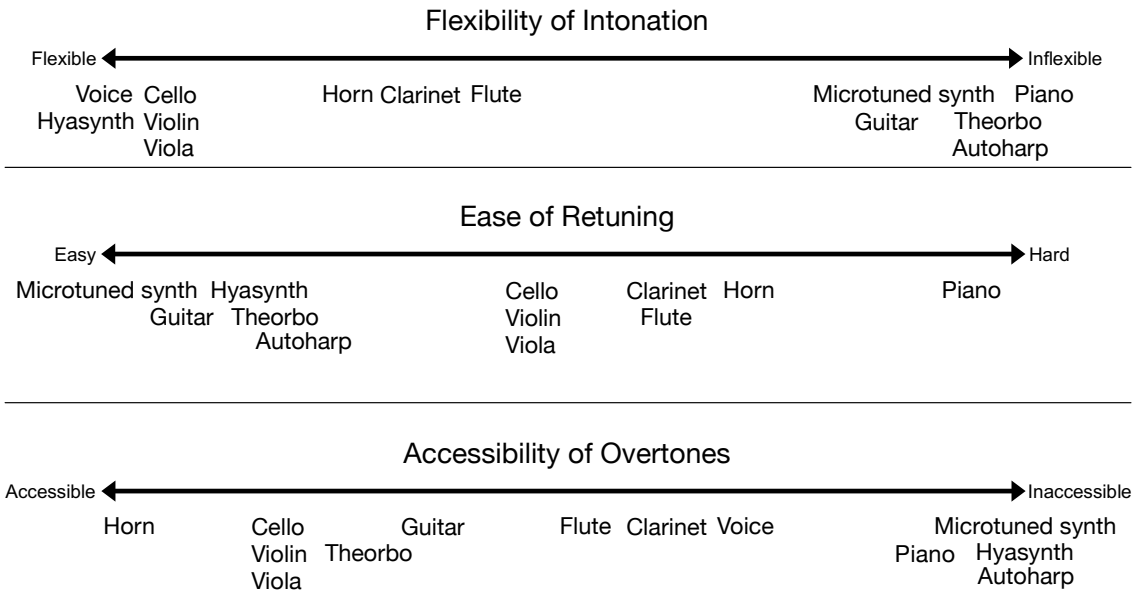


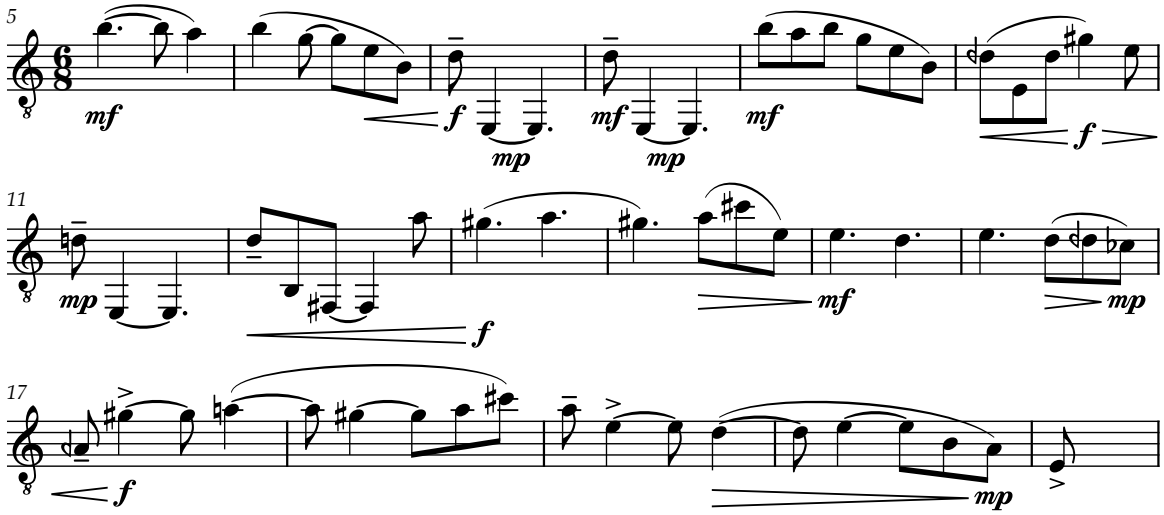
Figure I-55: three spectrums of microtonal affordance.

Guitar

The guitar is especially easy to retune; as a fretted instrument, alternative tunings do not disrupt a practice of intonation. In this regard, it resembles the microtunable synthesisers on which I initially composed my quartertone music. When writing *Odd Coils*, the only friction between the instrument and my system was registral. As I retuned only the middle strings,

it was challenging to use quartertones as the highest or lowest notes in a five- or six-note texture.

This caused the most issues in "Overneath," which was written to be playable by amateur guitarists. This meant I avoided placing the melody on the high frets of the middle strings, as in other movements; instead, the melody was often played on the higher strings. This largely 12EDO melody, shown in ◂ Figure I-56, is almost entirely diatonic: from bar 5-8 it is in E minor, from bar 8-20 it is in E mixolydian. This melody is accompanied by quartertone harmony and includes occasional quartertone pitches from the E subminor scale in passing. The diatonic nature of the melody had little impact on my compositional approach at the time but reveals a latent flexibility in the quartertone system that I had not yet appreciated.



◂ Figure I-56: the largely diatonic melody of bars 5-20, "Overneath," *Odd Coils*.

Unfretted strings

Intonationally flexible instruments like strings and voice can perform any pitch on the glissando continuum with almost equal ease, but the unfamiliarity of quartertones can make them challenging. However, the players I worked with were interested in microtonal music and skilled at realising it. This sometimes concealed the difficulties of the music I was asking them to play. In the rehearsals for *Straight Line Through A Landscape*, for example, I rarely discussed tuning with the cellist, Colin Alexander, as he was so proficient at performing quartertones.

The ability of unfretted strings to access the higher harmonics was of particular importance in *Nocturne*. From bar 139 to the end, the scordatura double bass plays natural harmonics. The consonant fifth harmonics that appear in this passage fall outside of my axis system and are, to my ears, the most effective moments of the piece. They illustrate the promise of more flexible approaches to quartertones.

Woodwinds

In the woodwind parts of *Straight Line Through A Landscape*, I was pushed towards harmonic flexibility in part because of the compromises needed to work with flute (doubling alto flute) and clarinet (doubling bass clarinet). I am indebted to Heather Roche's extensive work

documenting quartertone fingerings on the clarinet.[109] These charts illustrated which quartertones were possible and how to move between them. Following her advice sometimes meant changing a microtonal note to a 12EDO pitch, requiring flexibility. This was relatively uncommon, however, as Roche is very skilled in microtonal intonation.

I composed the flute part using my own flute, finding microtonal fingerings for the faster passages while allowing slower pitches to be altered with the lip or with the key holes. My flute writing was more circumspect than my clarinet writing, where Roche's charts made it clear how best to write for her. This caution resulted in a more melodically conjunct flute line, which is the source of quite a few of the diatonic chords discussed above.

Piano

While focusing on my quartertone axis system, I initially avoided working with the piano, due to its lack of microtonal affordances. *Nocturne*, written in 2021, was the first time I had written for piano since *A Noise So Loud*, in 2017. I thought of the piano in *Nocturne* as working within the F-B quartertone axis system that I was using for the piece. This axis contained two sets of four 12EDO notes that the piano could play (Figure I-57):

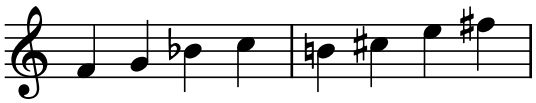


Figure I-57: central 12EDO notes in *Nocturne.*

I expanded these four-note collections into local pentatonic patterns. My approach to these pentatonic patterns was not systematic or governed by any specific tonal logic. At figure 7, for example, an E♭ is added to the collection to form a pentatonic, while the B♮ counterpole is used as a source of harmonic tension. However, I sometimes extend the four-note collection in the other direction on the circle of fifths, adding a G and a D. When these additions collide, as they do in bars 45-46, the piano plays in a pentatonically-inflected B♭ major. This can result in music that sounds a little cliched, resembling *chinoiserie*. Nonetheless, there are effective moments, particularly when I overlaid multiple harmonic approaches. At figure 10, for example, I use registral separation to facilitate a combination of B major pentatonics in the piano right hand, B♭ major pentatonics in the piano left hand, and F subminor in the double bass.

The result was a piano part that worked well enough in this quartertone context. This gave me the confidence to attempt solo piano pieces for the first time in many years. I began a piece that I viewed as variations on the piano part from *Nocturne*. In the sketch, *Nocturne Variations*, I used many overlapping pentatonic sets, with major and minor chords placed freely on each note of the pentatonics. I ensured that these overlaps included dissonant collisions to blunt the emotional resonance of the diatonic chords. I also frequently broke the

[109] Heather Roche, 'Three Octave Tremolo/Moving Passages Chart w/ Quarter Tones for Bb Clarinet', *Heather Roche* (blog), accessed 18 December 2023, https://heatherroche.net/2014/08/30/three-octave-tremolomoving-passages-chart-w-quarter-tones-for-bb-clarinet/.

procedural logics that I had established to govern these pentatonics, avoiding combinations I found too hackneyed or dissonant.

This combination of complexity and loose systematic writing resulted in a structural challenge. I quickly exhausted the material, but I had no harmonic principles with which to develop it. My shyness of the diatonic material I was working with stalled attempts at a more improvisatory approach to development. This sketch laid bare the challenges I faced with the quartertone axis system. Its relationship to diatonic material was undefined. I had found my previous free quartertone harmonic style parasitic on diatonic harmony; now, I found my attempts at diatonic harmony parasitic on my quartertone systems.

II. Making familiar chords sound strange: Just Intonation

This chapter considers how I used Just Intonation to explore alterity in familiar harmonic resources. In Part A, it considers the changing role of diatonic harmony in my music, first in 12EDO in The Hazelnut*, then in Just Intonation in* How To Go Outside*. Part B explores my attempts to integrate my quartertone axis system with Just Intonation. I show how this integration allows for harmonic recontextualisation of axis system harmony with the diatonic chords of the harmonic series and with combination tones, examining* Phasmid *and* Wound Honey.

A. Recontextualising diatonic harmony

Pentatonic 12EDO diatonicism in The Hazelnut *– Pentatonic Just Intonation diatonicism in* How To Go Outside *– Alternatives to common-practice functionality in* How To Go Outside *– The practicalities of Just Intonation in* How To Go Outside

12EDO diatonic harmony

As the last section details, diatonic harmony crept into my quartertone music, partly as a practical response to working with the microtonal affordances of given instruments. In *Straight Line Through A Landscape*, diatonic triads played an expressive but limited role. I found this use of diatonic harmony alluring and wanted to expand its role within my work, but I didn't know what its tonal logic might be. As discussed in the Introduction, I wanted to avoid both common-practice tonality and the soft-edged pandiatonicism of my earlier tonal works.

As a response to this uncertainty, I experimented with new approaches to diatonic harmony within 12EDO compositions, including two works for choir, *Some Parts Of Us* and *The Hazelnut*. I applied symmetrical processes to major and minor chords, motivated by my enjoyment of symmetry in my 24EDO works. I wanted to use the resonance of major and minor chords in ambiguous, indirect music, held together by the rigour of consistent harmonic processes. As well as making strange chords sound like home, I wanted to make familiar chords sound strange.

Symmetrical pentatonic scales in The Hazelnut

Like *Nocturne Variations*, *Some Parts Of Us* and *The Hazelnut* revolve around pentatonic scales. Rather than use a symmetrical chain of fifths, I generated these pentatonics by inverting major and minor chords around a fixed point of symmetry:

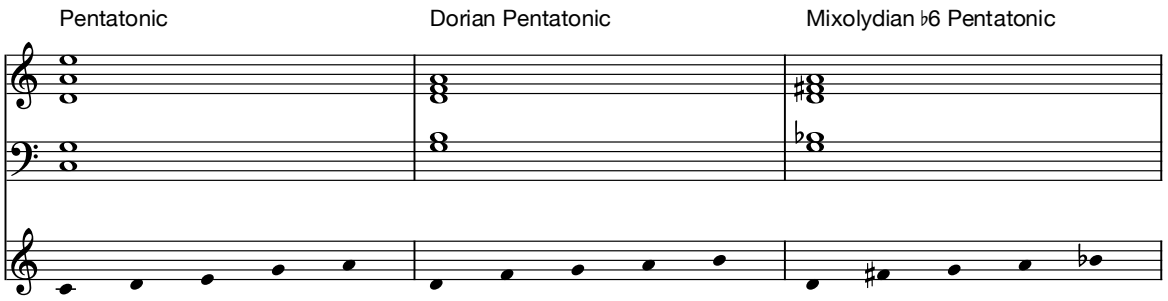
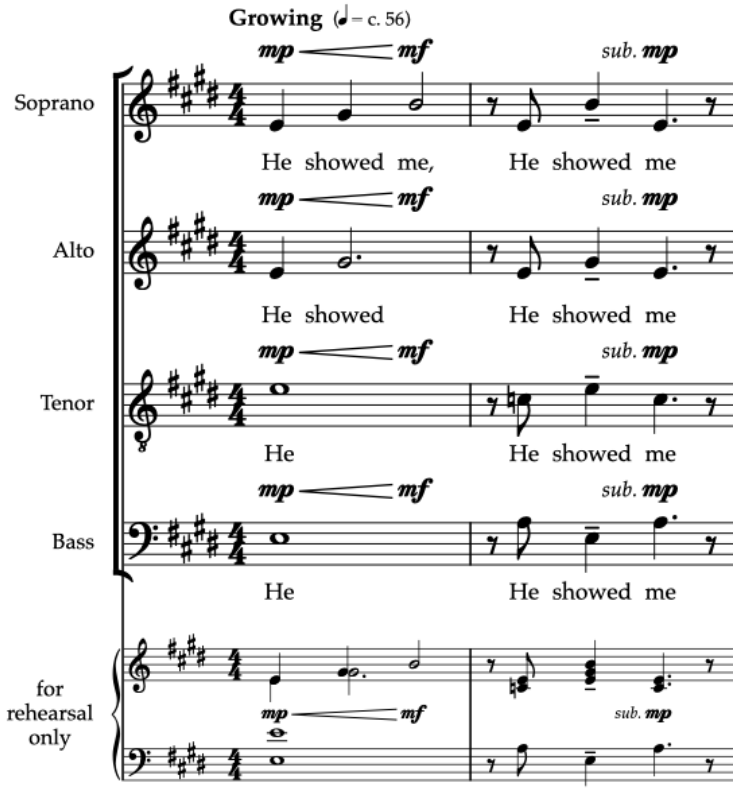


Figure II-1: symmetrical pentatonic collections around D.

I hoped to avoid the over-familiarity of conventional diatonicism by weakening the tonic-centredness of the scales. The Dorian pentatonic is oriented around a 'shuttle,' common in Latin music, that does not strongly signal a single tonic: it could be understood as a i-IV, I-v, or ii-V.[110] The E major to A minor shuttle in the Mixolydian ♭6 suggests a V-i in the harmonic minor. I tried to undermine this impression by emphasising the root of the E major chord. For example, in the opening of *the Hazelnut* (◂ Figure II-2), the E major chord is lengthened and emphasised:



◂ Figure II-2: the opening of *The Hazelnut*.

I further undermined the tonic by treating the pentatonics as transitory: both *Some Parts of Us* and *The Hazelnut* modulate frequently. I aimed to modulate through minor thirds in the

[110] Tagg, *Everyday Tonality II*, 373–79.

Dorian pentatonic in *Some Parts Of Us* and through major thirds in the Mixolydian ♭6 pentatonic in *The Hazelnut* (Figure II-3). In practice, the major third modulations proved too restrictive, as the space for conjunct motion in the Mixolydian ♭6 pentatonic is an awkward diminished tetrachord (F♯–G–A–B♭) that I found challenging to use for long melodic passages. As such, I revised the structural plan for *The Hazelnut*, choosing to alternate between Dorian and Mixolydian ♭6 pentatonics (Figure II-4). I struggled to execute even this more flexible plan, however, as the melodic space of the Mixolydian ♭6 was too restrictive. Instead, I gradually expanded my modal material, introducing full diatonic scales while treating the original pentatonic framework as a harmonic focal point.

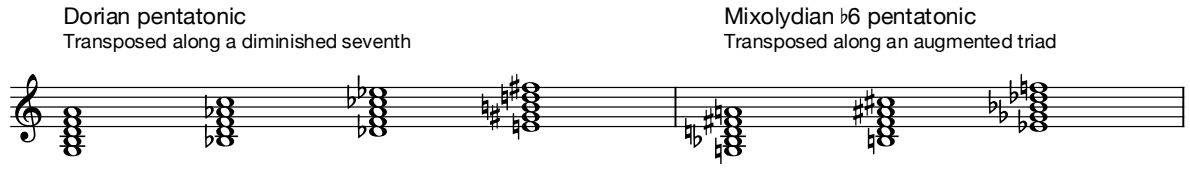


Figure II-3: intended modulatory schema in *Some Parts Of Us* and *The Hazelnut*.

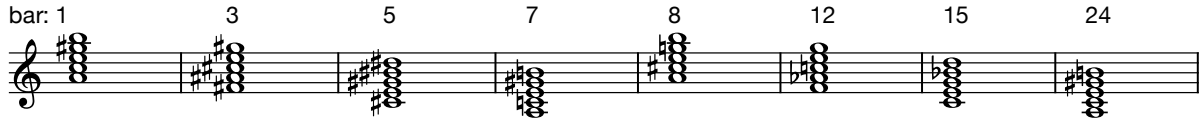


Figure II-4: revised modulatory scheme in *The Hazelnut*.

In these experiments in 12EDO tonality, I built on ideas from my 24EDO axis system: the symmetrical cycles and, in *Some Parts Of Us*, the minor-third and tritone key relationships. These pieces helped me develop a technique that better accommodates major and minor sonorities within my compositional aesthetic, avoiding progressions I perceived as hackneyed while maintaining a consistent harmonic logic. But in both pieces, the harmonic interest is tied to restrictive macroharmony. When I expand the pentatonics, I am left with a familiar diatonic palette. Moreover, while these pentatonics offer an interesting 12EDO sonority, they do not integrate with the quartertone axis system.

Just Intonation dissonance and distance in *How To Go Outside*

Just Intonation provided an alternative lens through which to consider diatonic harmony. I hoped that its different tuning of diatonic chords might help me find alterity within them and thus navigate the impetus of their strong semiotic associations. This was not what I found. Instead, Just Intonation proved a powerful tool for the recontextualisation of familiar intervallic relationships. It both allowed me to accentuate harmonic distance and to explore unexpected dissonances.

My first work in Just Intonation, *Us Alone*, pre-dates my PhD. It successfully used a scordatura, which encouraged me to take the same approach in writing *How To Go Outside*. *How To Go Outside* was composed as incidental music for an online play produced during lockdown; little recording time was available. To make the process of intonation easier, and thus reduce rehearsal time, I used scordatura open strings and harmonics as much as possible. I also wrote looped material that was designed to be recontextualised across

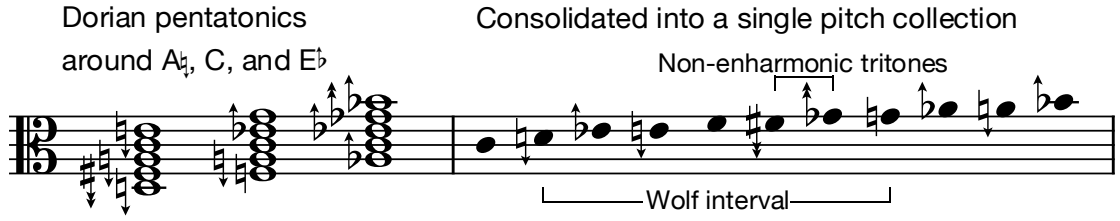
multiple movements of the piece. I later re-composed the piece for string quartet, as I wanted a version for live performance.

The piece was notated in Helmholtz-Ellis Just Intonation (HEJI) notation.[111] I had used aspects of HEJI in earlier works to indicate the non-24EDO tuning of the 5th and 7th string harmonics, but this was my first work that used it throughout.[112] To explain this notation system to the amateur group that went on to play this quartet, I created an explainer video that can be viewed here.

Just Intonation Dorian pentatonics

I approached harmony in the same manner as in *Some Parts Of Us*, using minor third relationships between Dorian pentatonics; I wanted to use diatonic harmony systematically without common-practice tonality. Here, however, I worked in 5-limit Just Intonation rather than in 12EDO. I built pentatonic collections symmetrically around A𝄲, C and E𝄳, creating an 11-note pitch collection on a 1:1 root of C (◂ Figure II-5).[113] I found these collections easier to understand on tuning grids (Figure II-6 to Figure II-9). These grids, which I first came across in Kyle Gann's work,[114] show relationships of 3:2 perfect fifths on the horizontal axis and of 5:4 major thirds on the vertical axis.

This Just Intonation process preceded compositional work and revealed musical resources that I would not have otherwise considered. First, the collection included two dissonant 40:27 'wolf fifths,' F – B𝄳 and D𝄲 – G. Second, the most distant pitches from C were two tritones, F𝄰 and G𝄳, separated by a 648:625 (37¢). In the piece, the D𝄲 – G wolf fifth becomes an important resource of harmonic tension, while the two non-enharmonic tritones provide moments of maximum harmonic distance. These resources helped defamiliarise the diatonic harmonies that they arose from.



◂ Figure II-5: the three pentatonic collections of *How To Go Outside*, as chords, then as a scale.

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[111] HEJI is a relational notation system devised by Marc Sabat and Robin Nicholson, in which each prime-numbered harmonic 'limit' is represented by a distinct notational symbol. Conventional notation is used to depict a 3-limit chain of fifths, which is then altered by arrows to show 5-limit intervals and by small sevens to show 7-limit intervals. For more details, see Appendix One. Marc Sabat and Robin Hayward, 'Towards an Expanded Definition of Consonance: Tuneable Intervals on Horn, Tuba and Trombone', *Plainsound Music Edition*, 2006, 4.

[112] While the chords from *Us Alone* are shown in HEJI in the introduction, the original score did not use HEJI.

[113] These Just Intonation collections were modelled and trialled in Leimma, a browser-based tuning program. I examine the impact of such software on my work in Chapter III.

[114] Kyle Gann, *The Arithmetic of Listening: Tuning Theory and History for the Impractical Musician* (Urbana: University of Illinois Press, 2019), 56.

F𝄲 25:18						
D𝄭 10:9	A𝄭 5:3	E𝄭 5:4	B𝄭 15:8	F𝄲 45:32	C𝄲 135:128	G𝄲 405:256
B♭ 16:9	F 4:3	C 1:1	G 3:2	D 9:8	A 27:16	E 81:64
G𝄳 64:45	D𝄳 16:15	A𝄳 8:5	E𝄳 6:5	B𝄳 9:5	F𝄮 27:20	
				G𝄫 36:25		

Figure II-6: pentatonic collection around C.

F𝄲 25:18						
D𝄭 10:9	A𝄭 5:3	E𝄭 5:4	B𝄭 15:8	F𝄲 45:32	C𝄲 135:128	G𝄲 405:256
B♭ 16:9	F 4:3	C 1:1	G 3:2	D 9:8	A 27:16	E 81:64
G𝄳 64:45	D𝄳 16:15	A𝄳 8:5	E𝄳 6:5	B𝄳 9:5	F𝄮 27:20	
				G𝄫 36:25		

Figure II-7: pentatonic collection around A.

F𝄲 25:18						
D𝄭 10:9	A𝄭 5:3	E𝄭 5:4	B𝄭 15:8	F𝄲 45:32	C𝄲 135:128	G𝄲 405:256
B♭ 16:9	F 4:3	C 1:1	G 3:2	D 9:8	A 27:16	E 81:64
G𝄳 64:45	D𝄳 16:15	A𝄳 8:5	E𝄳 6:5	B𝄳 9:5	F𝄮 27:20	
				G𝄫 36:25		

Figure II-8: pentatonic collection around E♭.

F𝄲 25:18						
D𝄭 10:9	A𝄭 5:3	E𝄭 5:4	B𝄭 15:8	F𝄲 45:32	C𝄲 135:128	G𝄲 405:256
B♭ 16:9	F 4:3	C 1:1	G 3:2	D 9:8	A 27:16	E 81:64
G𝄳 64:45	D𝄳 16:15	A𝄳 8:5	E𝄳 6:5	B𝄳 9:5	F𝄮 27:20	
				G𝄫 36:25		

Figure II-9: all three pentatonic collections.

I facilitated this harmonic scheme with a pair of viola scordaturas (Figure II-10) that produce seven of the eleven desired notes, omitting just E𝄳, F, F𝄲, and G𝄭. F and E𝄳 are an easily tuned perfect fourth away from C and A𝄳 strings respectively; only F𝄲 and G𝄭 proved challenging to tune by ear. I viewed the collection through the lens of Harry Partch's concept of otonality and utonality: the flats are part of the utonality, the naturals are part of the otonality.[115]

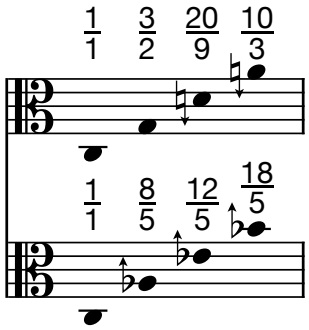
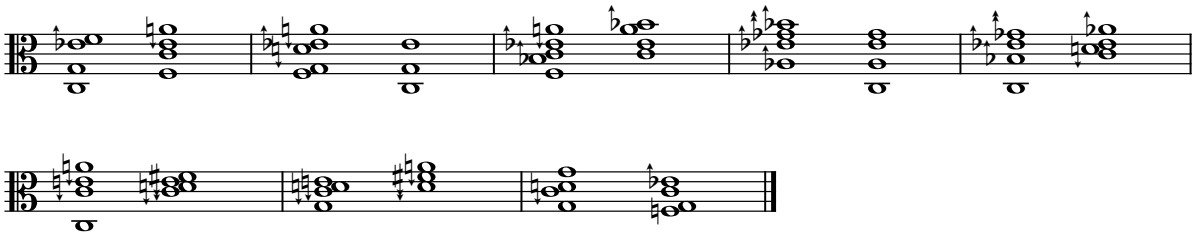


Figure II-10: the scordatura used in the original version of *How To Go Outside.*

Distance and dissonance: alternative functions for diatonic harmony

I did not use these eleven pitches exclusively; they were the basis of a chord progression which would become the spine of the work, appearing as the "Breathe In, Breathe Out" movements (movements I, III, VII, and IX) in the quartet version (◂ Figure II-11). This progression moves through the Dorian pentatonic collections, starting with the collection around C, then moving to the collections around E𝄭 and A𝄳.

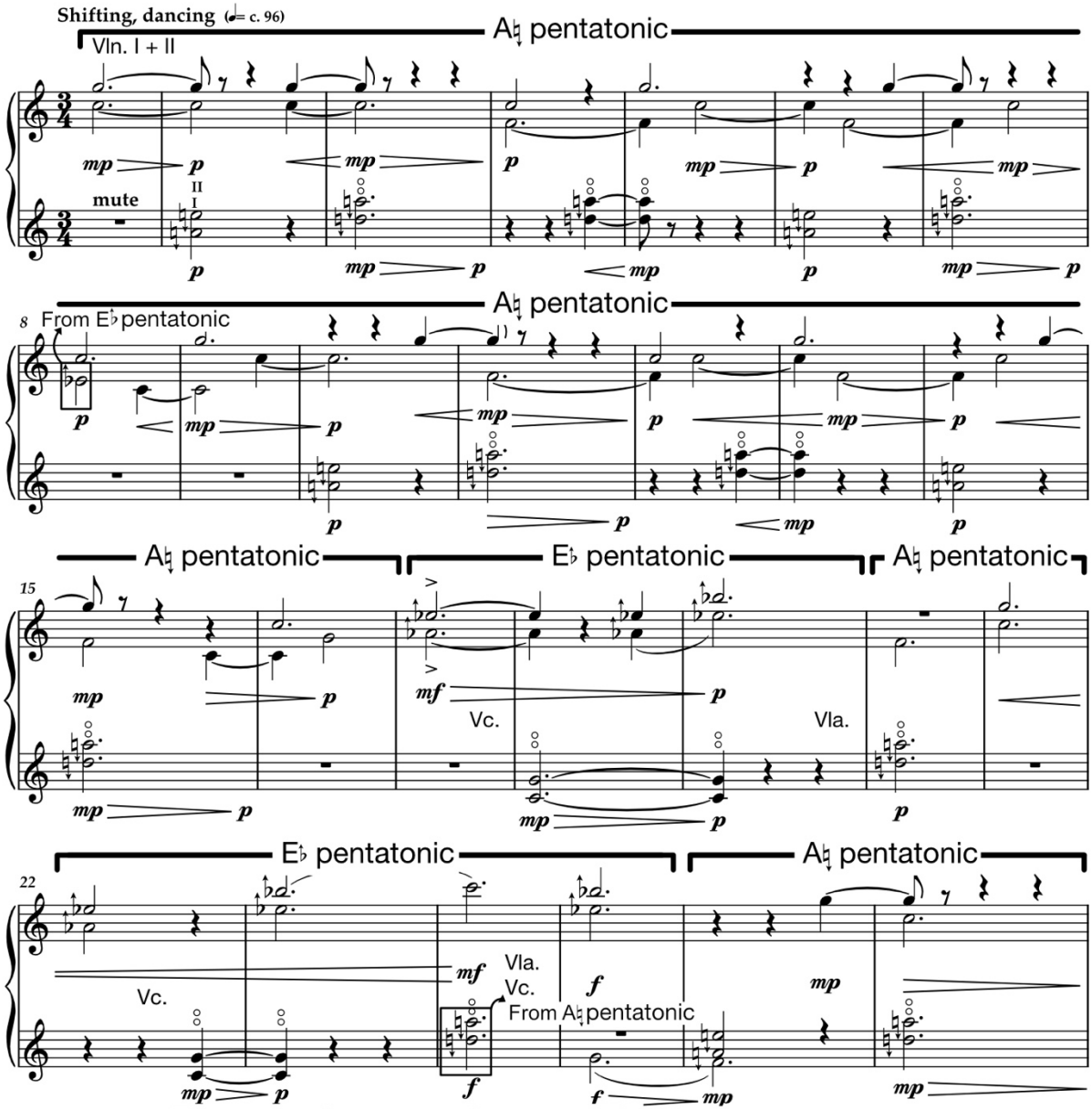
Within this harmonic landscape, I created new functional roles that provided an alternative to common-practice functionality. For example, throughout the sequence, I underpin dissonant or harmonically distant harmonies with mutually consonant pitches, typically F and C. In bars 5 to 6, the sequence modulates by a 45:32 tritone from E𝄭 pentatonic to A𝄳 pentatonic, drawing out the two non-enharmonic tritones, G𝄭 and F𝄲. The C is a stabilising pivot point, as it is consonant with both E𝄭 and A𝄳. Similarly, I use the mutual consonant reference point of F in bar 2 to render the dissonant wolf 40:27 fifth between G and D𝄳 unobtrusive. Later in the piece, I leave these distant modulations and dissonant intervals exposed, without an emollient point of mutual consonance.



◂ Figure II-11: "Breathe In, Breathe Out," *How To Go Outside*, chord progression, reduction.

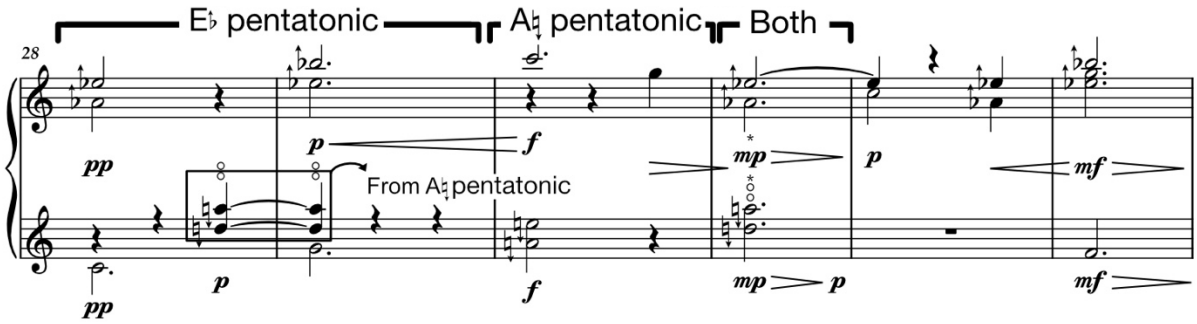
[115] Harry Partch, *Genesis of a Music: An Account of a Creative Work, Its Roots and Its Fulfillments*, 2d ed., enl (New York: Da Capo Press, 1974), 89–90.

It is not until the fourth movement, "How To Be Outside," that these sublimated tensions are laid bare (◂ Figure II-12).[116] Here, the pentatonic around E♭ is almost forgotten for the first 16 bars, which are based around A♮. (I use just one note from the E♭ collection briefly, in bar 8.) The rapid modulations from bar 15 are thus a shock. The tonality shifts without preparation to the A♭ collection, then alternates between the two key areas, not remaining in either for more than three bars at a time. The alternations increasingly overlap, until, at bar 31, they sound together in a dissonant tetrachord (Figure II-13). This combination of utonal and otonal harmonies recurs at important moments throughout the piece, used to create moments of maximum harmonic tension.



◂ *Figure* II-12 *continues on next page.*

[116] While there are significant dissonances in the second movement, the inharmonicity of the pizzicato texture renders them less noticeable.



◂ Figure II-12: bars 1-33, "How To Be Outside," movement IV, *How To Go Outside*.[117]

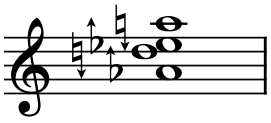
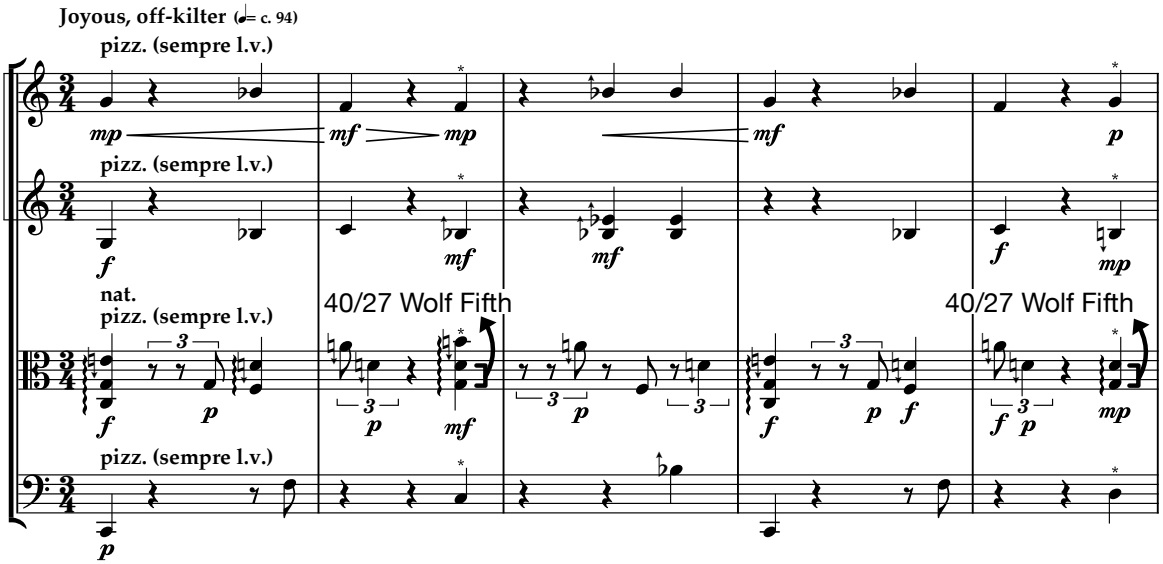


Figure II-13: dissonant tetrachord from bar 31, "How To Be Outside," Movement IV, *How To Go Outside.*

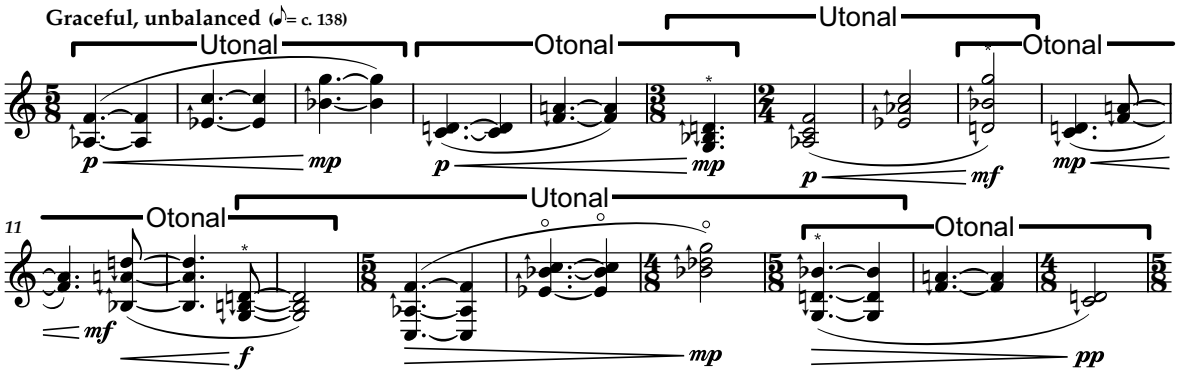
In movements V, "Earthing," and VI, "How To Be With Her," the dissonant 40:27 fifth is exposed. Throughout "Earthing," this harmonic exposure is gentle (◂ Figure II-14). It is heard as a plucked sonority; as in movement II, the inharmonicity of the pizzicato notes blunts the dissonance. Rather than creating tension that needs resolution, it contributes to the movement's off-kilter affect. The dissonance is non-functional and non-specific: the effect could be created by a differently detuned D string. However, this Just Intonation detuning allows the D string to be consonant one moment – at the end of bar 1 – and dissonant the next – at the end of bar 2. This recontextualisation illustrates the potential for alterity in familiar diatonic sonorities.



◂ Figure II-14: the opening of "Earthing," Movement V, *How To Go Outside*.

[117] 'A♮ pentatonic' here meaning the pentatonic around A, etc.

I use the same interval differently in movement VI, "How To Be With Her," where it follows a series of consonances (◂ Figure II-15). As in movement IV, "How To Be Outside," the dissonance emerges because of the overlap of otonal and utonal harmonic areas: the B♭ and G are part of the utonal passage that continues in bar 7, while the D is part of the otonal passage that began in bar 4. In bar 13, the D♮ in the chord is connected to the previous passage, while the implied G major chord (G and B♮) acts as a cadential figure into the utonal music of bar 14. When describing the effect to players, I describe the utonal and otonal sonorities as floating on top of each other like oil on water. Each layer is predictable when moving separately, but when combined, diffraction creates unexpected harmonies.



◂ Figure II-15: bars 1-20, "How To Be With Her," Movement VI, *How To Go Outside*, reduction.

I patterned consonance and dissonance through juxtaposition rather than through progression in part because I was composing using overdubbing. With limited recorded material, the unexpected overlapping of loops was necessary to achieve variety. The result is a piece in which major and minor sonorities are deliberately robbed of their familiar functional roles. The music's intensional logic proved an essential complement to Just Intonation, giving the diatonic harmony an ambiguous and indirect emotional affect.

Scordatura and the practicalities of Just Intonation

To adapt the incidental music for concert performance I first arranged the multitracked original for quartet, then composed a convincing structure for the piece, as the original relied on long looped passages of background music. The adaptation was an iterative process, based on feedback from the performers: Jordan Bergmans, the violist who originated the incidental music, the Ligeti Quartet and Quatuor Diotima, who workshopped the piece at the University of York, and an amateur quartet who played the final version.

The most important decision was how to manage the scordatura. The focus on the open strings and natural harmonics was born out of pragmatism but had aesthetic results that became an important aspect of the work: the comparative resonance of the open strings, particularly when plucked, and the opportunities they offer for double stops. As many of the performers emphasised the challenge of playing stopped notes with scordatura, I decided to keep only one scordatura, in the viola.

To make the part playable, I reduced the number of stopped notes to a bare minimum and ensured that they are approached in as sympathetic a way as possible. For example, in bar 2

of movement IV, "How To Be Outside," the violist plays the E on the D string, a ninth above the open string (Figure II-16). This positions their fingers near the octave harmonic point, facilitating the move into bar 3. However, this created a difference in volume between the two strings. The stopped string was dampened by the finger and the finger pressure lowered the string, reducing contact with the bow. The open string rang out, creating an imbalanced chord. Muting the instrument reduced this problem by curtailing the resonance of the open string.

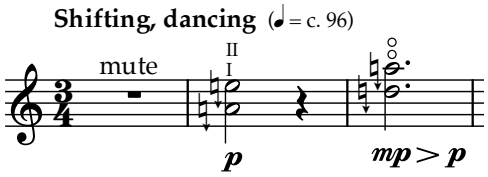


Figure II-16: viola part, bars 1-4, "How To Be Outside," Movement IV, *How To Go Outside*.

The two quartets who workshopped this version, Quatuor Diotima and the amateur quartet, had different reactions to the scordatura. For the amateur group, the pre-tuned reference pitches were helpful, providing an element of security in some passages and a source of confirmation in the rehearsal process. The process of tuning the scordatura also provided an opportunity to workshop the sonorities of the piece, hearing the resonance of the major and minor triads that the piece is built on. For Quatuor Diotima, who are accustomed to playing microtones, the scordatura was an unnecessary inconvenience that disrupted their physical relationship to the sounding pitches and so proved an obstacle to musical playing.

This posed a larger question: to what extent is Just Intonation a central component of the piece? Just Intonation played a vital role in my compositional process, suggesting alternative functional understandings of the role of pivot notes, for example. But with the compositional process complete, could the piece function within another intonational or notational paradigm?

Intonationally, the wolf fifth and the harmonically distant tritones often play an important musical role as pitches that they are consonant in one context and dissonant in another. This effect is generated by the displacement of these pitches by 5:4 major thirds, which are separated at their greatest extreme (F♯ – G♭) by four syntonic commas. This level of tertiary distance is hard to find in other intonations. For example, it would not function within a temperament such as 31EDO or ¼-comma mean tone, which might be the obvious alternative to 5-limit Just Intonation. Moreover, these temperaments offer few advantages over Just Intonation when working with unfretted strings.

Parts of the piece might work adequately tuned in 12EDO. The last movement, for example, makes relatively slight use of dissonance or harmonic distance available within the pentatonic scheme, and as a result risks sounding hackneyed. As such, the moments of Just Intonation dissonance that remain, such as the in the viola line's semiquavers from bar 17 onwards, are especially important to me. These moments of noticeable detuning help

defamiliarise the diatonic harmony, creating moments of strangeness within an otherwise conventional diatonic language.

Could a similar intonational effect be achieved with simpler notation? In my workshop with the Ligeti Quartet, it was pointed out that quartets often tune Just intervals when reading conventional notation. A quartet playing in this way might achieve similar results to a quartet playing with HEJI notation. For example, they might understand the importance of the harmonic distance between F♯ and G♭ without the need for arrows. But the viola scordatura and the effects that spring from the overlapping of utonal and otonal harmonies, such as those in ◂ Figure II-15, would be impossible to notate conventionally.

HEJI makes the harmonic relationships that create these dissonances comprehensible and thus repeatable. The amateur quartet said that their enjoyment of the piece stemmed from the way that the notation allowed them to understand the tuning decisions they were making. At first, they over-emphasised the difference of the notes from equal temperament – 'caricaturing' it, as the violinist put it. As the sonorities became more familiar, this problem disappeared. This satisfying process was part of the piece's appeal.

The scordatura helped with the initial process of familiarisation: it provided a repeatable reference point that helped the quartet learn to recognise the Just intervals. But once this process was complete, it becomes less useful. Given that players often find the retuning distracting and even unpleasant, I would only use scordatura in this way again if it were specifically requested by a performer. This experience changed how I thought about the affordance of retuning with the unfretted strings. While the physical layout of the instrument makes retuning fairly straightforward, the intonational practice of the musicians makes it challenging. This challenge is best overcome by writing music that doesn't require active intonation, that only uses the open strings and harmonics.

B. Recontextualising neutral and subminor harmony

> *Quartertone scales in Just Intonation – Relating the neutral/subminor axis to the diatonic chords of the harmonic series – Recontextualising quartertone harmonies with combination tones – Just Intonation in* Phasmid *– Just Intonation in* Wound Honey

While working on *How To Go Outside*, I tried to create a Just Intonation version of my quartertone axis system. I imagined that this might allow me to relate this axis system to major and minor harmony via the shared constant of the harmonic series. I also hoped that the resonant sound of Just Intonation might make the neutral and superperfect scales sound more 'in tune' and that this would enable me to use them as independent tonalities.

The neutral/subminor axis system in Just Intonation

In 24EDO, my generator-based circles formed a 'closed chain'; in Just Intonation, these become open chains.[118] To create these open chains, I needed simple Just Intonation versions

[118] In closed-chain tuning, the generator interval creates a cycle that returns to the original pitch class. In open-chain tuning, the generator interval creates a spiral that never returns exactly to the original

of 24EDO generators. Two of the generator intervals have analogues in 11-limit Just Intonation: the superperfect fourth is the 11:8 and the neutral third is the 11:9. As the 11:8 superperfect fourth uses only one prime number, it can be presented in a one-dimensional tuning grid (Figure II-17). This results in complex ratios: the final pitch in the superperfect scale is a 11^{13} above the fundamental, a 14-digit number. These pitches are hard to tune and lack the harmonic resonance that I had hoped might make a Just Intonation version of the superperfect scale more appealing.

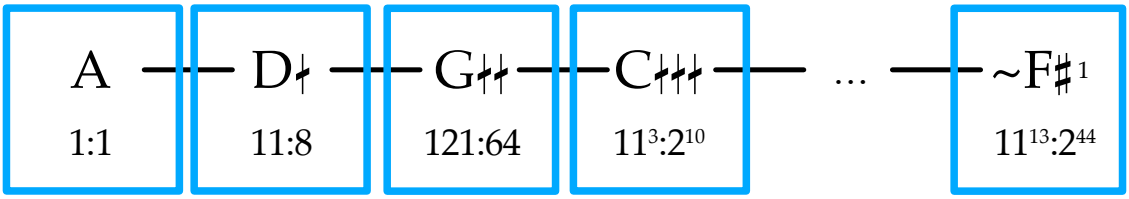


Figure II-17: a one-dimensional, 11-based tuning grid.

One can take a similar approach to the neutral scale, using the 11:9 as a generator interval whose compound, 121:81, is close to a perfect fifth. This is the approach taken by Gayle Young in *Harmonium For James Tenney*.[119] The 121:81 fifth is, however, notably dissonant. This 3- and 11-based tuning produces a simpler version of the neutral scale. It can be represented on a grid where horizontal steps represent a 3:2, and vertical steps represent an 11:8. An 11:9 has the shape of a knight's move on a chess board. The thirds in this grid recall those of maqām rāst, as specified by Al-Fārābi, but are here inverted, with the 11:9 placed below the 27:22.[120]

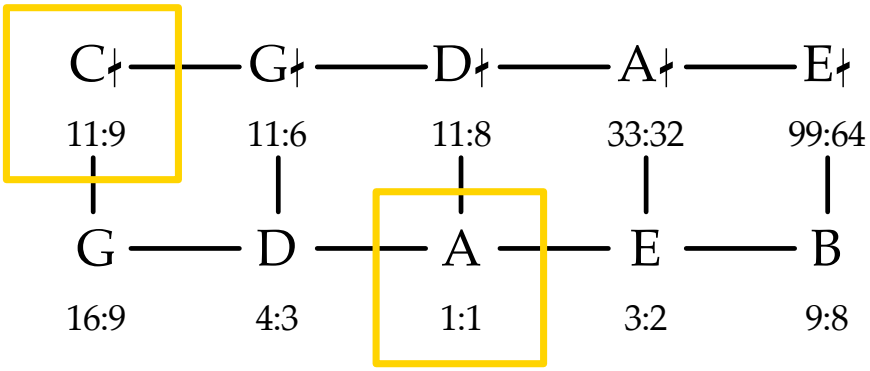


Figure II-18: an 11- and 3-based tuning grid.

The heptatonic scale highlighted in yellow in Figure II-19 has some merits: the intervals use small multiples of just two low-order primes. It is very similar in interval size to the 24EDO

pitch class. Patrizio Barbieri, *Enharmonic: Instruments and Music 1470-1900; Revised and Translated Studies*, vol. 2 (Il Levante, 2008), 279.

[119] Gayle Young, 'The Pitch Organization of Harmonium for James Tenney', *Perspectives of New Music* 26, no. 2 (1988): 204, https://doi.org/10.2307/833190.

[120] Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music', 156–57.

version of the neutral scale. The fifths deviate from 24EDO by only 2¢, and the neutral thirds are just 3¢ smaller; as such, it is not much more resonant than its 24EDO counterpart.

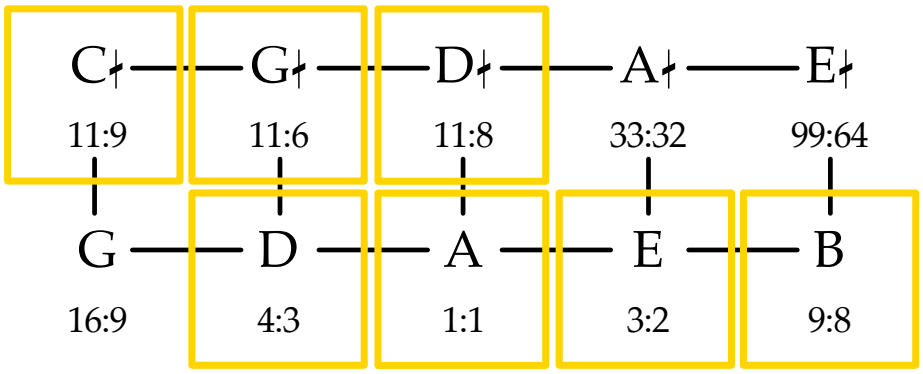


Figure II-19: a neutral scale on an 11- and 3-based tuning grid.

The scale can be simple because it uses multiple prime harmonics. This approach is less straightforward with the superperfect. Its compound generator, the major seventh, is complex in the 3rd limit: each step is 3^5:128, meaning that the final 3-limit note of the scale is 3^{15} above the fundamental. A simpler matrix would use three primes, rendering the compound generator as the 15:8 major seventh. In the matrixes in Figure II-20 and Figure II-21, three dimensions are shown, with 3:2 on the x axis, 5:4 on the y axis, and 11:8 on the z axis. Figure II-20 shows the beginning of an ever-extending chain that begins with an 11:8 and 15:8 above the fundamental. In Figure II-21, I have displaced the sequence on its fifth note, exchanging the 225:128, G𝄳, for the 16:9 G.

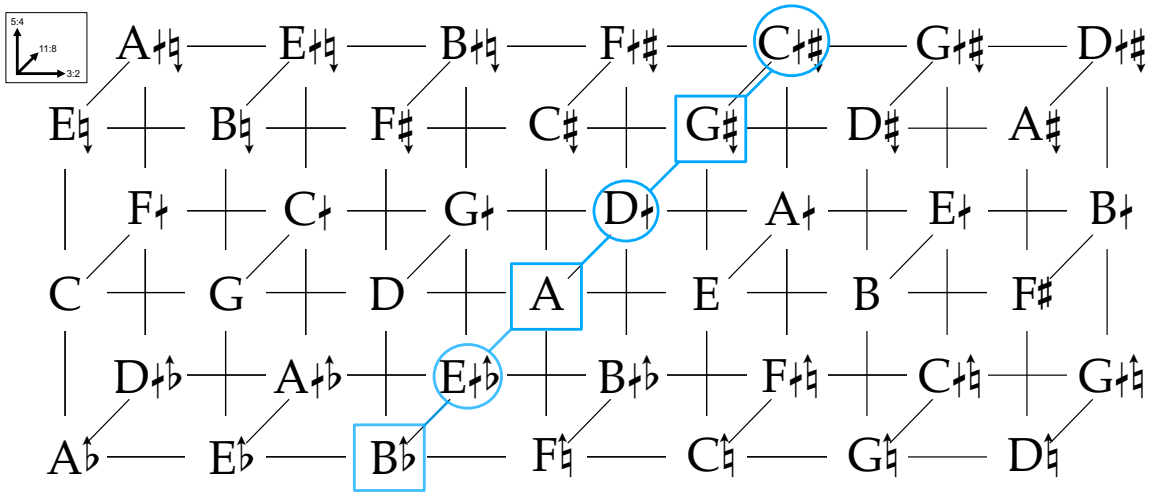


Figure II-20: the superperfect scale on a 3-, 5- and 11-based tuning grid, with a superperfect fourth generator interval in two different sizes (11:8 and 15:11).

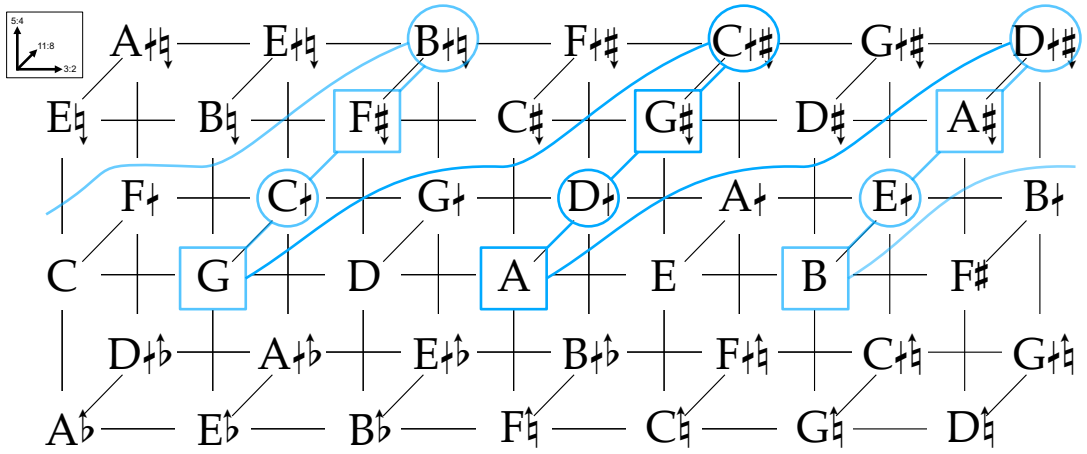


Figure II-21: the superperfect scale on a 3-, 5- and 11-based tuning grid, with a superperfect fourth generator interval in three different sizes (11:8, 15:11, and 1485:1024).

Little about these Just Intonation scales recommends them above their 24EDO cousins: they are equally dissonant and hard to use. They do situate the superperfect within the harmonic series in a way that may facilitate its linkage to other sonorities, but I have not explored that in this portfolio.

The subminor third has fewer satisfactory Just Intonation analogues than the other generator intervals. The candidate intervals are either relatively distant, involve high harmonics, or use higher-order primes:

Primes	Generator Interval	Size in cents	Distance from 250¢
7	7:6	267	17¢
3, 11	297:256	257	7¢
3, 5, 11	55:48	236	14¢
3, 5, 13	15:13	248	2¢
37	37:32	251	1¢

Table 6: subminor thirds in Just Intonation.

Of these, a 7-limit approach is simplest, and a three-dimensional 13-limit approach gives the closest low-prime approximation of the quartertone system.

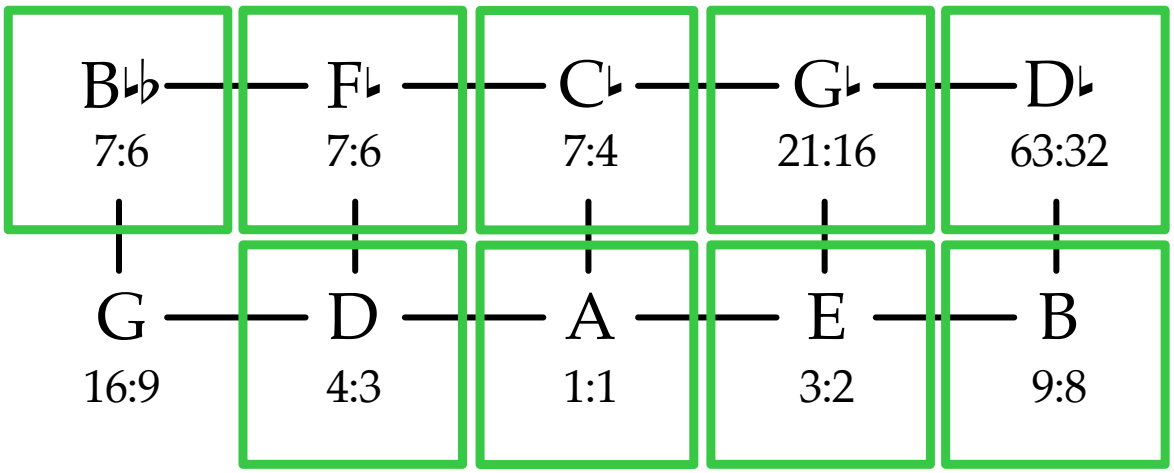


Figure II-22: a subminor scale on a 3- and 7-based tuning grid.

This work revealed obstacles to adapting the quartertone axis system to Just Intonation. A 3- and 11-based tuning results in complex ratios in the subminor scale. Using a 3- and 11-based tuning for the neutral and a 3- and 7-based, or 3, 5- and 13-based, tuning for the subminor would lose the quality of enharmonic equivalence between the scales. This problem clarified my interest in Just Intonation. The complex ratios of the 13-limit subminor and the 11-limit superperfect lacked the characteristics that I found appealing: tunability, resonance, and the appreciable suggestion of alternative harmonic resources. If I were to use hard-to-tune, inharmonic Just relationships, I may as well use quartertones.

As such, my Just Intonation interpretations of the quartertone axis system use a 7-limit subminor and an 11-limit neutral. While enharmonic equivalence is lost, the difference in sonority between the two prime limits adds a new expressive dimension to the system. In the figure below, notes that were enharmonic in the 24EDO axis system have become distinct. Close equivalents are separated by either an altered chromatic semitone (e.g. F𝄲 to F𝄭♯) or an altered diatonic semitone (e.g. E𝄲 to F𝄭). Between the diatonic equivalents, there is a small comma of 896:891 ($2^7 \cdot 7 : 3^4 \cdot 11$) or 10¢. Between the chromatic equivalents, there is a large comma of 45927:45056 ($3^8 \cdot 7 : 2^{12} \cdot 11$) or 33¢. The choice of comma is determined by the spelling of the scale and is consistent throughout the paired scales: close accidentals in D neutral and G♯ subminor are separated by the chromatic comma, close accidentals in D subminor and G♯ neutral are separated by the diatonic comma.

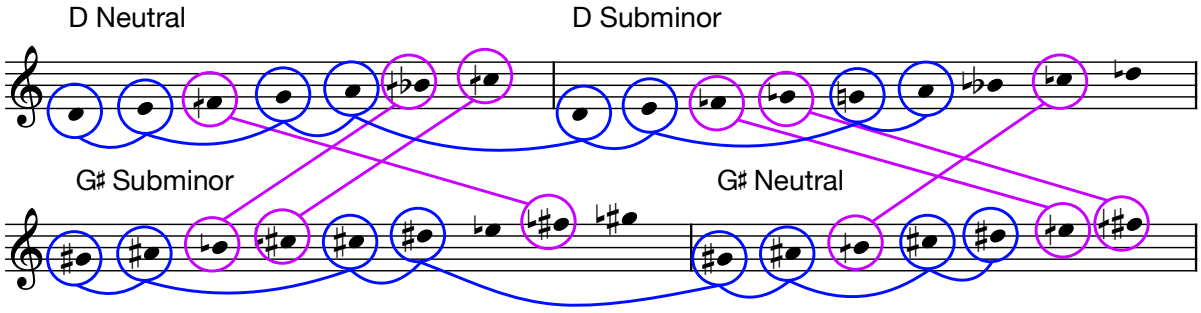


Figure II-23: the neutral/subminor axis system in Just Intonation.

A relational model of harmony

These new scales allowed me to reconsider how the neutral and subminor might relate to major and minor. Each scale implies a fundamental, allowing us to map them all on to the harmonic series. In Figure II-24, the diatonic, neutral and subminor scales are shown above a 1:1 of A. This places them in an unfamiliar modal configuration, with their tonics (coloured noteheads) in unexpected locations.

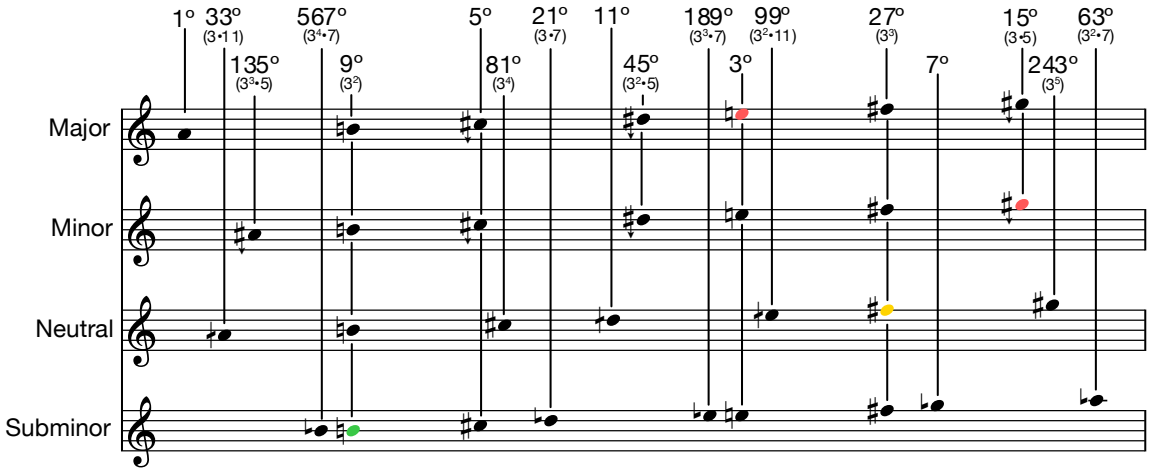


Figure II-24: Just Intonation diatonic, neutral and subminor scales shown within an octave-normalised harmonic series.

These surprising tonics occur because, in my choice of mode for my axis scales, I prioritised having perfect intervals on the fourth of the scale. This preference stems from my grounding in Western harmony, where the subdominant is an important counterweight to the tonic. As the 4:3 perfect fourth does not appear above the tonic in the harmonic series, the major scale must be rooted on 3°, as shown above. This feels counterintuitive. I identify the scale with its tonic triad; it acts as a synecdoche for scale. Figure II-25 to Figure II-28 shows the four tonic triads of the major, minor, neutral, and subminor as overtones of A.

This suggests that I am thinking about tonality relationally, with the tonic existing in a harmonic space that includes both its undertones and overtones. Salient intervals – fifths (3:2), fourths (4:3), and thirds (5:4, 6:5, 7:6, 11:9) – generate local harmonic structures – triads – which coalesce into a tonal region. These tonal regions contain transpositions of these triads, which are heard relationally to the tonic triad and its implied fundamental (Figure II-29 to Figure II-32).

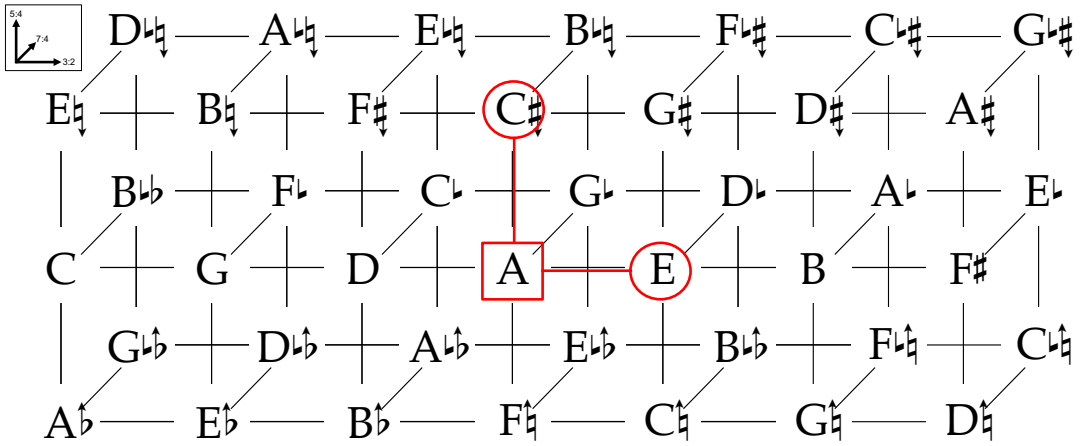


Figure II-25: major tonic triad (4:5:6) on a 7-limit tuning matrix.

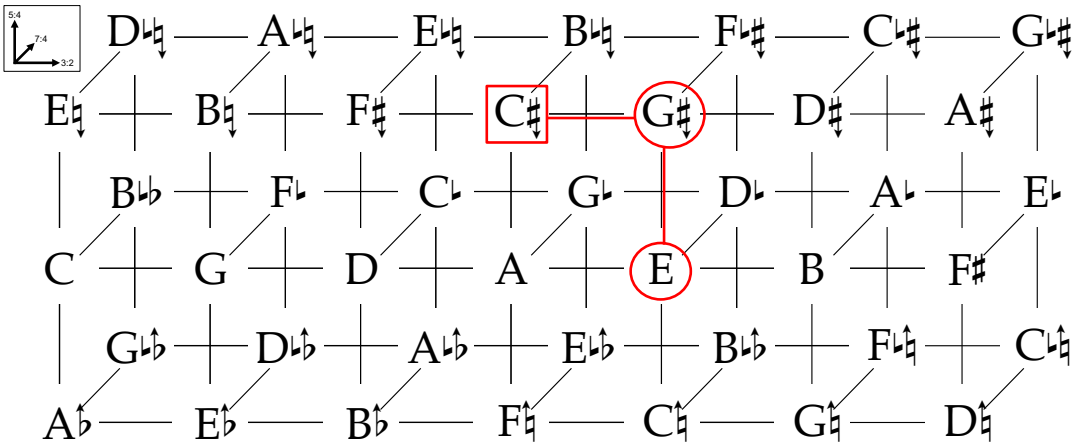


Figure II-26: minor tonic triad (10:12:15) on a 7-limit tuning matrix.

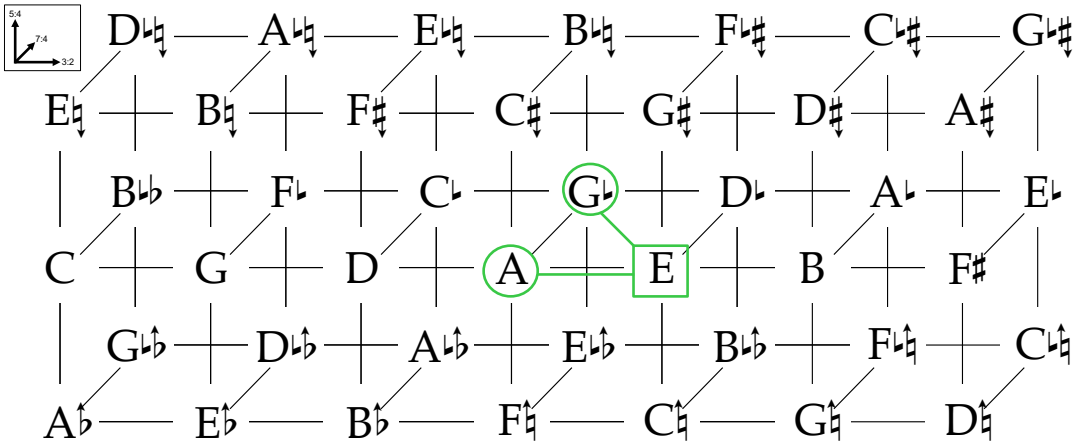


Figure II-27: subminor tonic triad (6:7:8) on a 7-limit tuning matrix.

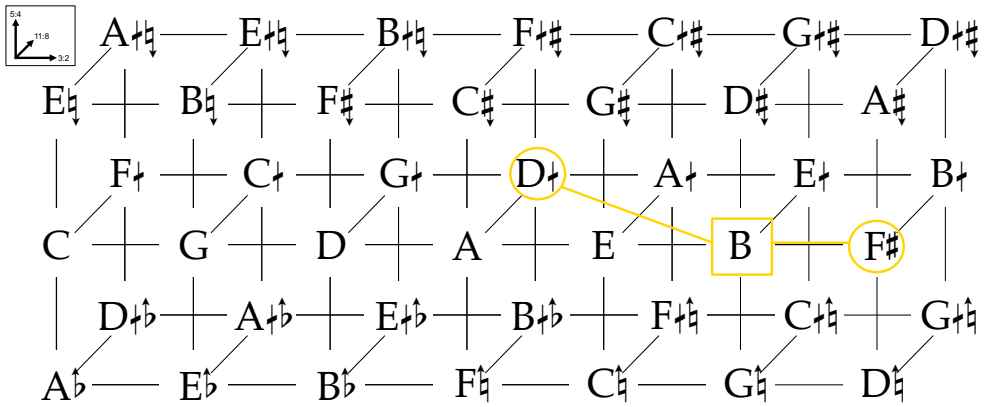


Figure II-28: neutral tonic triad (18:22:27) on a 3-, 5-, and 11-based matrix.

Tonal regions on tuning matrices

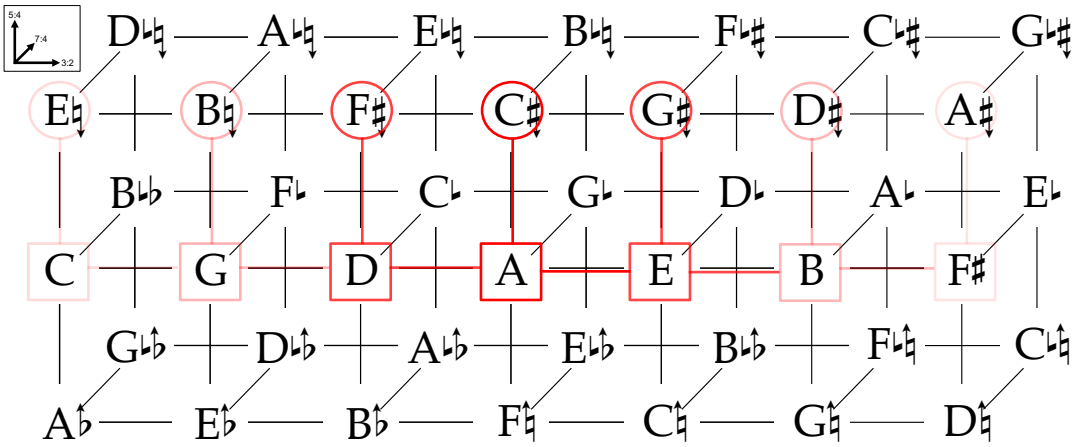


Figure II-29: major weighted tonal region on a 7-limit tuning matrix.

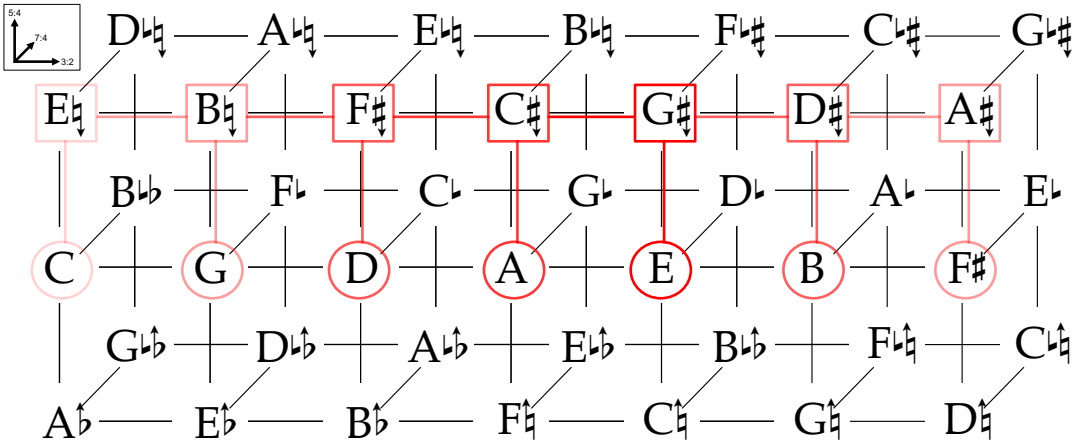


Figure II-30: minor weighted tonal region on a 7-limit tuning matrix.

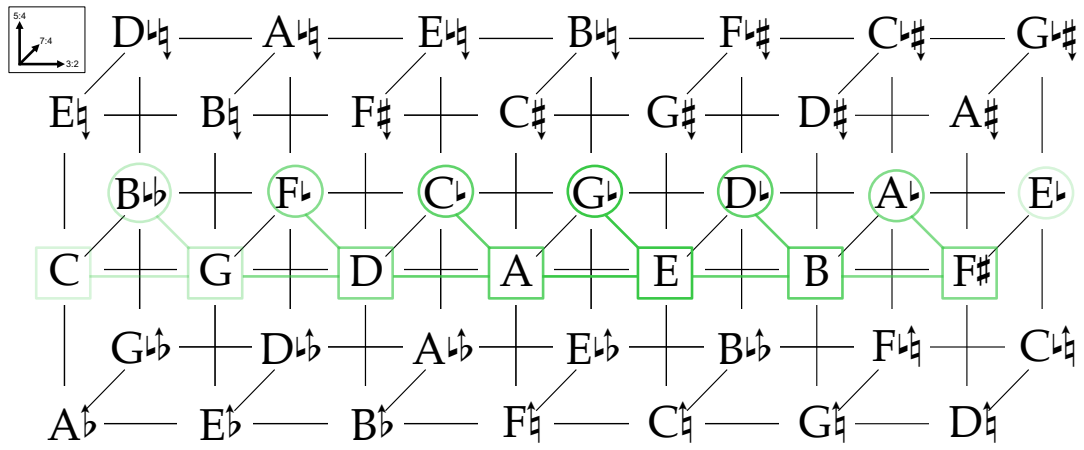


Figure II-31: subminor weighted tonal region on a 7-limit tuning matrix.

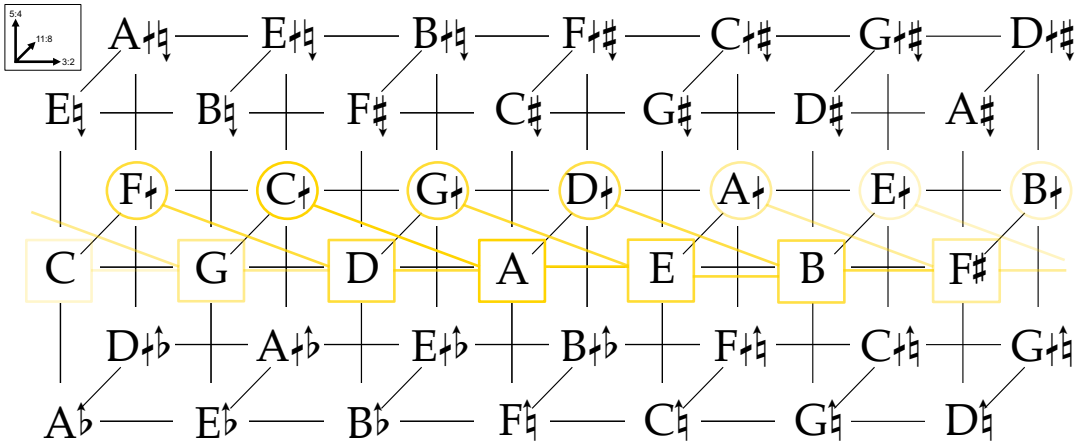


Figure II-32: neutral weighted tonal region on a 3-, 5-, and 11-based matrix.

These tonal regions resemble the generator circles of 24EDO. In Just Intonation, the weighted zone on a circle becomes a weighted area in tuning space, an area in which certain triadic geometries have tonal precedence. As with the generator circles, this aspect of harmonic weighting sits alongside the exigencies of conventional voice leading, which is better considered within the conventional glissando continuum. Tonality fluxes make use of the generative tension between these two forms of harmonic imperative: the proximate pitches in the flux are harmonically distant in their weighted areas of tunings space but proximate in the glissando continuum.

As the tuning space that includes diatonic, neutral, and subminor tonalities is 11-limit, it is four dimensional and thus challenging to depict. However, the weighted areas can be shown in pairs (major-subminor, minor-neutral) on a three-dimensional tuning grid, to give the impression of the overall orientation of these areas to one another.

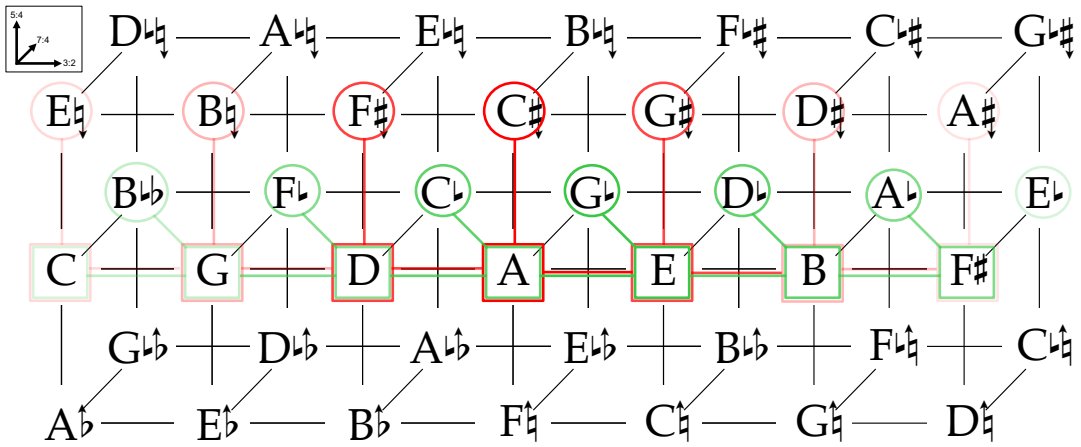


Figure II-33: major and subminor weighted areas on a 7-limit tuning matrix.

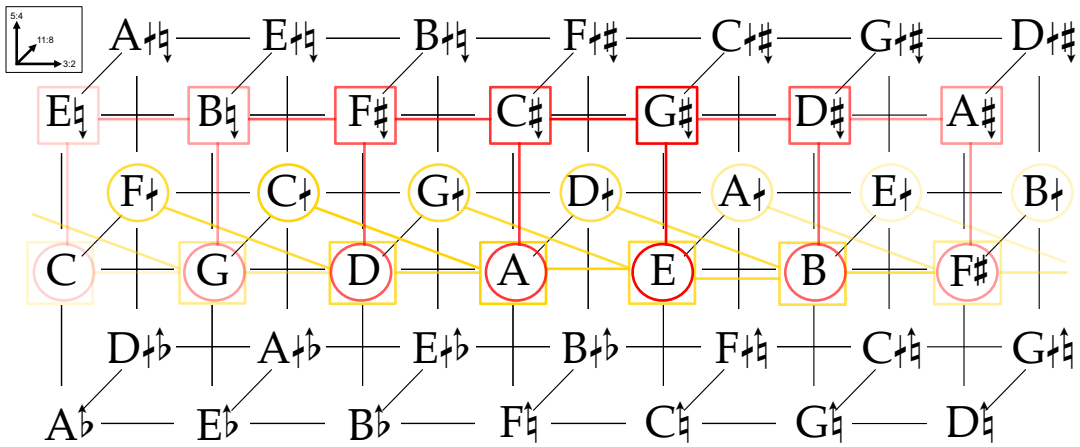


Figure II-34: minor and neutral weighted areas on a 3-, 5-, and 11-based tuning matrix.

This relational standpoint allows flexibility. Undertones and overtones can be freely mixed, and each harmonic moment can be seen in its own light: a chord might either relate back to the centre of the weighted area or become its own centre of tonal gravity. The salient trichords that form the bedrock of this system can be approached either as harmonics of a shared fundamental (◂ Figure II-35) or as triads that share a given root, implying multiple different fundamentals (◂ Figure II-36). These relationships can be approached in several ways: as extended chords, placing the neutral and subminor sonorities above or below the major and minor trichords, or as scalic relationships: the D subminor scale could modulate to B𝄲 minor; the D neutral might alternate in progressions with E𝄲 minor.

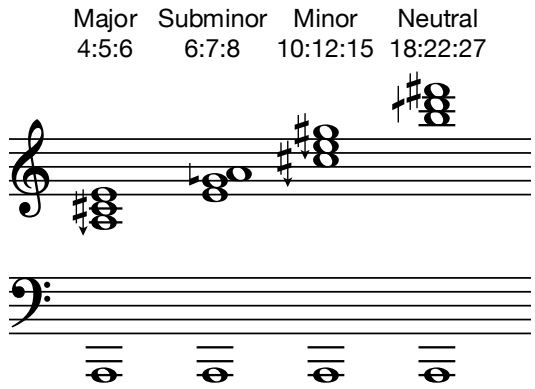


Figure II-35: tonic triads of a shared fundamental.

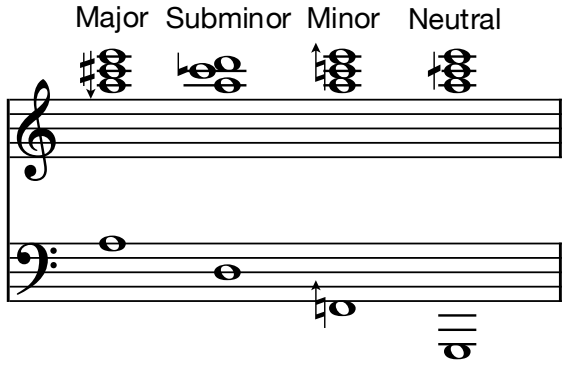


Figure II-36: tonic triads of a shared root, with their implied fundamentals.

Just Intonation is, in this aspect of my work, as much a conceptual tool as an intonation. It provides a logic that is distinct from the quartertone perspective of my earlier work and from traditional diatonic approaches. I describe this idea in 'Proportion And Symmetry As Mutual Antagonists In Tuning.' In that article, I propose that it can be productive to understand 24EDO as providing symmetrical aesthetic resources, like the axis system, and Just Intonation as providing proportional resources, like the harmonic series. I have found it useful to transfer ideas from one paradigm to another, producing new perspectives on existing material. This iterative process has allowed me to take material that I think I understand and shed new light on it, finding new sources of strangeness or fascination.

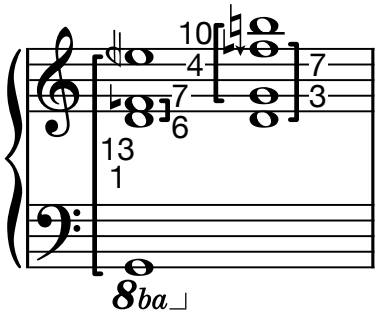
Combination tones

One example of this process is the recontextualisation of quartertone and diatonic intervals with combination tone harmony. This was prompted by Marc Sabat's work on tuneability and Mira Benjamin's work on intonation.[121] I was struck by the idea that Just Intonation could make microtonal sonorities easier to tune. Benjamin and Sabat both emphasise a relational understanding of pitch, in which complex intervals can be broken down into a series of simpler ones. These simpler relationships can be tuned through reference to their difference tones. The frequency of these tones is the difference between the frequency of the two principal tones: a 7:4 ratio would generate a difference tone of 3:1. This tunability concept encouraged my interest in Just Intonation, as I hoped it would make my preferred harmonic resources more performable.

It also sparked an interest in combination tones (including sum tones) as a harmonic resource. In this regard I follow the lead of Claud Vivier and Horațiu Rădulescu, whose use of combination tones has been an important influence on my work.[122] I took to using both

[121] Sabat and Hayward, 'Towards an Expanded Definition of Consonance: Tuneable Intervals on Horn, Tuba and Trombone'; Benjamin, 'Thick Relationality: Microtonality and the Technique of Intonation in 21st Century String Performance'.
[122] Bryan Christian, 'Combination-Tone Class Sets and Redefining the Role of Les Couleurs in Claude Vivier's Bouchara', *Music Theory Online* 20, no. 2 (July 2014), https://doi.org/10.30535/mto.20.2.2; Bob Gilmore, 'Spectral Techniques In Horatiu Radulescu's Second Piano Sonata', *Tempo* 64, no. 252 (April 2010): 66–78, https://doi.org/10.1017/S0040298210000197.

the difference and sum tones of a dyad as a means of recontextualising its harmony, placing it in the harmonic series in often unexpected ways. Combination tones move non-logarithmically: they are not subject to octave equivalence. As a result, transposing one note of the dyad by an octave produces different chords. The example below shows how the dissonant combination tone tetrachord of the 7:6 becomes a consonant tetrachord when the one note is transposed by an octave, to a 7:3. These chords allowed me to access resonant new sonorities that cut across the scalic logic that operates in most of my work. They act almost as a form of randomisation, producing results I find unpredictable.



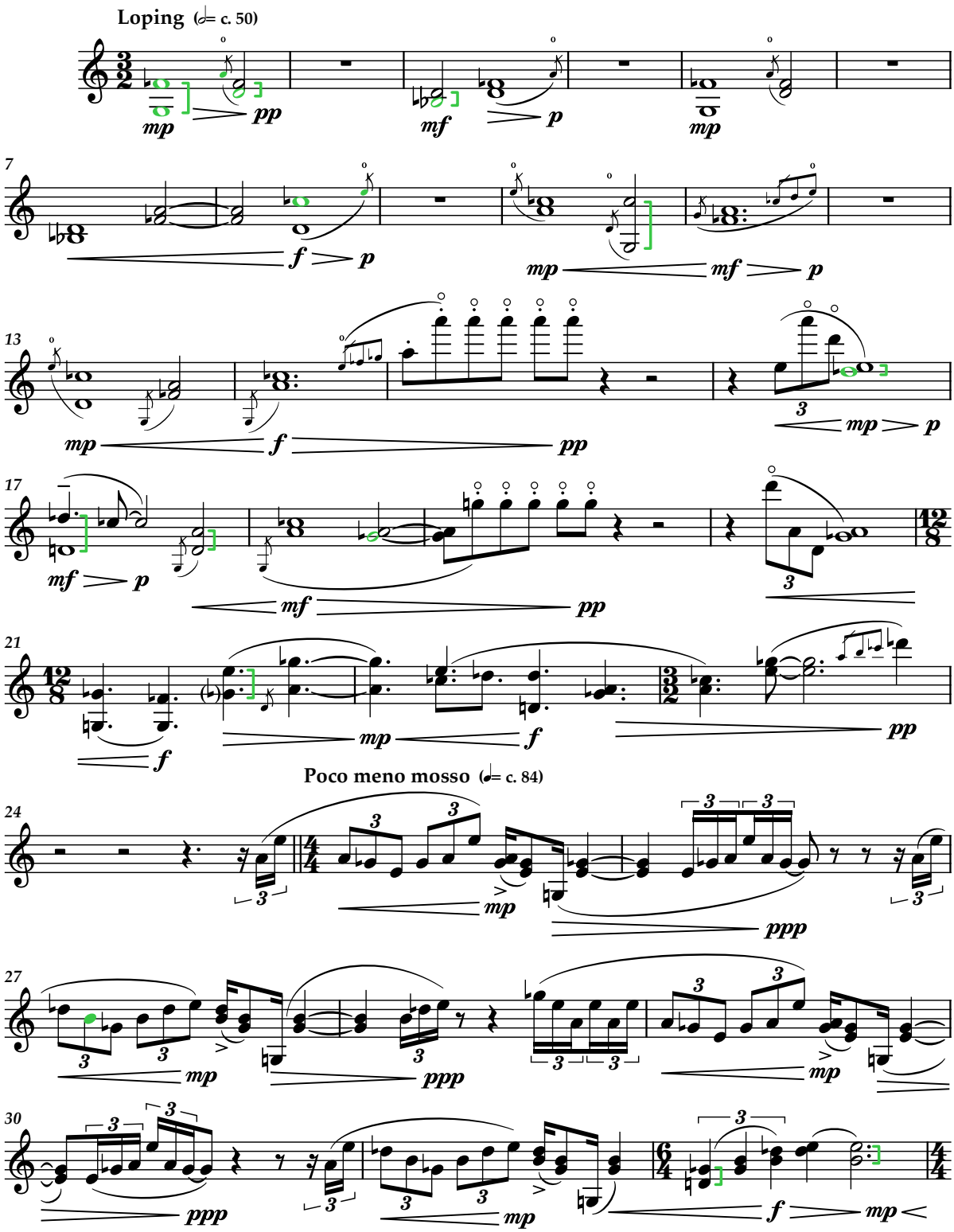
◂ Figure II-37: combination tones of 7:6 and 7:3.

Just Intonation scales in *Phasmid*

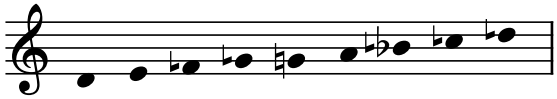
In *Phasmid*, I use the 7-limit subminor alongside combination tone harmonies. To start, I created a list of 3- and 7-based subminor dyads that could be created against the open strings. This procedure for generating material recalls my search for triads on the guitar in *Odd Coils*: a period of abstract harmonic exploration, based on the qualities of the instrument, is followed by a process of elimination, in which impractical or unpleasing (often excessively dissonant) chords are removed. The process has become an important part of my compositional technique and will be further discussed in Chapter III.

In *Phasmid*, the simpler dyads introduce nine pitch classes, constituting a subminor scale (◂ Figure II-39), which are then used to find more complex harmonies. In ◂ Figure II-38, each new pitch class is coloured green, and each new interval is bracketed. In the reduction, Figure II-40, every new dyad is listed, with new intervals underlined and new notes coloured.

This illustrates how every new pitch class is introduced alongside an already established pitch and shows that each new microtonal pitch class is introduced as part of a dyad with an open string. Similarly, each new interval class is introduced in a dyad with an open string. This eases intonation, allowing the player to concentrate on tuning just one pitch. Moreover, the new microtonal pitches are introduced in one of two finger positions above their open string: a subminor third for the first three, and a semidiminished fourth for the next two.



◂ Figure II-38: the opening page of *Phasmid*, with new pitch classes coloured and new interval classes bracketed.



◂ Figure II-39: the subminor scale used in *Phasmid*.

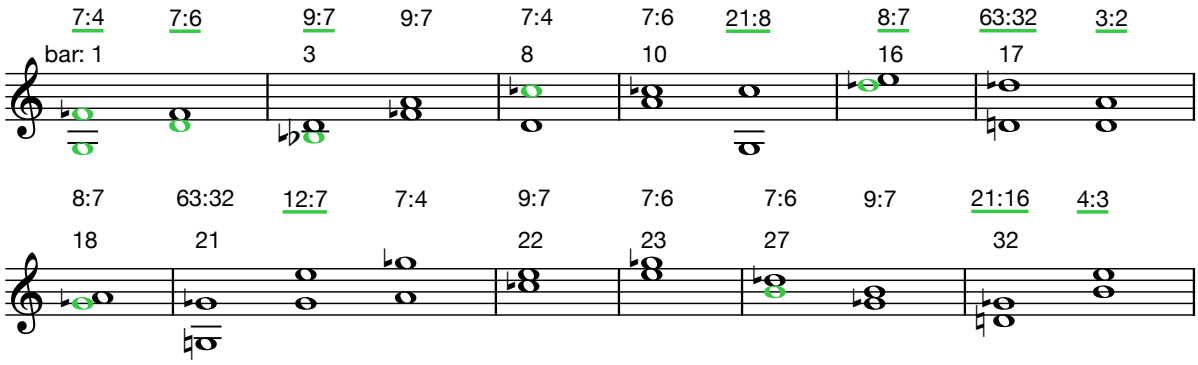


Figure II-40: reduction of the opening page of *Phasmid*, showing each new interval. New pitch classes are coloured, new interval classes are underlined.

This process is audible in the structure of the work. The opening 24-bar passage comprises a simple melody using double stops that introduces all the pitches of scale. I use increasingly complex intervals, with the three 63:32 semidiminished octaves in bars 17, 21, and 22 acting as moments of increased harmonic tension. I intended this passage to acclimatise the ear of the player and the listener to these microtonal pitches, introducing them in their most consonant forms before revealing the extent of their potential dissonance. I find the contrast between consonance and dissonance more powerful in Just Intonation, where the simplest forms of the subminor intervals, the 7:4 and 7:6, are more consonant than their 24EDO equivalents.

The second passage, bars 25-32, introduce quadruple stops and a new note. The B in bar 27 is outside the original nine-note subminor collection; it is adjacent to the initial subminor area. This passage moves the scale round the generator chain, leaving behind the B𝄫 to explore fifth-based harmonies on E (see Figure II-41 and Table 7). This is part of a larger structural shift sharpwards that culminates in the transposed recapitulation of the opening in bar 65. As in earlier 24EDO works, exploration of the edges of the weighted zone is an important source of diatactical interest. But in *Phasmid*, this is combined with a secondary harmonic resource: combination tone harmony.

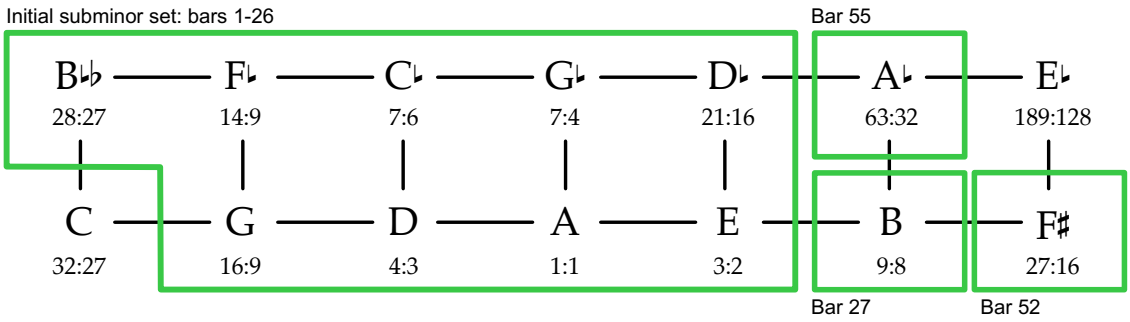


Figure II-41: a 3- and 7-based tuning grid, showing where notes are added to the initial subminor set of *Phasmid*.

Bars	Subminor harmonies
1-26	Initial subminor set
27-32	B𝄬 replaced by B𝄮
41-48	
49-78	G and F𝄬 replaced by A𝄬 and F♯
79-96	Initial subminor set, with B𝄮 and F♯
106-121	Initial subminor set

Table 7: the harmonic structure of the subminor sections of *Phasmid*.

Combination tones in *Phasmid*

Following the quadruple-stopped passage that ends in bar 32 is a passage with a similar texture that introduces 11-limit harmonies derived from the combination tones of a 7:4 subminor seventh. I freely transposed the 3:4:7:11 difference tone tetrachord to create practical quadruple stops. While this revoicing dampens the resonance of the combination tone chords, the practice of searching for combination tones is a source of harmonic inspiration as well as an exploration of acoustic phenomena. My interest in combination tones was secondary to the practicalities of performance: only a few combination tone chords were practical on the violin in their untransposed form.

The contrast between these difference-tone inspired chords and the subminor passages becomes the key structural element of the piece (Table 8). The quadruple-stopped moments of combination tone-inspired harmony are climactic, occurring just twice in the piece. The tension they produce requires resolution by the prevailing subminor tonality. This has been an important development in my microtonal language. Combination tones provide a secondary tonal logic that can complement the neutral/subminor axis system, integrating new sonorities based on existing material.

The second passage of combination tone introduces pitches beyond the 11-limit and uses more literal combination tone harmony. The first five chords of this passage, in bars 97-101, are transpositions of the 3:4:7:11 chord from the first combination tone section. But from bar 102-105, the moment of maximum dissonance in the piece, literal combination tone chords are used. I hoped that this would grant these dissonant chords greater resonance, in part due to their spacing, which is directly derived from the harmonic series. I use this resonance to support a moment of high harmonic tension, leading to a greater sense of resolution when the piece returns to the subminor in bar 106.

Bar	Harmonic Language	Texture
1	Subminor	Dyads
25	Subminor	Quadruple stops
33	Combination tones	Quadruple stops
41	Subminor	Quadruple stops
45	Subminor	Dyads
97	Combination tones	Quadruple stops
106	Subminor	Quadruple stops

Table 8: a structural diagram of *Phasmid.*

The harmonic complexity of the 8:13:21:34 chord in bar 104 led to a challenging decision regarding notation. It is the most dissonant chord in the piece, and the only one to exceed the 11th limit. As such, it introduces two new HEJI accidentals, which are only used in this bar. This risks confusion for the performer, who has so far navigated a consistent harmonic world with only two microtonal accidentals. I thus considered approximating these pitches. The lower pitch could be written as an E𝄲 rather than as the less familiar E𝄲 but is 12¢ higher. With the G𝄳, I chose between five options:

- G𝄳, spelling the pitch as intended, with a complex accidental.
- G𝄲, using HEJI to indicate that the pitch is an equal tempered note 5¢ lower than the intended pitch.
- G♯, suggesting a 3-limit note that is 9¢ higher than the intended pitch.
- G♯, intended as an equal tempered note, changing the piece's notation such that all conventional accidentals are to be read as tempered fifths, i.e. 12EDO.
- G♯, intended as equal tempered note, but as an exception to the general notation system that prevails through the rest of the piece.

The tuning difference between these notes, while audible, is within the margin of error in a tricky, fast passage: Knipper and Kreutz found deviations that exceeded 67¢ in stopped microtonal pitches in recordings of an 18EDO piece by Klaus Huber.[123] As such, I was most concerned about producing notation that is clear for the performer.

For the lower pitch, the decision was clear. Either choice introduces a new microtonal accidental, it may as well be accurate. For the higher pitch, I was ambivalent. I ruled out the last option, as it requires explanation but produces little advantage. Tempering all the fifths

[123] Knipper and Kreutz, 'Exploring Microtonal Performance of "…Plainte…" by Klaus Huber for Viola d'amore in Third-Tone Tuning'.

would be clear for the performer, but changes the tuning of other pitches, such as the F♯ in bar 52, more than I wanted. As I felt that any of the first three options would require some form of annotation, I chose the first option, and provided an indication of the cent deviation from equal temperament for both pitches. I value the consistency of HEJI and often work with players who are interested in this approach to tuning.

To aid tuning throughout the piece, I included an appendix, which includes details of the size, in cent and as ratios, of all the intervals used in the piece. This is of particular importance for intervals that include two microtonal pitches, where it is easy to lose track of the total distance between the two notes.

The axis system and combination tones in *Wound Honey*

My piece for clarinet trio, written in collaboration the trio terra invisus, uses a similar structural principle of alternating sections of diatonic material with combination tone harmony. As was habitual by this point, I began by exploring the harmonic resources that I might use in this piece. Like in *Phasmid*, I listed the neutral/subminor axis-system dyads available against the open strings of the cello. I then created combination tone tetrachords from these dyads, which I winnowed down to those I enjoyed. This process created a repertoire of simple dyads and complex tetrachords that I intended to be the spine of the piece. As in *Phasmid*, I created a structure that alternates between these two different harmonic frameworks.

The piano and clarinet transformed this structure, however. Their different relationship to microtonal pitch necessitated alternate approaches. For the clarinet, approaching microtonal pitches by step often made tuning easier. This prompted the use of pitches that were not in the core diatonic collection, resulting in music with less restricted macroharmony that *Phasmid*. See, for example, the opening bars, where the alternations between F and F𝄭 and C and C𝄭 are at odds with the prevailing subminor harmonic area. The decision to move to F𝄭 via F in the clarinet part eases the tuning of that line and suggests the possibility of a contrary motion movement in the cello from C𝄭 to C.[124]

As discussed above, my writing for piano in microtonal contexts had primarily used fifth-based harmonies, resulting in a pentatonic harmonic language that I found limiting. In this piece, I decided to use the piano to produce approximations of higher harmonics. I created a list of the first 128 harmonics in order of their distance from 12EDO (Table 9). The first eleven harmonics in the list were derived from the prime numbers 3, 17, and 19, inspiring me to treat the instrument as though it were tuned in 3-, 17-, and 19-based Just Intonation. This resembles Marc Sabat's treatment of 12EDO, which he describes as a 'Well-Tempered' tuning using the same harmonics.[125] I decided to notate these tempered 3-, 17-, and 19-based pitches with conventional 12EDO notation, alongside HEJI notation for the remaining pitches.

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[124] Roche, 'Three Octave Tremolo/Moving Passages Chart w/ Quarter Tones for Bb Clarinet'.
[125] Marc Sabat, 'Three Tables For Bob', *Tempo* 70, no. 278 (October 2016): 48–51, https://doi.org/10.1017/S0040298216000334.

Harmonic	Cents	Cents from octave	Cents from 12EDO	Prime Factors	
1	0	0.0	0.0	1	
57	6999.5	999.5	-0.5	3	19
3	1902.0	702.0	2.0	3	
19	5097.5	297.5	-2.5	19	
121	8302.6	1102.6	2.6	11	
9	3803.9	203.9	3.9	3	
17	4905.0	105.0	5.0	17	
27	5705.9	905.9	5.9	3	
51	6806.9	806.9	6.9	3	17
81	7607.8	407.8	7.8	3	
85	7691.3	491.3	-8.7	5	17

Table 9: the 11 harmonics under 128° closest to 12EDO.

This decision expanded my harmonic resources, including high-limit Just Intonation and the pitches of 12EDO. This had implications for the neutral/subminor axis system: I could use the equal tempered tritone rather than a 3-limit approximation. This simplified the tonality flux between the 7- and 11-limit accidentals. In a Just Intonation version, the chromatic and diatonic semitones create two sizes of comma, 10¢ and 33¢. In this hybrid version, chromatic and diatonic semitones are the same size. The near-equivalent accidentals are now consistently 18¢ away from one another (see Figure II-42). This tempered comma is used as an expressive resource. In bars 16-20 of Movement I (◂ Figure II-43), for example, the cellist uses this comma to move from the neutral to the subminor and back. I thought the effect plaintive and delicate; it became a central part of the movement's aesthetic.

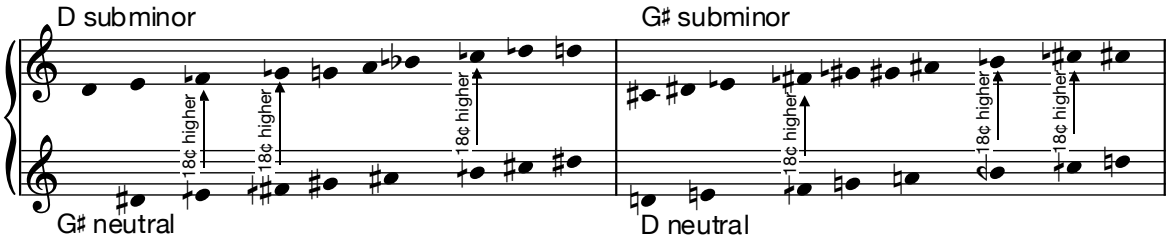
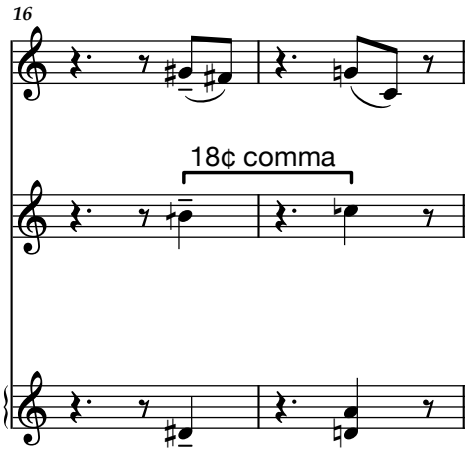
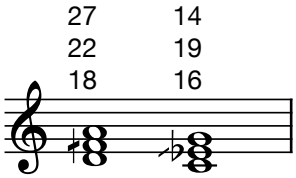


Figure II-42: the subminor and neutral scales used in *Wound Honey*.

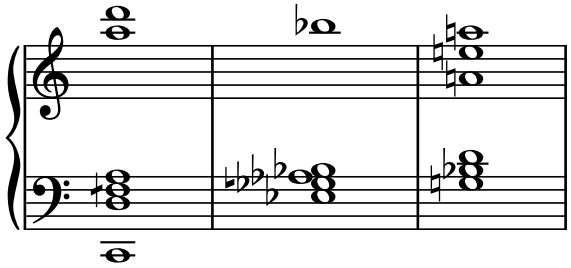


◂ Figure II-43: use of the tempered comma in bars 16-17, Movement I, *Wound Honey*.

Rather than remaining below the 11th limit, I now considered harmonies up to the 19th limit. I became especially interested in combining the neutral triad, 27:22:18, with the 19-limit minor triad, 24:19:16 (◂ Figure II-44). Throughout the third movement of *Wound Honey*, these two chords become increasingly aligned, to the extent that D neutral ends up bitonally connected to C minor. This correspondence compliments the neutral/subminor axis system: the counterpole of the D neutral scale is the subminor scale on A♭, which shares E♭, A♭, and B♭ with the C minor scale. In *Wound Honey*, this is exploited in bars 18-20 of movement III, where the motion from a E♭ subminor pivot chord to a G minor chord is aided by the B♭ that they share (◂ Figure II-45). The final chord in this sequence omits the implied C𝄲: the association between G minor and A neutral is strong enough by this point in the movement that the key microtonal pitch can be omitted without losing the sense of implied harmonic motion back to the D neutral/C minor harmonic area.



◂ Figure II-44: an 11-based D neutral triad shown alongside a 19-based C minor triad.



◂ Figure II-45: bars 18-20, Movement III, *Wound Honey*, reduction.

Re-imagining the piano as a 19-limit instrument expanded my repertoire of combination tone harmony. This recalls Radulescu's approach to the piano, though with a more restricted

acceptance of approximation.[126] I repeated my combination tone process, creating dyads by combining 17° and 19° with each other and with 2°, 3°, and 9°, then creating 32 tetrachords from their combination tones. These harmonic resources – three tonal areas associated with three sets of combination tone tetrachords – became the structural basis for the piece, which alternates contrasting, conjoined movements. Movements I and III are fluid and sparse; movement I is in D subminor, contrasted with neutral pivot chords on the A♭ counterpole, movement III is in a bitonal combination of D neutral and C minor (see Table 10).

Movements II and IV are combination tone chorales, written in free tempo. Movement II is created from 7-limit dyads, movement IV uses 19-limit dyads. In these movements, each dyad is harmonised twice: first, briefly, as a diatonic chord within the neutral/subminor axis system, then, after a period of being sustained unaccompanied, it is treated as the generating dyad of a combination tone tetrachord. I had hoped that unaccompanied dyads would allow the performers, and perhaps the audience, to hear the combination tones before they were played on the instruments. In practice, the timbral differences between the instruments made this challenging. This local structure emulates the piece's superstructure, which accentuates the contrast between combination tone chords and diatonic chords to create highly contrasted movements.

Movement	**Harmonic Language**	**Idiom**
I	D subminor (with some A♭ neutral)	Metred
II	Combination tones (mainly derived from D subminor)	Free tempo chorale
III	D neutral (paired with C minor)	Metred
IV	Combination tones (mainly based on D neutral/C minor)	Free tempo chorale

Table 10: structural diagram of *Wound Honey.*

The chorale movements were written in free tempo. In practice, this caused problems when the piece was workshopped. The free notation prevented the players from coordinating the complex tuning and managing the challenges bowing and breathing. As such, I wrote two versions of each movement: one in free tempo, and one in measured time. This process was useful for the performers but also revealed problems in the free tempo version that I was able to correct.

I was concerned that the contrast between the free-tempo and metred movements would lead to a piece with little structural momentum. As in *Phasmid*, I was able to use the constructive tension between contrasting harmonic approaches to structure the piece. This

[126] Gilmore, 'Spectral Techniques In Horatiu Radulescu's Second Piano Sonata'.

teleology was primarily effected by the piano. In the first movement, the piano is constrained, only able to play the 3-limit notes in the Just Intonation neutral/subminor axis system. In the second movement, the emergence of combination tone tetrachords leads to a more animated piano part and the emergence of higher limit harmony. In movement III, the use of 19-limit C minor liberates the piano, which traces quiet arpeggios through an increasingly wide range. In the final movement, the use of 17- and 19-limit dyads as the source of the last movement's combination tone tetrachords allows the piano to take a leading role. The arpeggios of the second movement become florid cadenzas that push the piece towards its climax.

III. Making myself at home: systems and hybridity

This chapter describes how I developed a new understanding of intonation through a dialogue between theory and practice. In Part A, I describe my movement towards a hybrid practice, considering how changes in my epistemology were prompted both through wider reading and by changes in the instruments with which I composed. In Part B, I discuss the role of hybridity in the most recent works in the portfolio, Study for the Hyasynth *and* Ink, Colour, And Gold On Paper. *Part C concludes the commentary, revisiting my goal of resisting the attention economy.*

A. Developing a hybrid microtonality

Abstraction and materialism – Placing my work in its historic context – Embodiment and instrumentation – Material agency in Straight Line Through A Landscape

Phasmid and *Wound Honey* both testify to my increasingly hybrid approach to harmony and intonation. While *Phasmid* is written only in Just Intonation, it is conceptually hybrid, in that it uses the subminor scale, which originates in my 24EDO axis system. *Wound Honey* also uses the harmonic resources of the 24EDO axis system in Just Intonation, making expressive use of the tonality flux generated by the resulting comma. Its tuning system is hybrid; the spine of fifths that runs through its HEJI notation is tempered into 12EDO, allowing the piano to play alongside the 7- and 11-based harmonies of the neutral/subminor axis system.

Hybridity allowed the limited macroharmony and consistent harmonic language of the neutral/subminor axis system to sit alongside other harmonic resources: diatonic chords and combination tone harmony. These additional consonant resources act as a structural counterweight and an expressive alternative to the axis system. Crucially, I sufficiently differentiated these resources from common-practice tonality, finding strangeness within Just Intonation diatonic harmony.

Working with hybridity also revealed to me the contingency of my quartertone system. When I constructed it, I viewed it as a conceptually complete and musically independent harmonic language that would be capable of sustaining my musical language indefinitely. My Neoplatonic approach abstracted the musical system from its cultural context, from the music that instantiates it, and from the intellectual processes that created it. This approach has had its benefits. By discarding my concern for cultural context and the practicalities of performance, I was able to explore harmonic ideas that would not otherwise have occurred to me. By being systematic, I was able to find surprising sources of coherence in these ideas.

But working concertedly within an abstract framework entailed a delimitation of that framework that excludes other approaches. It becomes an intellectual autarchy whose reliance on its own resources resulted in impoverishment. This was apparent when the reality of instrumental construction caused problems for my idealist system (e.g. in *Nocturne* or *Odd Coils*), or evoked diatonic or orientalist topics that sat uncomfortably with my

xenharmonic tonality (e.g. in the fugues and *Straight Line Through A Landscape*). Moreover, the Neoplatonic mindset draws a falsely absolute distinction between things inside and outside of the system. My cyclical approaches to 24EDO are not so separate from other tuning systems. Young's arrival at a similar idea through different means or Wyschnegradsky's pursuit of the same methodology to different ends illustrate the fragile borders between seemingly distinct approaches to tuning.

In developing a hybrid approach, I have benefited from the creative stimulation of an abstract systematic approach while reaching a more realistic understanding of my materials that permits creative flexibility and pragmatism. In the previous chapters, I show how my practical needs and aesthetic preferences led me towards this hybrid approach. But this shift was also influenced by my changing understanding of the history of tuning and an epistemic interest in a more embodied approach to intonation. Influenced by the work of Marc Sabat, Mira Benjamin, and Khyam Allami, I came to better understand my previous epistemic framework and find new approaches. These approaches resulted in both new music (*Study for the Hyasynth* and *Ink, Colour, And Gold On Paper*) and in the development of a new instrument, the Hyasynth. This new practice has allowed me to blend an abstract understanding of microtonal tonality with intuitive, embodied responses to it, making myself more fully at home in this harmonic language.

Epistemics and embodiment

As discussed, my microtonality resembled that of early Twentieth Century Western composers, particularly Carillo, Wyschnegradsky, and Hába. These composers tended to discuss their work in abstract terms rooted in Nineteenth Century music theory. They position microtonality as a natural progression from early Twentieth Century chromaticism, viewing it both as a new frontier to be explored and a resurrection of pre-industrial forms of music making.[127] Partch's influential explorations of Just Intonation had a similar epistemic basis. He projected a teleological history, in which composers explored ever higher prime limits before the natural progress of history was disrupted by the rise of equal temperament.[128] Like the microtonalists of the 1920s, he described his project both as one of restoration, of a pre-12EDO trajectory, and of progression, to the 11th-limit and beyond.

I began my microtonal practice with a similar mindset. I viewed microtonality as a rich source of musical novelty that could be encountered through abstract engagement with the mathematics of music. I felt stimulated and engaged by the process of cataloguing and naming, by the sensation of discovery. This practice located me within a contemporary context of digital microtonality, in line with the web cultures that have explored xenharmonic music, such as Xenharmonic wiki. This PhD and the process of reflection it has encouraged has altered my approach.

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[127] Kate Molleson, *Sound within Sound: Opening Our Ears to the 20th Century* (London: Faber, 2022), 26; Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*, vii–xi; Annika Forkert, 'Microtonal Restraint', *Journal of the Royal Musical Association* 145, no. 1 (May 2020): 75–118, https://doi.org/10.1017/rma.2020.6.
[128] Partch, *Genesis of a Music*, 361–97.

First, I have reframed my understanding of the history of microtonality. Rather than viewing European microtonalists as unprecedented explorers, I have come to understand the increasing hegemony of 12EDO as an historical exception: the coexistence of multiple evolving tuning cultures has more global and historical precedents than does 12EDO's relatively recent dominance.[129] The process of standardisation facilitated within European music by industrialisation was exported in the Twentieth Century through the colonial and post-colonial spread of European culture and commerce.[130] The same narratives of modernist progress that underlie the contributions of early Western microtonalists also underpinned the spread of the musical system that they railed against. My growing scepticism of such narratives altered my understanding of the musical contribution I might make. Whereas I was previously interested in the creation of microtonal systems as a form of knowledge discovery, I am now less concerned with the novelty of microtonal systems for their own sake. Instead, I have become more interested in the ways in which encounters between musical systems might be artistically generative.

Second, I have become more interested in the perceptual aspects of microtonality. The works of Wyschnegradsky and Hába evince little interest in the relationship between their work and the aural practices of the musicians it might involve. If early Western microtonal theorists tended to treat tuning as an abstract source of sonic novelty, later theorists have tended towards a more sensory approach. This understanding, pioneered by Partch and Tenney, centres psychoacoustics and the physics of sound to a greater extent than the composers of the 1920s. This perspective has tended to lead towards an interest in Just Intonation rather than extended equal temperaments. The work of the composers associated with the Plainsound collective – particularly Marc Sabat, Chiyoko Slavnics, and Catherine Lamb – have been particularly important to my recent thinking, as has the writing of Mira Benjamin. These theorists have emphasised the embodied aspects of intonation, suggesting the possibility of a productive dialogue between the abstract and the sensory.

Digital microtonality and Neoplatonism

The contrast between these approaches can be illuminated by a framework proposed by Benjamin. She distinguishes between two 'mutually beneficial' ways of knowing pitch, intonation and microtonality, writing:

> 'Intonation is known in the body through technique, and instantiated in practice… [It is] a *relational epistemology* of pitch (one in which pitches are modelled, defined and imagined in relationship to other pitches) … Microtonal models furnish socially

[129] For a history of European classical music's experiments with intonation, see Barbieri, *Enharmonic: Instruments and Music 1470-1900; Revised and Translated Studies*.
[130] Walden, 'The Politics of Tuning and Temperament: Transnational Exchange and the Production of Music Theory in 19th-Century Europe, Asia, and North America'; Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music', 61–71.

> defined, symbolic descriptions… [which can] feed into a reflective dynamic of embodied technique.'[131]

This symbolic approach to pitch is conceptual; it describes the explicit knowledge of ratios, equal temperaments, and acoustic theory. My initial work with quartertones was characterised by a microtonal technique; my shift to a more intonational hybrid practice has been facilitated by changing the instruments with which I composed.[132]

In my early microtonal work, I forestalled the development of an intonational practice by relying on digital realisation. This included DAW-based digital synthesisers, programmes that aid the creation of tuning files (Scala, OddSound, Leimma), and notation software. Notation software has been central to my composition process and to my audiation of my music since childhood, and the microtonal capabilities of Sibelius and Ableton have been important to my ability to write xenharmonic music. To return to the terms of Chapter I, these digital resources can easily be retuned, but they do not have flexible intonation. Changes in tuning are separate from the act of playing; they involve an encoding of the pitch, normally through a screen or the triggered by a controller. They remove the contingency of intonation choice present in intonationally flexible instruments.

The lack of contingency in pitch production was the central appeal of these instruments. By encoding my desired tunings, I was able to reliably reproduce microtonal pitches without thinking about intonation. This allowed me to familiarise myself with the sound of quartertones and improvise within a quartertone system, discovering which of its sonic qualities I was drawn to. Digital instruments facilitated a separation of tuning from playing, which encouraged a Neoplatonic view of my quartertone system. I was able to see the system as autonomous, unbound by the messy reality of instrumental and cultural practice. This mindset has been critiqued by Khyam Allami, who argues that new digital xenharmonic tools are constrained the assumptions of their Western experimental heritage.[133] He argues that this mindset tends to decontextualise tuning, reifying pitch choices into scales – linear arrangements of notes oriented around a root. Most modern microtuning software uses tuning files organised in this way.

I was aware of the influence of the digital keyboard and notation software on my work from the beginning, but from a different perspective. I was concerned that the physical familiarity of the keyboard would shape my music, undermining the autonomy of my quartertone system. I used a retuned autoharp as an alternative. The autoharp is an intonationally inflexible zither with buttons that dampen strings to produce chords. Improvising at the autoharp was an important part of my earlier axis system work and became the basis for *Nocturne*. Played by the percussionist and manipulated through live electronics, the

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[131] Benjamin, 'Thick Relationality: Microtonality and the Technique of Intonation in 21st Century String Performance', 209–10.
[132] I first described this process in a conference paper: Joe Bates, 'Electronic Tuning As An Embodied Practice' (C21MP, University of West London, 2023).
[133] Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music', 71–84.

distinctive timbre of the autoharp resulted in a piece that was significantly different from earlier works. But my harmonic language was unchanged. I tuned the autoharp according to the quartertone axis system, fixing my pitch choices to my preconceived ideas.

Allami proposes that one understands tuning systems as relational networks rather than linear objects, designing software (Apotome and Leimma) on this basis.[134] I use Leimma, whose initial selection menu allows you to select tuning systems from multiple musical cultures. When building a custom system, you start from a point (your 1/1) and generate a line (using ratios or cents), which is then projected into an octave circle. The key difference with other software lies in the next step: you select pitches from your circular set and combine them into subsets. For example, Leimma's presets include Al-Farabi's 25-tone tuning, based on a ten-fret oud.[135] This set of 25 pitches can then be narrowed down to various maqams, such as maqam rast, which contain only seven of the 25 available notes. Allami argues that this set and subset mentality is more culturally neutral way of understanding tuning, noting that few scales outside of Western experimental music use more than twelve notes within any given subset.[136]

Leimma encouraged and facilitated my shift towards Just Intonation. I used it to build the pentatonic subsets I used in *How To Go Outside* and to experiment with them while composing. But it also helped me break down my scalic perspective, helping me to see the local macroharmonic environment as a mutable subset of a larger set of intonational choices.

Contingency and material agency in *Straight Line Through A Landscape*

In *Straight Line Through A Landscape*, I made a shift in my compositional practice, opening my pitch choices to the forces of chance. The piece was written around a collection of four glass demijohns, connected by siphons and played by a percussionist. When the system is filled with water, raising or lowering a demijohn will cause water to flow, changing the pitch.

I hoped that this process would move me away from my Neoplatonic perspective and towards a new use of harmony. The pitches produced by the demijohns would be hard to control; my writing would have to adapt to this loss of compositional agency. This hope is clear from my programme note for the piece:

> 'In the 'straight line mission,' YouTuber Thomas George Davies attempts to cross a country in a straight line. Guided by GPS, he follows his pre-planned route, no matter the hedgerows, rivers, or angry farmers that bar his way. Beyond their entertainment value, these videos reveal much about a modern landscape: how

[134] Allami, 115–20.
[135] Khyam Allami and Counterpoint Studio, 'Leimma', accessed 24 May 2024, https://isartum.net/leimma.
[136] Allami, 'Échos-Monde: Towards a Hybrid Repertoire of Contemporary and Experimental Acoustic, Electroacoustic and Electronic Arabic Music', 82.

> nature collides with digital logic, how laws and customs rebuff an abstract line on a map.
>
> This reminded me of tuning theory, which is full of numbers representing frequency ratios. As a good theorist, you make the numbers dance, creating wonderful chords arrayed on a page. But these are refigured by reality: our instruments, our ears, and our muscle memories have their own ideas about which tunings have significance, and which are merely inflections.
>
> In this piece, glissandos act as straight lines through a tuned landscape. It was important that this line be inevitable and self-willed, but an electronic sonority felt wrong. Instead, we witness the inevitability of a physical process: siphons connect four glass vessels, retuning them as they move. To me, it is ceremonial, a procession through pitch space in which four musicians animate the machinery of gravity, water, and glass.'[137]

My approach can be understood in relation to Scott McLaughlin's work with 'material indeterminacy,' a 'compositional strategy grounded in the productive tensions of […] the contingent sounding of physical things.'[138] McLaughlin discusses embracing contingency and allowing a 'dance of agency' between the composer, the materiality of the instrument, and the 'sedimented' practice of the player.[139]

I wrote the piece in several stages. First, I tried to understand the demijohns. I charted the pitch they produced when struck against the volume of water in them (Figure III-1). I needed a spectrograph to do this, as the demijohns are inharmonic, producing several clearly audible pitches. I then converted this measure to show the height of water in the demijohn, in centimetres (Figure III-2). The siphon system settles when the water level in all vessels is at the same height, so by charting pitch against height I could see what pitches would be produced for a given volume of water. I decided what initial set of pitches I wanted between the demijohns and calculated what volume of water would create that initial pitch set (Number 1 in Figure III-3). That then allowed me to calculate which chords would occur when the demijohns were raised or lowered by a given height. I chose seven height positions for the demijohns, based on the chords produced at those heights (Figure III-4). Finally, I timed the transitions, seeing how long it took the water to flow between the demijohns and to settle at the new pitch (Figure III-5). This provided me with seven height/pitch set ups and the approximate time it would take to move between them. Finally, I workshopped the material with percussionist Angela Wai Nok Hui. My writing responded both to her both as a musician but also as a physical force: the movements of the demijohns had to be timed according to her ability to move the heavy glass vessels.

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[137] Joe Bates, *Straight Line Through A Landscape*, 2022.
[138] Scott McLaughlin, 'On Material Indeterminacy', *Contemporary Music Review* 41, no. 2–3 (4 May 2022): 218, https://doi.org/10.1080/07494467.2022.2080456.
[139] McLaughlin, 219–22.

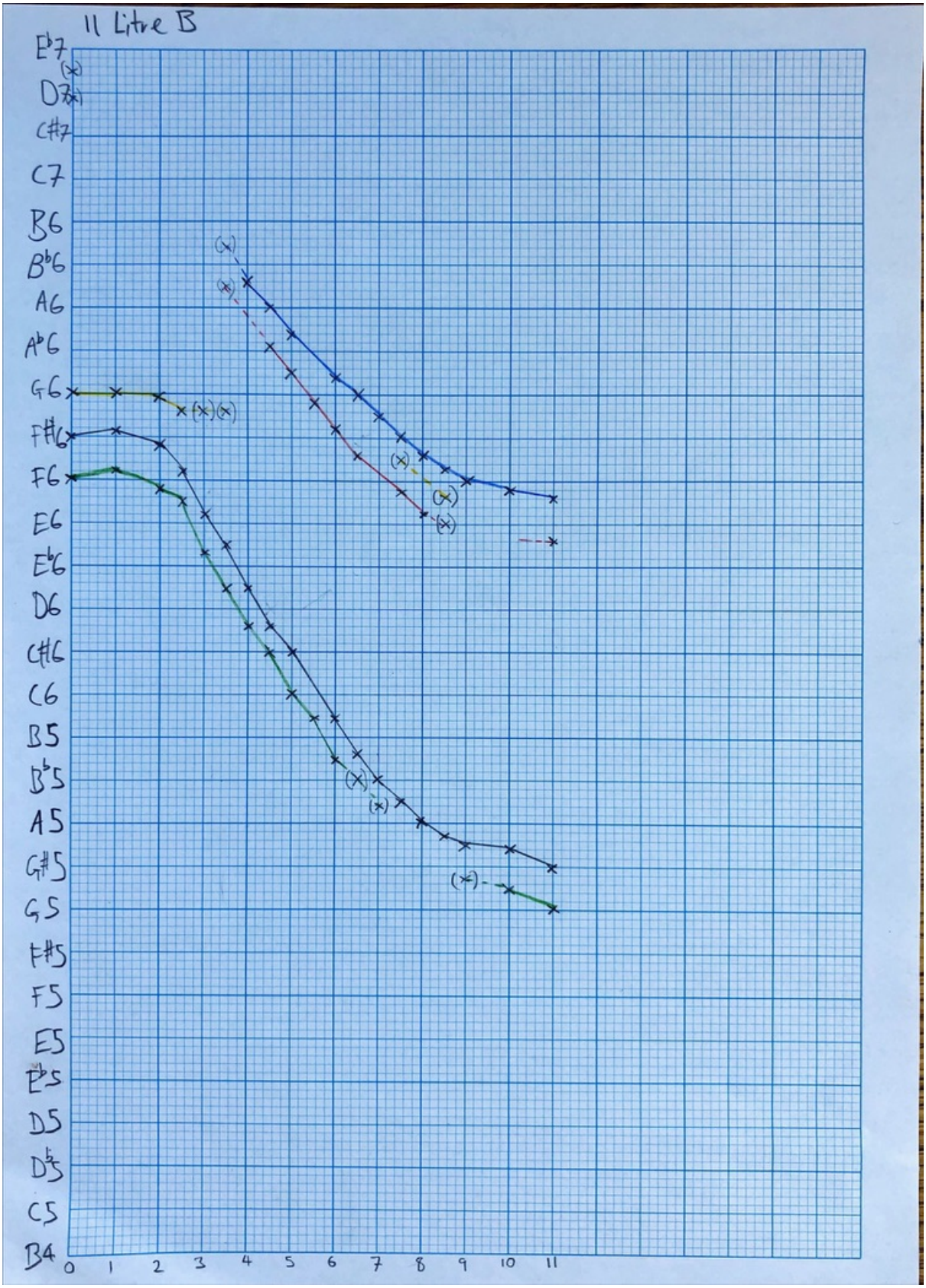


Figure III-1: the pitches produced by one of the two 11 litre demijohns, against the volume of water it contains in litres.

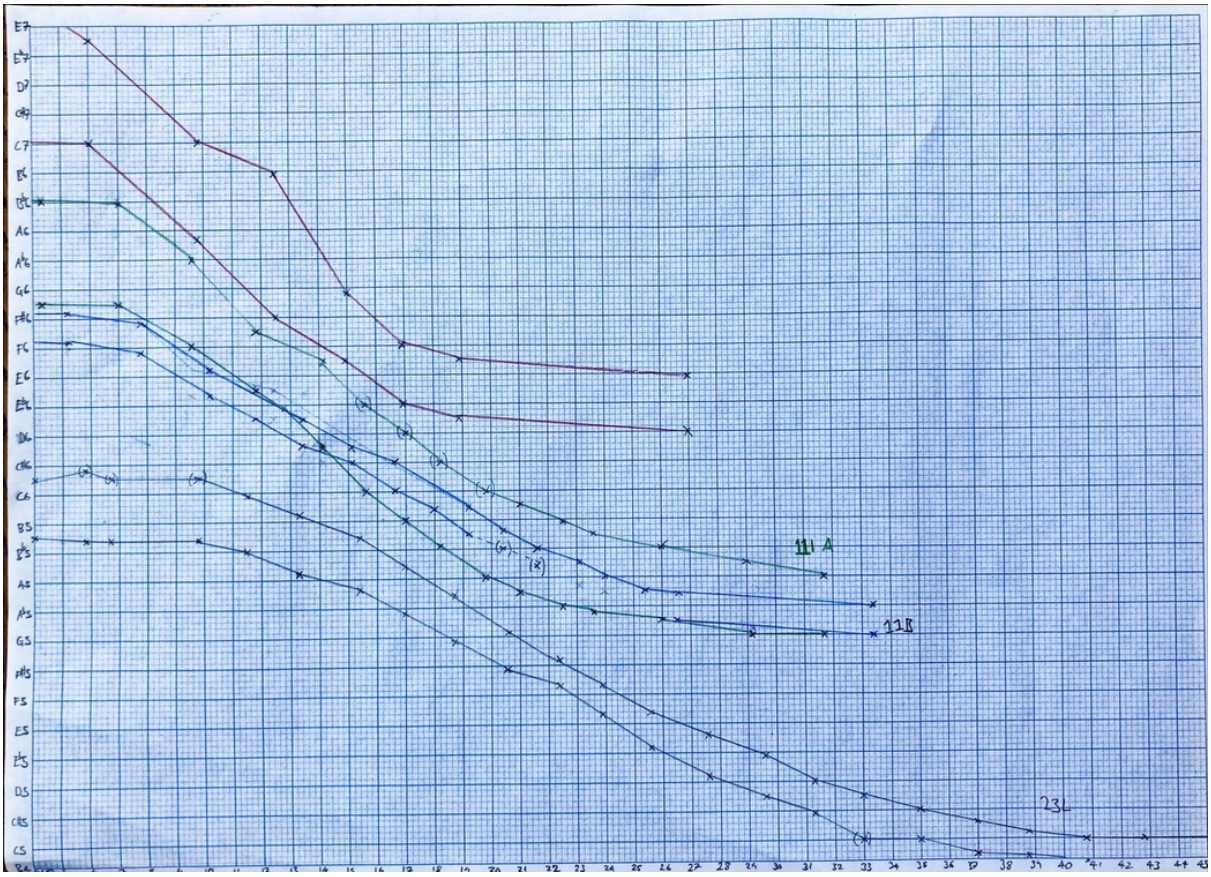


Figure III-2: the pitches produced by all four demijohns, against their water level in centimetres.

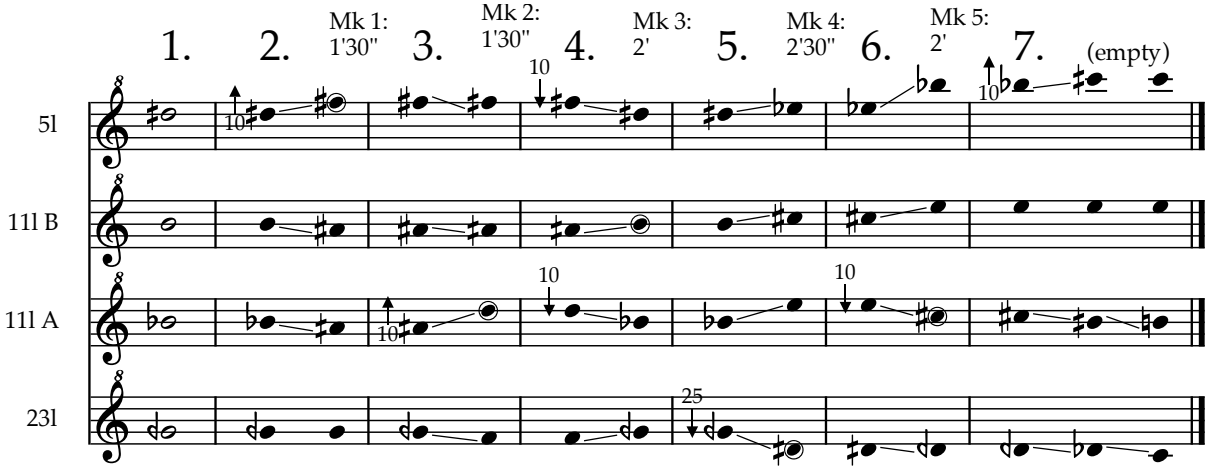


Figure III-3: the seven pitch/height set ups for the demijohns.

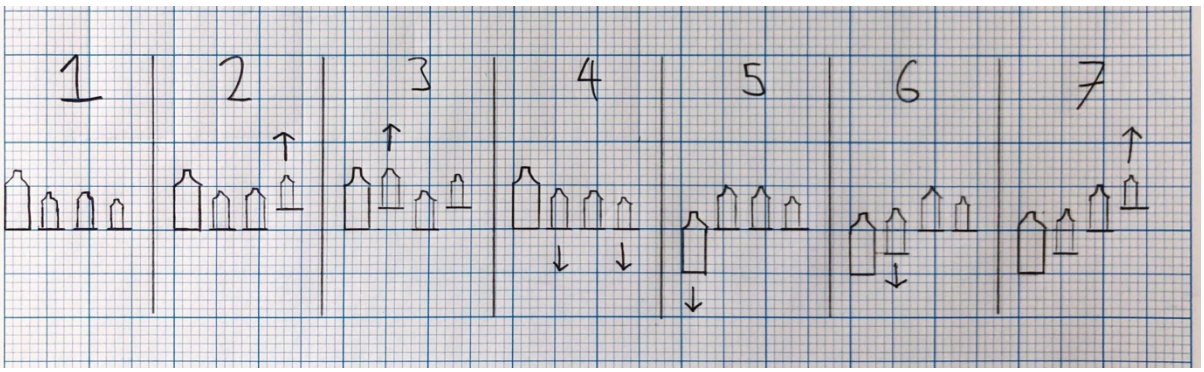


Figure III-4: the transitions between the seven pitch/height set ups.

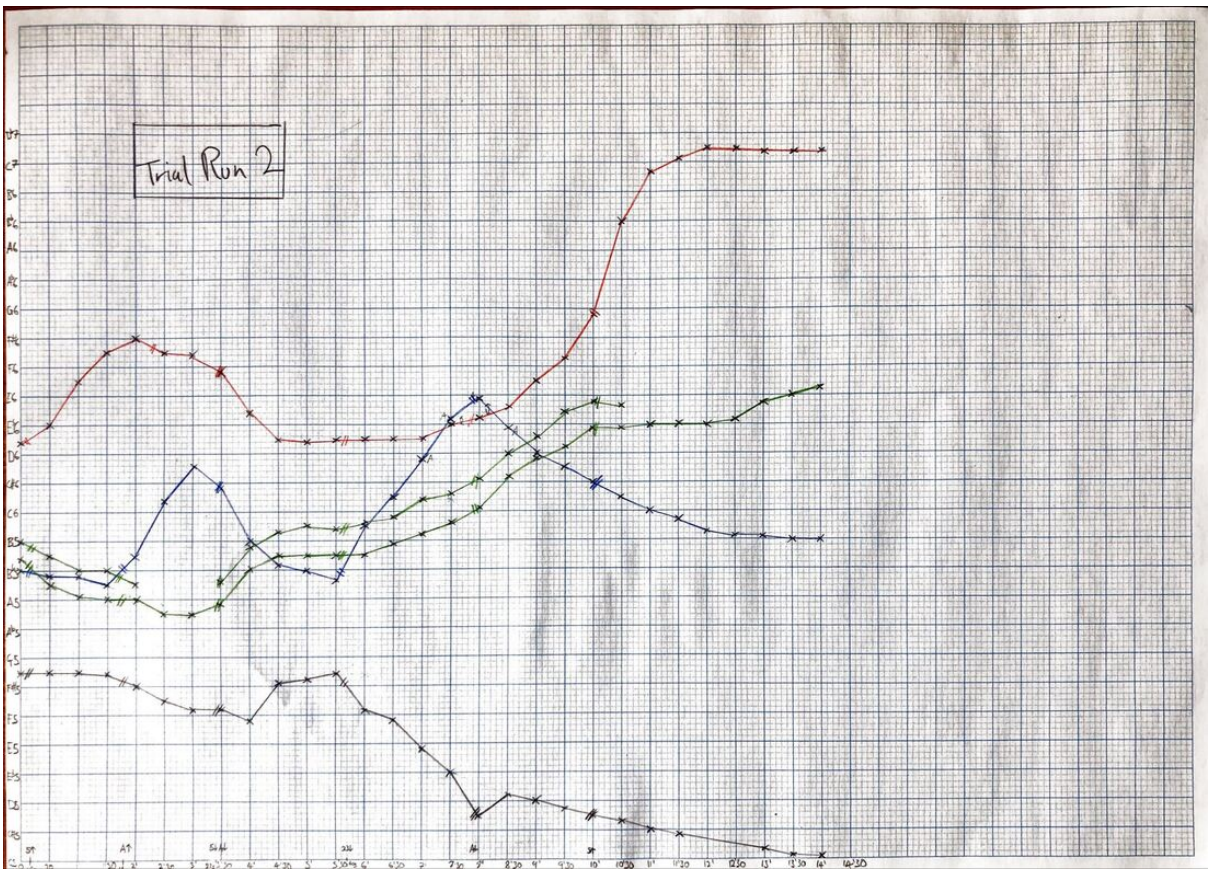
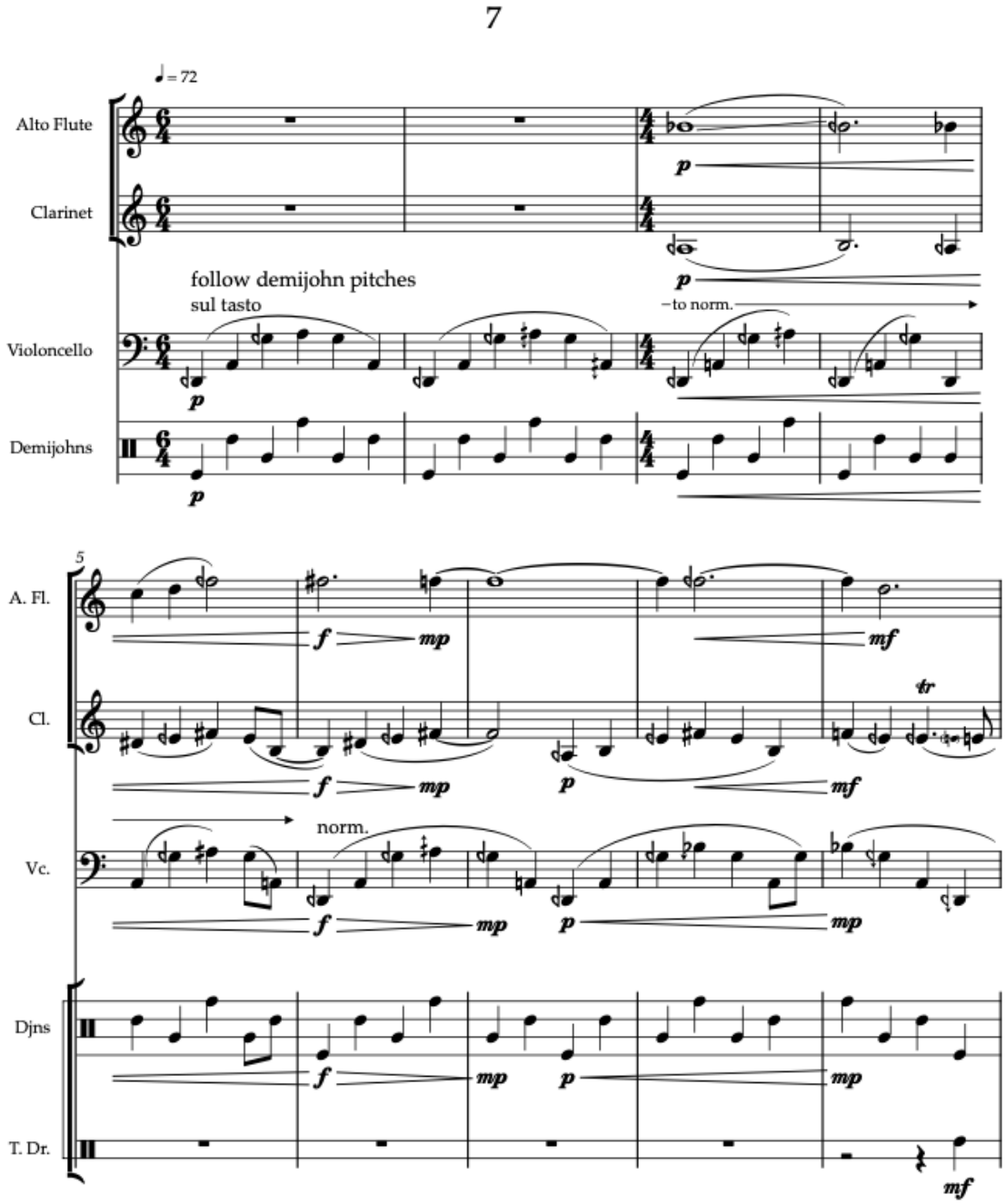


Figure III-5: the second trial run of the piece, showing the pitch over time.

The description of this process emphasises my agency in pitch choice in choosing to understand the inharmonic sounds as single pitches, quantised into 24EDO, and in working with Wai Nok Hui. However, the material agency of the demijohns in the composition process remained substantial. The inharmonic pitches could not be contained within my quartertone axis system and the height set ups always involved compromises in terms of pitch. The timing of transitions between demijohn positions gave the piece a pre-determined structure with aspects of indeterminacy due to the random variation in the length of these transition times. The agency of the demijohns resulted in a piece that departed substantially from my previous quartertone practice, embracing a more varied pitch world.

This is particularly the case in the last movement, where the cellist is instructed to follow the transitioning pitch of the demijohns, with the given pitches acting as guides rather than prescriptions (◂ Figure III-6). Writing in this way meant abandoning control twice. First, my music had to follow the logic of the transitions that I had timed and mapped, taking on their harmonic trajectory rather than one I created from scratch. Second, I had to accept that this might not happen as planned, that the pitches performed by the cello might wander from my imagined harmonic scheme.



◂ Figure III-6: bars 1-9, Movement VII, *Straight Line Through A Landscape*.

This was a significant shift from my previous practice, in which careful control of pitch and tuning was central to my conception of the musical language. However, the musical style of *Straight Line Through A Landscape* is not dramatically different from earlier works. In some sections, as discussed in Chapter I, I use repeating passages from which players may omit bars freely to allow the water levels of the demijohns to settle in their expected place. This ensures my control over the pitch collections that are reached at the beginning of each movement. In other passages, I am still writing as if I there is no material contingency. For example, in the passage above, I imagined the fifths and fourths between the clarinet and cello in bar 9 as producing that exact pitch relationship, despite knowing that they may not. Moreover, the cellist sometimes couldn't track the percussion in performance as planned, due to the inharmonicity of demijohns. In short, I did not musically internalise the level of contingency in the system.

My approach in *Straight Line Through A Landscape* thus differs from McLaughlin's practice both in manner and extent. My encounter with the materiality of the siphoned demijohns was primarily pre-compositional and the impact of contingency was, in McLaughlin's terms, 'obviated' through open-ended compositional devices and the reduced importance of specific harmonic verticalities.[140] The piece resembles my work with guitar and violin, in which my pre-compositional work is a dialogue between my musical interests, the materiality of the instrument, and the practice of the performer.

The difference in *Straight Line Through A Landscape* is that the contingencies of the siphoned instrument resisted my typical schematic approaches. This forced me to adopt more a flexible harmonic language and to be more relaxed about the precision of pitch. This partial embrace of material indeterminacy both produced striking sonic results, with which I remain pleased, and revealed to me that my specificity of pitch was circumstantial. When sounds are inharmonic, when gesture and theatricality take priority, and when pitches move at speed, the precision of my microtonality is less important.

B. Building a hybrid practice

Building a custom synthesiser, the Hyasynth – Composing for the Hyasynth – Hybridity and notation in Ink, Colour, And Gold On Paper

Building the Hyasynth

My interest in the materiality of instruments grew alongside my desire to develop an embodied understanding of pitch. This desire was provoked in part by Marc Sabat and Robin Hayward's work on consonance.[141] Sabat and Hayward take a sensory approach, viewing the consonance of intervals as related to their tuneability. They distinguish three interval types: consonant tuneables, dissonant tuneables, and untuneables. Consonant intervals can be precisely tuned by ear, using the beating between pitches and the

[140] McLaughlin, 219.
[141] Sabat and Hayward, 'Towards an Expanded Definition of Consonance: Tuneable Intervals on Horn, Tuba and Trombone'.

generation of combination tones. Dissonant tuneables can be found through a sequence of consonant tuneables. For example, a 63:32 might be found as the 7:4 of a 9:8. Untuneables cannot be found through a sequence of tuneable pitches, and must be learnt by rote, fixed in the pitch memory of a performer. Sabat and Hayward note that non-pitched considerations (player experience, register, timbre) affect tuneability, but that in general tuneability is associated with lower-order prime frequency ratios.

I became aware that my electronically mediated approach to composition flattened the difference between these interval types. Any interval can be precisely reproduced on a digital microtonal instrument. Yet for the performer of my work, or for its listener, the perceptual difference between these intervals remains. I found the disjuncture between my experience as a composer and the experience of the performers of my music unsettling. For the performers I worked with, the process of tuning was at the heart of my music. For me, it played a relatively minor role. It is no surprise that my most straightforward quartertone collaborations were with a guitarist and a harpist, for whom the acts of tuning and performance were also separated.

To audiate my music with less electronic support, I took to singing while composing, using the piano to hold reference pitches. This process was fruitful – I wrote the opening of *Wound Honey* in this way; it led to a stylistic tendency to prioritise melody. But it was also frustrating. My limited vocal range and inconsistent pitch control slowed me down, and I was unable to use the technique to build larger chords.

I built a new instrument, the Hyasynth, as a response to these frustrations. While several electronic instruments have microtonal capabilities (the Lumatone, for example), the Hyasynth has a unique approach. It is an intonationally flexible instrument designed to support a more embodied approach to tuning. It is named for Giacinto Scelsi, whose name means Hyacinth in Italian,[142] and whose experiments with the ondiola opened new avenues of microtonal experimentation.[143]

I also wanted to build an instrument on which I could perform electronic music live. When writing *Switchback*, I had intended to write a suite of pieces that would constitute an EP. In this planned EP, I wanted live performance to be a central concern from the beginning. The live performance of DAW-based music exists on a spectrum. At one extreme, a whole piece could be triggered by a single button press, at the other, every sound and each timbral alteration could require the press of the button or the turn of a knob. This continuum exists because there is little gestural relationship between the triggering of the sound and its sonic properties. A key stroke on a MIDI controller might produce a sound of any timbre, amplitude, or pitch. I find this alienating, undermining the connections between the performer, the audience, and the music.

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[142] I owe this crucial pun to Richard Causton.
[143] Marco Fusi, 'The Creative Performer and Giacinto Scelsi: Building a Creative Performance Practice in Dialogue with Giacinto Scelsi's Artefacts' (Antwerp, University of Antwerp, 2022), https://repository.uantwerpen.be/docstore/d:irua:12321.

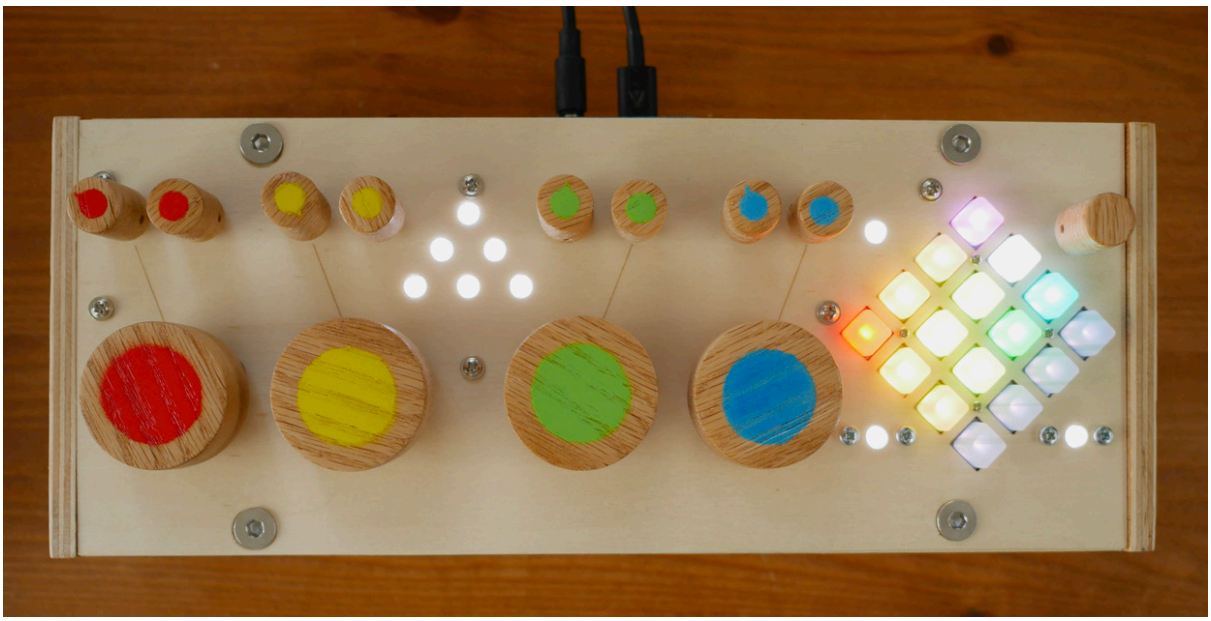

Figure III-7: the second prototype of the Hyasynth.

Yet in practice, I found my electronics constantly sliding along the continuum away from immediate control. I solved compositional problems through the creation of dense harmonies and timbres that I could then no longer perform. My reliance on such flexible digital means of microtonal pitch production had embedded complexity into my work. I hoped that the gestural control of the Hyasynth, in which pitch is intuitively and visibly controlled, might act as a form of restriction that would help me create more meaningfully live electronic music.

The synthesiser is currently in its second prototype. It is an Arduino-based controller communicating with a Max patch via serial port. It uses three means of pitch control: the rotary encoder pitch wheels, the combination tone keypad, and the mutual control functions. Each of these allows for a different type of interaction with pitch: pitch as continuum, pitch as proportion, and pitch as symmetry.

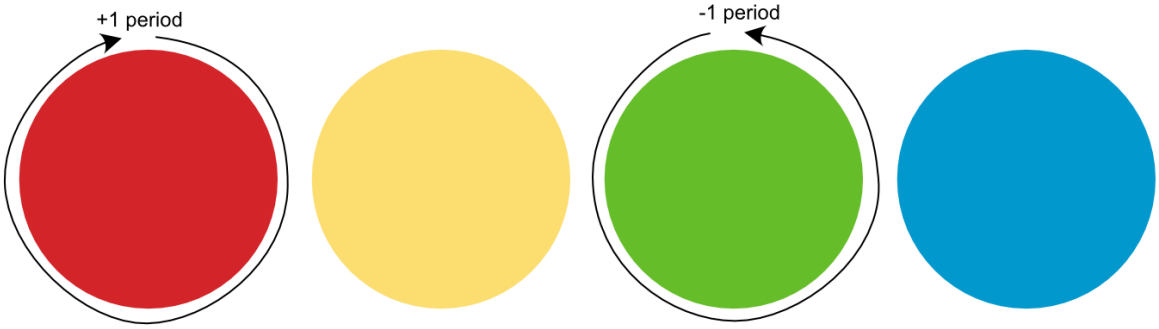

Figure III-8: the control wheels of the Hyasynth.

At the heart of the synthesiser are four high-resolution rotary encoders. They give the electronic performer intuitive access to pitch as a glissando continuum and the ability to use the beating of pitch relationships to tune. These are mapped to the pitch of four synthesiser

voices and allow for within 1¢ of accuracy. This precision also introduces contingency. Unlike the reliable intonation of a microtuned synthesiser, it is easy to mistune a pitch on the Hyasynth.

By default, a 360° rotation of the encoder is mapped to an octave of pitch space, but this is editable: any ratio may be selected as "the period." This allows for varied geometric relationships to the pitch circle. For example, half- and quarter-circle rotations are easily found visually, but these two- and fourfold divisions of the period produce different intervals depending on the size of the period. For a 2:1 octave, the four quarters of the circle produce a diminished seventh chord, for a 3:2 fifth, they produce a scale of 175¢ steps.

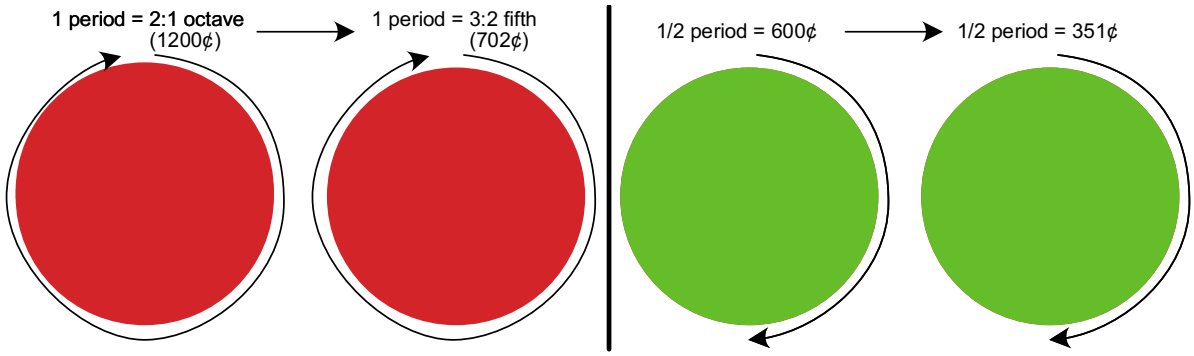

Figure III-9: varying period size on the control wheels of the Hyasynth.

A combination tone keypad enables the performer to trigger the combination tones of these four voices, adding a further twelve voices to the instruments. The frequency of each voice is either the sum or difference of the frequency of two of the pitch wheel's voices. All sixteen voices (the four pitch wheels and the twelve combination tones) can be triggered with MIDI, allowing for arpeggiation and sequencing.

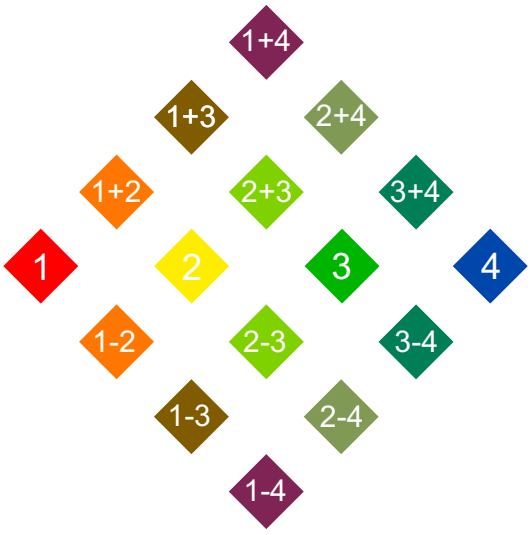

Figure III-10: the combination tone keypad.

These combination tones allow for a proportional interaction with pitch. Finding consonant tuneables in Just Intonation tuning is made easier by tuning a pair of notes to their combination tones. Dissonant tuneables are also easier to find, as intermediary steps in tuning sequence can be sustained on each of the respective pitch wheels. The combination tones can reveal the proportional relationships latent in pitches whose Just relationship is unknown, placing them on the harmonic series in surprising ways.

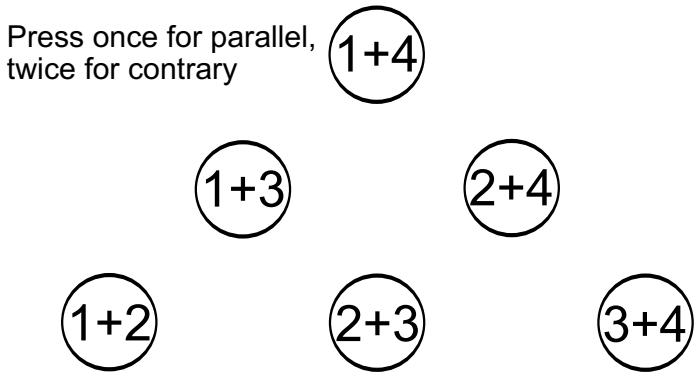

Figure III-11: mutual controls on the Hyasynth.

Finally, each of the four pitch wheels can control the pitch of the others. Using a keypad, any wheel may be locked to any other, which then moves it in parallel or contrary motion. Parallel motion allows for the preservation of intervallic relationships; contrary motion allows for the discovery of new relationships. These settings provoke symmetrical configurations, as the contrary motion continuum, when laid out on a circle, creates symmetry around the tritone. This idea draws on Tymoczko's musical geometries, which are rooted in the observation that all pitch combinations can be reached via parallel and contrary motion.[144]

In summary, the Hyasynth uses simple gestures to move pitches along the glissando continuum; buttons allow for the addition of combination tones and the mutual control of pitches. I developed this unique approach to pitch production alongside a theoretical framework, which I detail in 'Proportion and Symmetry as Mutual Antagonist In Tuning: The Resources of Quartertone Harmony.'[145] In this essay, I observe that the equal divisions of the fourth and fifth by the neutral and subminor thirds have properties related to the equal division of the octave by the tritone. I connect the harmonic resources of these three intervals, suggesting how the quartertone intervals may also possess the productive dissonance of the tritone and its power as a transpositional device.

For me, the unique appeal of the Hyasynth is the way that it combines a powerful theoretical tool with embodied, gestural control. It is, in some ways, counter-intuitive to find an embodied relationship with pitch in an electronic instrument. It is certainly distinct from the

[144] Tymoczko, *A Geometry Of Music: Harmony and Counterpoint in the Extended Common Practice*, 67.
[145] Joe Bates, 'Proportion And Symmetry As Mutual Antagonists In Tuning: Some Quartertone Resources', *Tempo* 78, no. 309 (2024).

embodiment of a string player, who is in immediate contact with the vibrating body of the instrument. Nevertheless, the connection between the psychoacoustic experience of pitch, the gestural control of the instrument, and the visual positions of the dials creates a strong sensory interaction.

Composing with the Hyasynth

This has resulted in a very different experience as a composer. Some notes are harder to tune than others, but due to challenges in audiation, rather than pitch production. This results in a process-oriented approach to tuning, where complex intervals are found through multiple steps. This then effects the structure of the work, tying harmonic complexity to temporality.

My initial work for the Hyasynth was written as part of a practice of tuning. It was inspired by Wolfgang von Schweinitz's *Plainsound Etudes*, which explores 11-limit Just Intonation on the violin.[146] The sine tone works of Chiyoko Szlavnics influenced the choice to use only sine waves, with minimal electronic processing.[147] The simplicity of these wave forms makes beats especially audible and leaves little space for the attention to rest other than on the gradual searching for pitch. I intended the austerity of this sound to highlight the process of intonation, contributing to a distinctive aesthetic of tuning that I detected in both Schweinitz's and Szlavnics's work. I do not view this as the only kind of music that the Hyasynth is suitable for, but by starting with such austere material I am able to familiarise myself with the physicality of my new embodied tuning practice.

I composed *Study for the Hyasynth* around a target tetrachord, which would be tuned in stages using the dials. It was built around the syntonic comma, with a target of 36:54:80:81 being reached in bar 8. This dissonant tuneable then acts as fixed point for voice-led variation, with the four primary pitches locked into parallel and then contrary motion. This leads to the emergence of extremely complex chords. Above these complex chords, I perform improvised combination tone melodies that animate the harmony with the higher partials of its implied harmonic series.

I have notated this piece using a relatively open form of notation (◂ Figure III-12). The music is not metred, as the process of tuning is not predictable. The piece highlights tuning as a process, making my search for each pitch an integral part of the structure of the work. This results in a structural progression from simple to complex sounds. Faster melodic movement is made available by the combination tone keypad. I have notated this with a form of graphic notation; pitches on the keypad are connected inside shapes, with right-angled vertices for chords and curved vertices for melodies.

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[146] Wolfgang von Schweinitz, *Plainsound Etudes*, Plainsound Music Edition, 2014.
[147] Chiyoko Szlavnics, 'Opening Ears: The Intimacy Of The Detail Of Sound', *Filigrane*, no. 4 (2006).

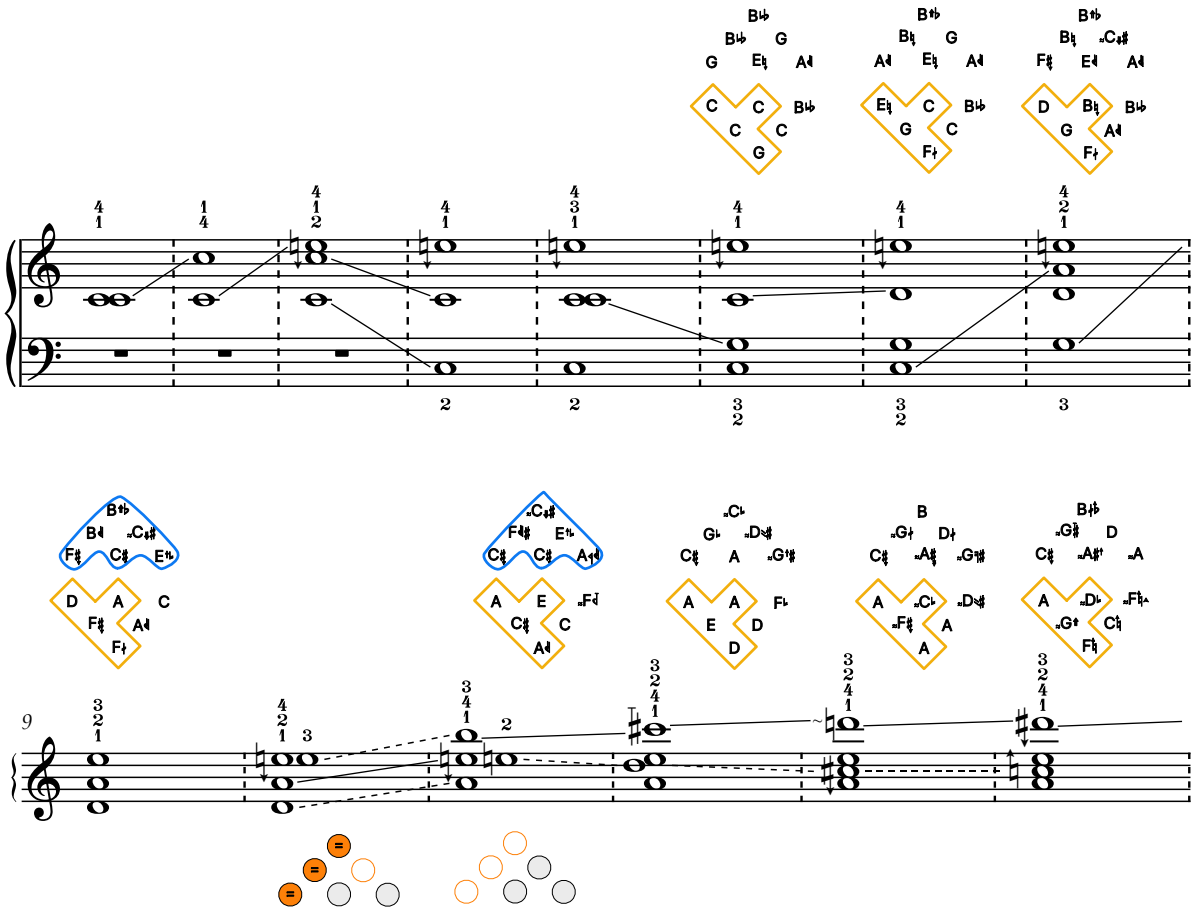


Figure III-12: the opening of *Study for the Hyasynth*.

Combined resources in *Ink, Colour, And Gold On Paper*

Ink, Colour, And Gold On Paper was written for a French festival, CIEL 2023, where it was performed by Ensemble Linea and where I premiered *Study for the Hyasynth*. It is the only work in this portfolio that includes all aspects of my hybrid practice. Hybridity suited the unusual instrumentation: flute, horn, theorbo, violin, and cello. The combination of intonationally flexible and inflexible instruments, the presence of brass, and the addition of the theorbo presented a unique challenge. In writing music that suits this ensemble, I went the furthest towards combining my quartertone axis theory, Just Intonation diatonicism, and combination tone harmony of any work I have written so far.

The work undertaken for this portfolio has resulted in a methodology for beginning pieces. I start with an abstract engagement with the harmonic resources available on the given instruments. Then I engage with the performers to assess the practical and aesthetic potential of these harmonic resources. This leads to a series of initial sketches. I then consider how the musical material in these sketches might be recontextualised, constructing the outline of a musical structure.

I based the piece's intonation on the affordances of the instruments involved. My consideration of the harmonic resources of the ensemble began with the theorbo, which I wanted to retune. The theorbo has two string courses, one fretted (the petit jeu) and one

unfretted (the grand jeu). On Linea's theorbist Caroline Delume's instrument, the lower course, the grand jeu, covers the six white notes from G1 to E2. The eight strings of the higher course, the petit jeu, cover F2 to B3. I lowered string IV and V by a quartertone:

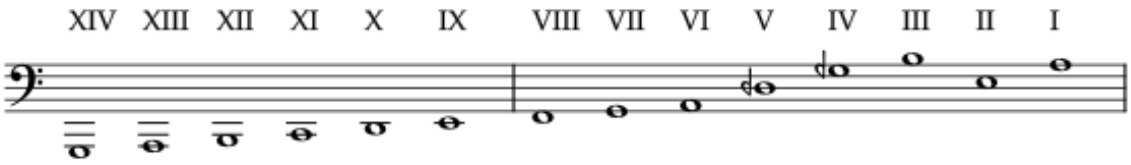


Figure III-13: theorbo tuning, *Ink Colour, And Gold On Paper*.

This tuning was based on my guitar tuning from *Odd Coils*; I hoped to use the theorbo to provide a 24EDO spine to the piece. My initial sketches were oriented around quartertone axis system chords, particularly the subminor circle zone around D𝄲–E–G𝄲. Throughout the rehearsal process, I worked closely with Delume to revise the theorbo part, reducing its harmonic density to allow for greater resonance.

I wanted to experiment with a deeper integration of diatonic and quartertone harmony. I decided that the strings would primarily play Just Intonation diatonic harmony, to which they are suited by their flexible intonation and the reference points of their open strings. The flute would play diatonic harmony and quartertones. I took care to plan where notes would be bent by lip and where they would use alternate fingerings. I exploited the horn's access to the high partials of the harmonic series, including moments of 13-limit harmony.

This would be notated in HEJI, with the 3-based accidentals (i.e. conventional notation) and the 11-based accidentals (i.e. quartertones) tempered. The 5-, 7-, and 13-based accidentals would then relate to this tempered spine of 24EDO pitches. I discussed initial sketches over email with the theorbist to develop an initial idea, which now occupies bars 36-40.

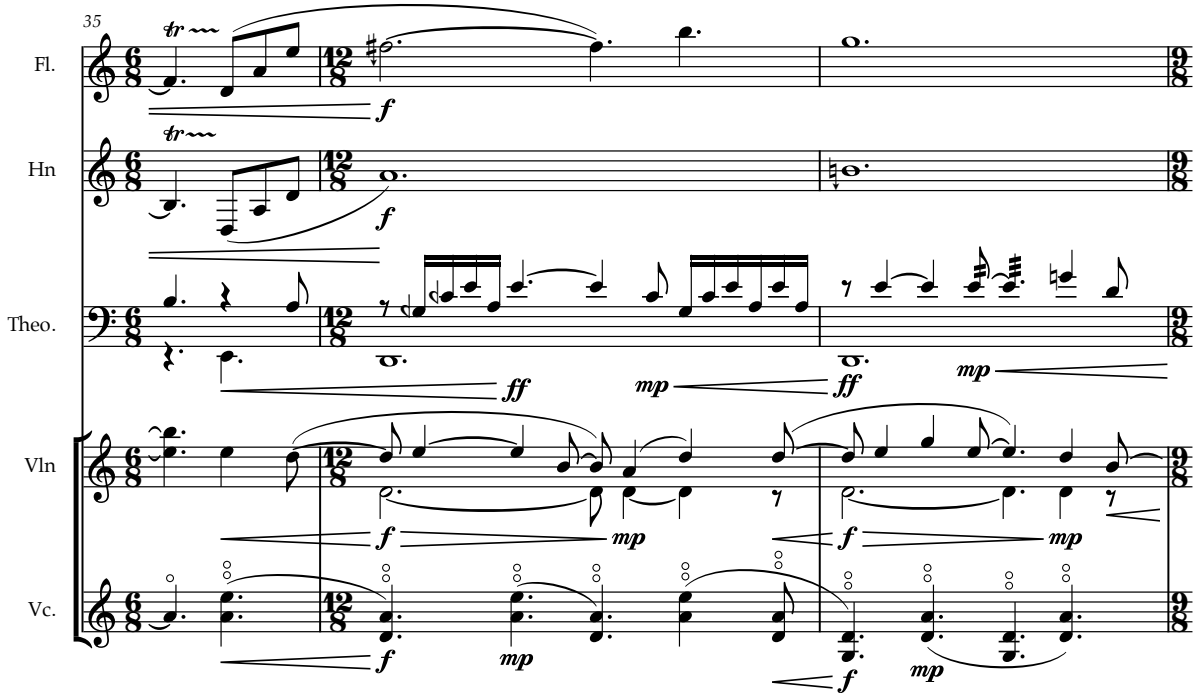
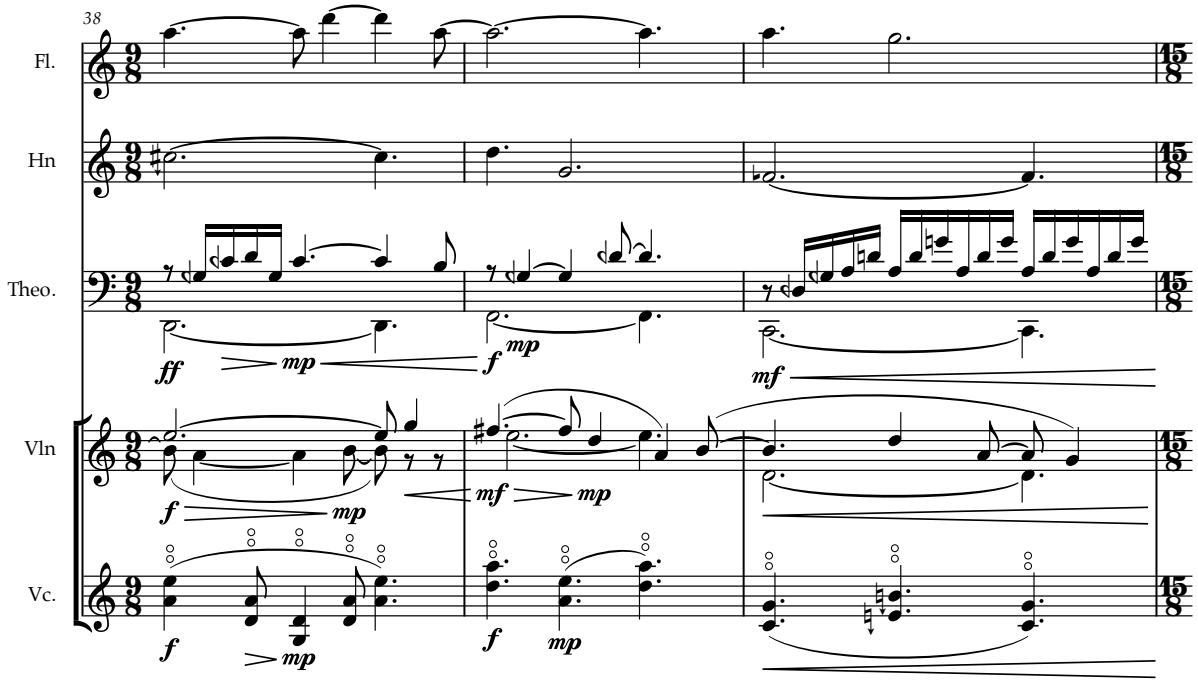


Figure III-14 continues on next page.



◖ Figure III-14: bars 36-40, *Ink, Colour, And Gold On Paper*.

In this piece, I experimented with allowing multiple intonational principles to work alongside each other, linked loosely. In this passage, I relate the 24EDO subminor harmony to the diatonic chords as if it were 7-limit. This renders the C𝅘𝅥 and G𝅘𝅥 in bars 36 and 38 as the 7° and 21° of a D major chord then an A major chord. This level of approximation is not something I had been happy to consider before. The Just Intonation diatonic and 24EDO subminor harmonic maintain their own intonational logic, even when that leads to dissonances. In both bar 36 and 38, subminor stacks in the theorbo add notes that clash with the major thirds of the prevailing chords. This dissonance is emolliated by a two-octave displacement, the inharmonicity of the theorbo, and the busy texture of the passage.

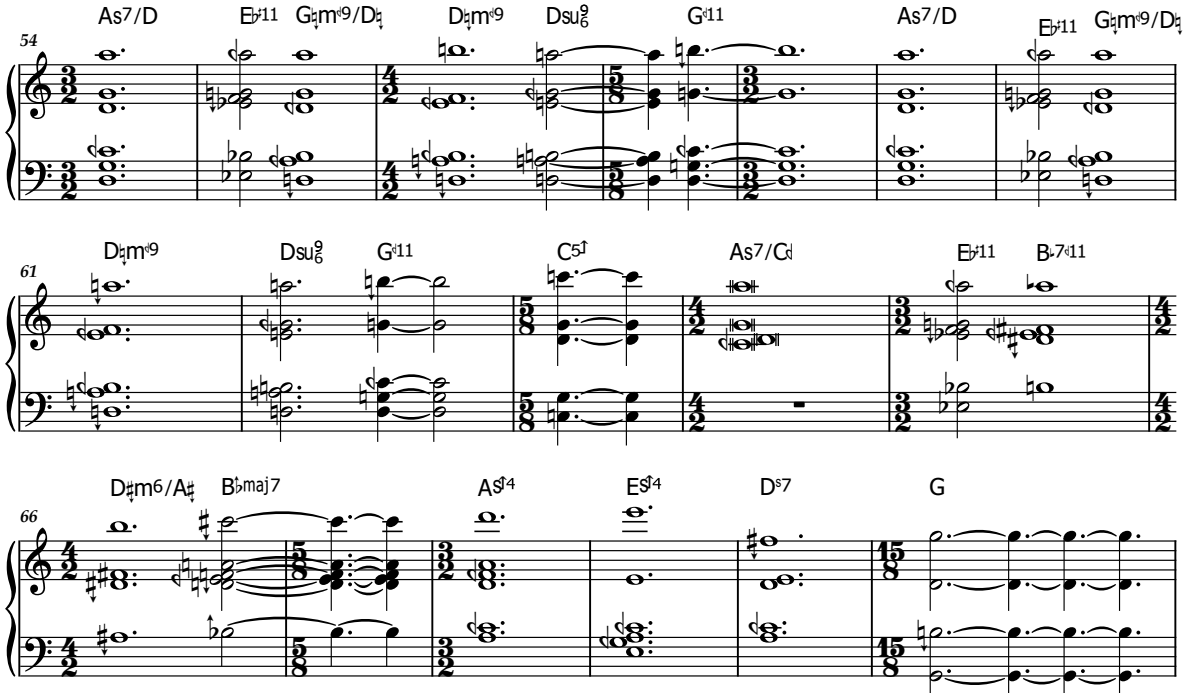
After this initial sketch was written, I considered how to recontextualise its material, building the beginnings of a diatactical structure. The piece's thematic structure is episodic; the piece is inspired by folios of Mughal miniatures in which unconnected scenes are bound together, connected by their framing in gold arabesque. In *Ink, Colour, And Gold On Paper*, it is the shifting microtonal harmonic language that binds together the melodic episodes. Throughout the piece, I pair neutral and subminor scales with diatonic harmonies. I link these harmonic languages either by using the quartertones as specific partials in the implied harmonics series of the diatonic harmony – 7°, 11°, and 21° – or by giving their triadic harmonies shared root notes. In each section, I maintained part of the previous section's harmonic language, providing continuity.

For example, in the dense harmony of the passage that follows Figure C (◖ Figure III-15), subminor harmonies are recontextualised alongside diatonic chords in Just Intonation, with quartertones treated as 11°, rather than as 7°. In bar 55-56, the A𝅘𝅥 acts as the 11° of E♭ and the

B𝄲 as the 11° of F. Unlike in the previous sections, the diatonic chords are generally minor. Strong dissonance between the quartertones and Just minor chords dissolve on the subminor harmonies of bars 59, 64, and 68-69, tonicising the G subminor harmonic area. In the final two bars of this section, 70-71, the harmonic strategy of Figure B re-emerges, with the quartertones of the subminor treated as the 7° and 21° of major chords.

Bars	Thematic material	Harmonic language			Harmonic link
1	A	Subminor			N/A
36	A′	Subminor	Major		7°, 21°
53	B	Subminor	Major	Minor	11°
71	C	Subminor	Major		Shared roots
114	B	Subminor	Major	Minor	11°
149	D	Neutral		Minor	11°
188	A	Neutral			N/A
201	A′	Neutral	Major		11°
209		Subminor	Major		7°
215	A	Subminor	Major		Shared roots

Table 11: structural chart of *Ink, Colour, And Gold On Paper*.



◂ Figure III-15: bars 54-71, *Ink, Colour, And Gold On Paper*, harmonic reduction.

The horn melody that flows over this harmony was an improvised vocal line, as are several other melodies in this piece. This includes aspects of the string lines in bars 81-93, the flute line in bars 120-132, and the flute melody in bars 172-175. This intuitive method gave me the confidence to write melodies that are in friction with their harmonic contexts. These lines evidence the change in my thinking about musical pitch after writing *Straight Line Through A Landscape*. Their horizontal logic reduces the importance of microtonally precise pitch and allows the resulting dissonance to be integrated into the piece's syntax.

Notational paradoxes in *Ink, Colour, And Gold On Paper*

I communicated this combination of harmonic languages in adapted HEJI. The theorbo's notation was simple, as it stayed in 24EDO, while the strings were almost always in diatonic Just Intonation, with occasional 7- and 11-based notes shown in HEJI. I showed the intended harmonics on the horn using HEJI, noting where a series of pitches could be played as the overtones of a single harmonic series.

The notation of the flute part, however, posed questions. From bar 78-105, the shorter note values make precision of intonation harder and less important. The part uses quartertone notes that I knew could be achieved with specific fingerings alongside diatonic pitches that sound in simple relationships to the other instruments. In the other instruments, these pitches are written in HEJI, reflecting my intention for them to be carefully tuned in Just Intonation.

As I intend the flute to play in tune with these instruments, I wrote its part in HEJI as well. This results in a very complicated looking flute part. I considered simplifying the part, as the intonation of these shorter note values is not very important. But I was concerned that this would lead to confusion in rehearsal when players noticed the difference between their pitches and tried to play the passage accordingly.

This is complicated further by the theorbo's part. As this is in 24EDO, it contains pitches that will be slightly out of tune with the surrounding context, though this effect is mitigated by the inharmonicity of the plucked sounds. In the passage in ◂ Figure III-16, for example, the C major harmony in bar 82 is embellished by an A𝄲 in the horn. The theorbo and flute in bar 81 play figuration that includes A𝄲; this continues into bar 82. There is, theoretically, an intonational clash between the subminor harmonies of the theorbo and flute and the Just Intonation of the horn and strings. In practice, this clash is of little specific musical importance, instead contributing to a blurry friction between the musical lines.

There is no good notational answer for the flautist's part. My decision is that the longer note values ought to be spelled to harmonies with the Just Intonation harmony, while the shorter note values are written in 24EDO, to be in tune with the subminor harmony of the theorbo. More important is the performance note for the flute player, that clarifies that they should in general tune with the strings and that precision of intonation is not of utmost importance in this passage. In rehearsal, this passage proved straightforward, with the flautist intuiting a working intonation for their part.

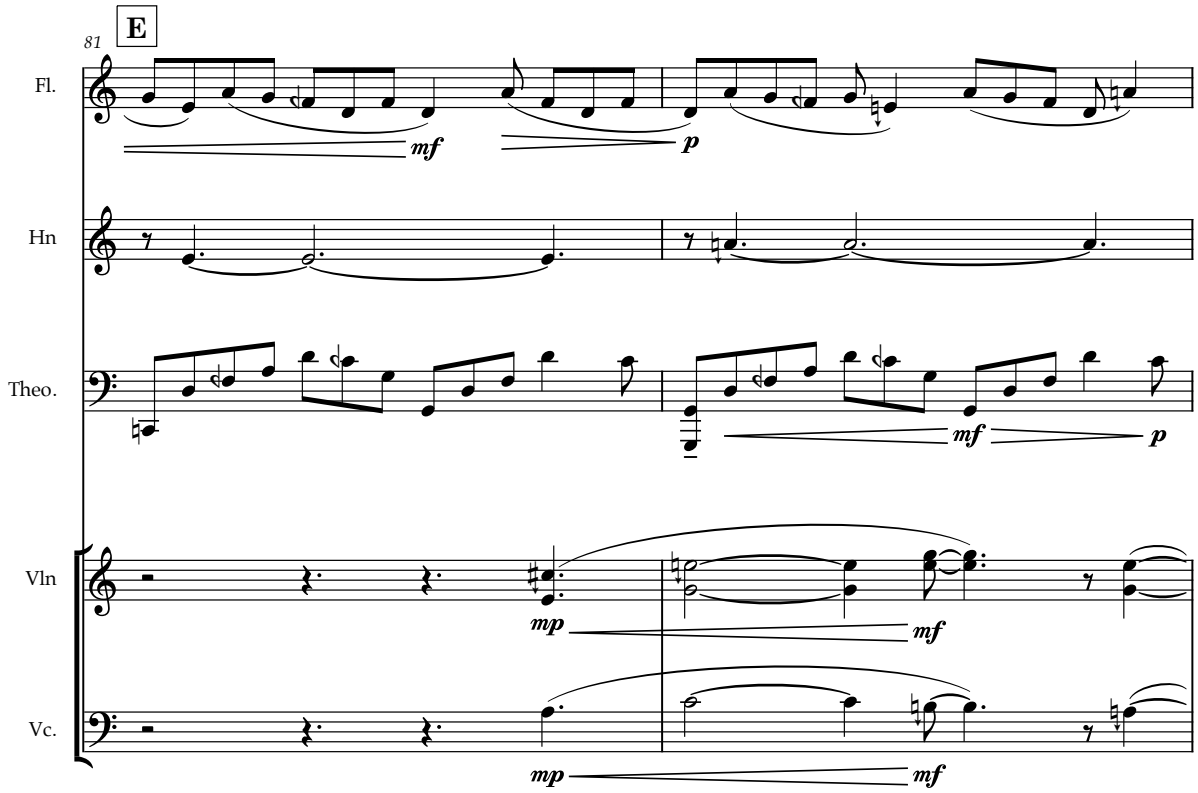


Figure III-16: bars 81-82, *Ink, Colour, And Gold On Paper*.

C. Conclusion

Ink, Colour, And Gold On Paper illustrates not just a stylistic change from my earlier microtonal practice, but a shift in my understanding of what a microtonal practice might mean. In it, I intuitively and eclectically combine the harmonic resources of my systematic approach to microtonality with diatonic, improvisatory material. The piece integrates the systematic harmony of the axis system with musical approaches generated through the critical process of engaging with that system's limitations.

Taking an abstract, systematic approach to microtonal harmony – whether through the quartertone axis system or with combination tone tetrachords – has been enormously beneficial to my work. It has allowed me to find harmonic resources that feel both strange and familiar; chords with enough connections to familiar consonances that I can forge a musical language from them, but different enough that alterity remains. These systems have helped make these chords sound like home, by aiding the production of a consistent harmonic language based on the principle of weighted zones in harmonic space. Moreover, by working consistently within this legible harmonic system, I was able to internalise its logic, allowing me to access a more instinctive approach to its sonorities.

Working with this system also revealed its contingency and incompleteness. It could not, on its own, tonicise my xenharmonic material; rhythm, syntax, and diatactical structure are crucial in the formation of tonal language. These temporal elements do not inhere in the systems but are adhered to them by my compositional choices. These choices have, however,

been guided by the affordances of the system, particularly by its tritone relationships, which have played an important role in my musical structures.

These systems could not remain self-contained. Extroversive reference to familiar tonal systems is inevitable, requiring a theory of relationship between the system and its social context. This is also necessary for understanding the exoticist tropes and orientalist histories that inevitably colour the reception of xenharmonic music in the West. One must also understand the realities of instrumental writing, given that instruments and the practices of the musicians who play them have been shaped by conventional approaches to pitch.

Contextualising my systematic approach within a broader material and social context has resulted in a hybrid practice. Seeking ways to relate my axis system to diatonic harmony resulted in an embrace of Just Intonation, both as a tonal resource and as a way to recontextualise intervals with combination tones. In this hybrid 24EDO/Just Intonation practice, I have found a new pragmatism as regards the capacities of instruments and realities of tuning. My former exactitude has relaxed in the face of experiments like the use of inharmonic demijohns in *Straight Line Through A Landscape*. My engagement with an embodied approach to tuning, realised through the Hyasynth, has encouraged me to differentiate intervals in terms of their tuneability. This both means thinking about the possibility of tuning complex, dissonant pitches step-by-step, as in my electronic studies, or the slow chorales of *Wound Honey*, and knowing when to abandon an excessive concern with tuning precision, as in the quavers of the flute part of *Ink, Colour, And Gold On Paper*.

My research has changed my mind about my own work. I no longer view the axis system itself as my most interesting contribution, though I still value its affordances. Rather, I am most proud of the process of transforming a rigid, abstract system into an embodied, flexible, and interconnected harmonic practice. My practice still involves abstract, systematic thinking, often at the initial stages of a composition. These initial moments of exploration have proved vital in allowing me to find and understand surprising harmonic resources. But I now follow abstraction with connection, integrating my new ideas into an embodied and material practice that considers the intonational agency of the musicians and the instruments involved in the work.

Initially, my understanding of abstraction contained an underexamined irony. I hoped to resist the false connections of the attention economy by opting out of its semantic saturation, using alterity and systematic thinking to nurture an interior, abstract, and discursive music. This resembled what Odell calls a strategy of 'retreat': an attempt to avoid the clamour of contemporary life through solitude,[148] or, in my case, to find musical connection through a withdrawal into the abstract. These interior resources are important, but it is in their contact with and transformation by the material world and the practices of other musicians that they acquire vitality.

[148] Odell, *How to Do Nothing*, 30–62.

IV. End Matter

Appendix One: Microtonal Terminology

Interval names

In this commentary, interval names are approximate. For example, the term 'minor third' might be applied to a 12EDO interval (300¢) or several Just Intonation intervals (6:5, 19:16). This is also true of xenharmonic intervals: a 'quartertone' might be the 50¢ interval in 24EDO, or the 33:32 interval in Just Intonation. Where necessary, the intonational context for the interval will be supplied alongside the interval name: 300¢ minor third, 6:5 minor third, 19:16 minor third.

The xenharmonic interval names used in this commentary are derived from Wyschnegradsky's *Manual of Quartertone Harmony*.[149] These interval names relativise xenharmonic intervals to familiar diatonic pitches, placing them in a culturally specific Western context.

The interval between a unison and a minor second is called a quartertone. Intervals between major and minor intervals are called neutral; intervals lower than major, minor, or perfect intervals are given the suffix 'sub' and 'super'. This differs from Wyschnegradsky's designation of intervals larger and smaller than perfect as 'major' or 'minor' fourths and fifths. In some cases, I add 'semi' or 'super' to the terms 'diminished' and 'augmented' to indicate that an alteration is increased or decreased. In Table 12, these generic interval names are shown in a 24EDO context.

Just Intonation intervals

Just Intonation intervals, whether xenharmonic or not xenharmonic, are referred to in one of three ways:

- By their simple name (e.g. subminor third, major third) in a context where their Just tuning is either not important or is clear from context,
- With their ratio (e.g. 7:6 subminor third, 5:4 major third),
- Or with their prime limit (e.g. 7-limit subminor third, 5-limit major third).

More complex intervals are always described with their ratio – e.g. a 19:17 major second.

[149] Wyschnegradsky, Kaplan, and Kaplan, *Manual of Quarter-Tone Harmony*.

Cents	Interval names		
50	Quartertone		
150	Neutral second		
250	Subminor third	Supermajor second	
350	Neutral third		
450	Supermajor third	Subperfect fourth	
550	Superperfect fourth	Semiaugmented fourth	Superdiminished fifth
650	Subperfect fifth	Semidiminished fifth	Superaugmented fourth
750	Superperfect fifth	Subminor sixth	
850	Neutral sixth		
950	Subminor seventh	Supermajor sixth	
1050	Neutral seventh		
1150	Supermajor seventh	Semidiminished octave	

Table 12: interval names in 24EDO.

Chord names and symbols

Chord names and symbols are derived from Tagg, though I do not adopt all his neologisms.[150, 151] As in diatonic harmony, triads that span a perfect fifth are named by their third and given a corresponding symbol: subminor triad (s), neutral triad (n), and supermajor triad (su).

Alterations to the perfect fifth of a triadic chord are specified with the terms semidiminished, etc. These are shown in chord symbols with an accidental: ♯5, ♭5. Alterations to sevenths are shown in the same way: ♯7, ♮7, ♯♯7, ♭7.

Finally, chords made up of self-similar, non-triadic intervals are named, after Tagg, as stacks: the subminor stack (s↑), the quartal stack (4↑), and the quintal stack (5↑). In inversion, quartal and quintal stacks are shown with symbols 2 and 4, rather than the more familiar sus designations.[152]

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[150] Tagg, *Everyday Tonality II*.
[151] Tagg, for example, notes the ambiguity arising from the correspondence between the words 'dyad' and 'triad.' He uses -ad suffixes to show the number of notes in a chord (dyad, triad, tetrad, etc.) and -al suffixes to show the quality of those intervals (tertial, quartal, quintal, etc.). This system is admirably clear, but I feel the need to limit my neologisms given the profusion of microtonal terminology in this commentary.
[152] In Tagg's words, 'because if there's nothing suspended… about a chord, it's perverse to designate it as if there were.' Tagg, *Everyday Tonality II*, 291.

Stacks emanating upwards from a note are shown with an upwards arrow: 4↑. Those surrounding a principal note are shown with arrows facing both up and down (4↕). Stacks with more than three notes specify the number of notes as part of the chord symbol: (4↕5).

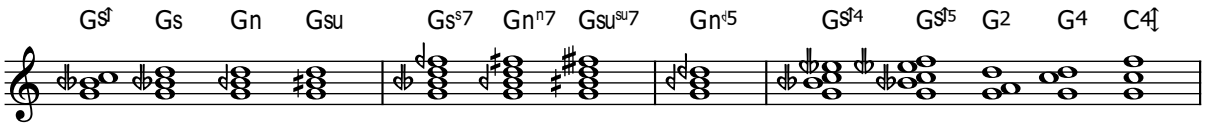


Figure IV-1: chord symbol examples.

Helmholtz-Ellis Just Intonation notation

I use Helmholtz-Ellis Just Intonation (HEJI) to specific Just Intonation intervals. This notation was developed by Marc Sabat and Wolfgang von Schweintiz in the early 2000s, integrating symbols originally created by earlier microtonal theorists, such as Giuseppe Tartini, Richard H. Stein, and Gérard Grisey.[153] Conventional notational symbols – the seven diatonic notes, sharps, flats, and double sharps and flats – indicate a 3-limit open-chain series of fifths.

Pitches based on other primes are shown by adding accidentals to these standard notes; each accidental alters the note it is attached to by a comma between that limit and the third limit. For example, the comma between the third and seventh limit is a 64:63. The HEJI accidental for the seventh limit is a 𝄭. The interval A–G𝄭 is thus a 7:4, while the interval A–G is a 16:9. Accidentals can be combined to show alteration by two such commas. For example, the 7:4 of a 7:4, a 49:16, can be shown with the interval A–F𝄫. Intervals that combine two prime limits, such as a 35:32, require two accidentals, e.g. A–B𝄭♮.

Generally, this portfolio only uses accidentals up to the eleventh limit, with the 13th to 23rd limit being used sparingly. In *Wound Honey*, I also use the 43rd limit. Table 13 shows the HEJI accidentals used in this submission. It uses the most recent version of HEJI. [154]

[153] Marc Sabat and Wolfgang von Schweinitz, 'The Extended Helmholtz-Ellis JI Pitch Notation', trans. Natalie Pfeiffer, *Plainsound Music Edition*, 2005, https://masa.plainsound.org/pdfs/notation.pdf.
[154] Marc Sabat and Thomas Nicholson, 'The Extended Helmholtz-Ellis JI Pitch Notation', 2023, https://heji.plainsound.org.

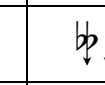
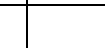
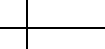
Limit	Comma	Accidental	Double Accidental
3	N/A		
5	81:80		
7	64:63		
11	33:32		
13	27:26		
17	2187:2176		
19	513:512		
23	736:729		
43	129:128		

Table 13: HEJI accidentals used in the portfolio.

Appendix Two: Generalising The Axis System

The axis system described in a Chapter I is an instance of a more general type that can be found in many other equal temperaments. First, the intervallic circles at its core are found in every equal temperament. They have a special role, however, in equal temperaments of non-prime cardinality. Second, the relationship between the circles of the 24EDO axis system relates to the invertibility of their composites, the perfect fifth and fourth.

This appendix will briefly illustrate some of the general principles underlying intervallic circles in equal temperaments. The topic, however, requires further research to produce a fuller understanding of the sound of these circles.

Generalised generator circles

For an interval circle to be non-chromatic, it must have a generator whose interval size (g) of greater than 1.

For an interval circle to be complete, g must not be a divisor of the cardinality of the temperament (n). Any g that divides into the tonal cardinality will result in an interval circle that repeats at the octave. This is expressed $g \nmid n$.

For an interval circle to be included it must not be a subset of another circle, as the augmented chord is of the whole tone scale. As such, g must be prime.

Interval circles that are inversions of one another (i.e. where $g_1 + g_2 = n$) are considered identical. As such, we can discard all generators lager than n/2.

In summary, we are interested in interval circles where $g \nmid n$, $g<n/2$, and g is prime.

In temperaments where n is prime, all prime-numbered intervals smaller than $n/2$ generate complete intervallic circles.

Generator circles with invertible relationships

Theory

The neutral/subminor axis system's unique properties derive in part from the mutual invertibility of the perfect fourth and fifth, the composite of their generators, the neutral and subminor third. Similar cyclical relationships will arise in other equal temperaments.

Binary divisions of mutually invertible intervals

We can express the relationship between the neutral and subminor in the 24EDO axis system in the following way, where g_1 is the subminor third, g_2 is the neutral third, a is the perfect fourth, b is the perfect fifth, and n is the cardinality of the octave:

$2g_1 = a$; $2g_2 = b$; $a+b = n$

This suggests a more general typology, of pairs of generator intervals, each of which is half the size of a pair of mutually invertible intervals. We can find such generator intervals by solving the simultaneous equation for n:

- $2g_1 + 2g_2 = n$

- $g_1 + g_2 = n/2$

This shows that if any two generator intervals combine to make a tritone ($n/2$), they will have an axis relationship.

Non-binary divisions of mutually invertible intervals
We might generalise this twice more.

First, rather than assuming that g_1 and g_2 must divide a and b in half, we might re-express our initial condition set as:

- $xg_1 = a;\ xg_2 = b;\ a+b = n$

Which simplifies to:

- $g_1 + g_2 = n/x$

This allows us to find axis relationships with generator intervals that coincide on mutually invertible intervals after more than two steps. For example, there is an axis system in 36EDO between the intervallic circles whose generators divide the perfect fourth/fifth into three parts.

Unequal divisions of mutually invertible intervals
Second, rather than assuming that g_1 and g_2 must divide a and b into the same number of parts, we might re-express our revised condition as:

- $xg_1 = a;\ yg_2 = b;\ a+b = n$

Which simplifies to:

- $xg_1 + yg_2 = n$

This shows us axis relationships between scales that subdivide their mutually invertible compounds into different numbers of parts. For example, there is an axis system in 31EDO between the intervallic circles whose generators divide the 387¢ major third (~5:4) into five and seven parts.

Summary
Axis systems occur when the generators of two intervallic circles within the same temperament coincide on mutually invertible intervals. In the subminor/neutral axis system examined in this portfolio, the generators coincide on the perfect fourth/fifth.

Examples

The tables below show axis systems in equal temperaments up to 72EDO, and with generators of interval class size up to the eleventh prime, 31. Each table has been filtered to remove generator intervals (g_1 and g_2) that are divisors of the EDO's cardinality (n).[155]

[155] These removed scales, where a complete intervallic circle coincides with a Mode of Limited Transposition, are themselves interesting phenomena worthy of further research.

Some of these are of particular interest and so have been underlined. Each of the equal division tables contains one example in which a perfect fifth/fourth are equal subdivided into 2, 3, and 4 parts. These occur in 24, 36, and 48EDO respectively. These related axis systems will have similar properties due to the shared size of their invertible intervals.

While the equal divisions all occur in temperaments of non-prime cardinality, prime EDOs predominate amongst the unequal divisions. These include axis systems whose mutually invertible intervals are close approximations of 5:4 major third/8:5 minor third (31EDO) and the 6:5 minor third/5:3 major third (53EDO).

These scales might make an interesting basis for further research: this listing of them is just the first step towards an appreciation of the resources that might be found through equal subdivision of mutually invertible intervals. I discuss the aesthetics of such resources in greater depth in 'Proportion And Symmetry As Mutual Antagonists In Tuning.'[156]

[156] Bates, 'Proportion And Symmetry As Mutual Antagonists In Tuning: Some Quartertone Resources'.

Equal divisions of mutually invertible intervals

Mutually invertible intervals divided in two			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a*, *b* cents**
16	3, 5	225, 375	450, 750
20	3, 7	180, 420	360, 840
24	5, 7	250, 350	500, 700
28	3, 11	128, 471	257, 942
32	3, 13	112, 487	225, 975
32	5, 11	187, 412	375, 825
36	5, 13	166, 433	333, 866
36	7, 11	233, 366	466, 733
40	3, 17	90, 510	180, 1020
40	7, 13	210, 390	420, 780
44	3, 19	81, 518	163, 1036
44	5, 17	136, 463	272, 927
48	5, 19	125, 475	250, 950
48	7, 17	175, 425	350, 850
48	11, 13	275, 325	550, 650
52	3, 23	69, 530	138, 1061
52	7, 19	161, 438	323, 876
56	5, 23	107, 492	214, 985
56	11, 17	235, 364	471, 728
60	7, 23	140, 460	280, 920
60	11, 19	220, 380	440, 760
60	13, 17	260, 340	520, 680
64	3, 29	56, 543	112, 1087
64	13, 19	243, 356	487, 712
68	3, 31	52, 547	105, 1094
68	5, 29	88, 511	176, 1023
68	11, 23	194, 405	388, 811
72	5, 31	83, 516	166, 1033
72	7, 29	116, 483	233, 966
72	13, 23	216, 383	433, 766
72	17, 19	283, 316	566, 633

Mutually invertible intervals divided in three			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a*, *b* cents**
36	5, 7	166, 233	500, 700
48	5, 11	125, 275	375, 825
54	5, 13	111, 288	333, 866
54	7, 11	155, 244	466, 733
60	7, 13	140, 260	420, 780
66	5, 17	90, 309	272, 927
72	5, 19	83, 316	250, 950
72	7, 17	116, 283	350, 850
72	11, 13	183, 216	550, 650

Mutually invertible intervals divided in four			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a*, *b* cents**
32	3, 5	112, 187	450, 750
40	3, 7	90, 210	360, 840
48	5, 7	125, 175	500, 700
56	3, 11	64, 235	257, 942
64	3, 13	56, 243	225, 975
64	5, 11	93, 206	375, 825
72	5, 13	83, 216	333, 866
72	7, 11	116, 183	466, 733

Mutually invertible intervals divided in five			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a*, *b* cents**
50	3, 7	72, 168	360, 840
70	3, 11	51, 188	257, 942

Unequal divisions of mutually invertible intervals

Mutually invertible intervals divided in two by g_1 and in three by g_2			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a, b* cents**
19	5, 3	315, 189	631, 568
23	7, 3	365, 156	730, 469
29	7, 5	289, 206	579, 620
31	5, 7	193, 270	387, 812
31	11, 3	425, 116	851, 348
35	13, 3	445, 102	891, 308
37	11, 5	356, 162	713, 486
41	13, 5	380, 146	760, 439
43	5, 11	139, 306	279, 920
43	11, 7	306, 195	613, 586
43	17, 3	474, 83	948, 251
47	7, 11	178, 280	357, 842
47	13, 7	331, 178	663, 536
47	19, 3	485, 76	970, 229
49	5, 13	122, 318	244, 955
49	17, 5	416, 122	832, 367
53	7, 13	158, 294	316, 883
53	19, 5	430, 113	860, 339
55	17, 7	370, 152	741, 458
55	23, 3	501, 65	1003, 196
59	13, 11	264, 223	528, 671
59	19, 7	386, 142	772, 427
61	5, 17	98, 334	196, 1003
61	11, 13	216, 255	432, 767
61	23, 5	452, 98	904, 295
65	7, 17	129, 313	258, 941
67	5, 19	89, 340	179, 1020
67	17, 11	304, 197	608, 591
67	23, 7	411, 125	823, 376
67	29, 3	519, 53	1038, 161
71	7, 19	118, 321	236, 963
71	19, 11	321, 185	642, 557

Mutually invertible intervals divided in three by g_1 and in four by g_2			
n	$g_1 + g_2$	g_1, g_2 **cents**	***a, b* cents**
29	3, 5	124, 206	372, 827
37	3, 7	97, 227	291, 908
41	7, 5	204, 146	614, 585
43	5, 7	139, 195	418, 781
53	11, 5	249, 113	747, 452
53	3, 11	67, 249	203, 996
59	13, 5	264, 101	793, 406
59	5, 11	101, 223	305, 894
61	11, 7	216, 137	649, 550
61	3, 13	59, 255	177, 1022
65	7, 11	129, 203	387, 812
67	13, 7	232, 125	698, 501
67	5, 13	89, 232	268, 931
71	17, 5	287, 84	861, 338

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